# ANNUAL PROGRESS REPORT 2013-14

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


**Compiled and edited by**

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ICAR

NBAII

**National Bureau of Agriculturally Important Insects (NBAII), Bangalore 560 024**

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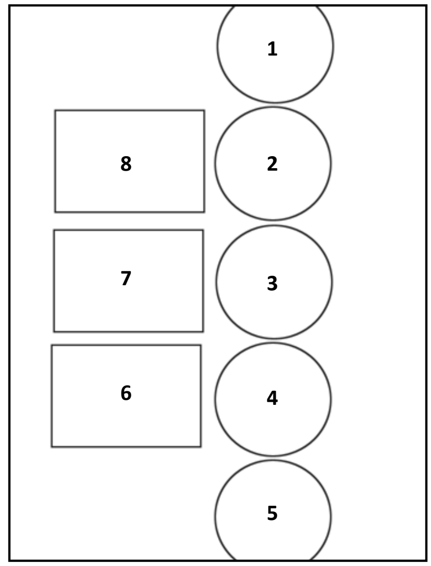


**Cover page**

1. Scientists who piloted the biocontrol based management of the sugarcane woolly aphid in Maharashtra.
2. A water body largely free of *Salvinia molesta* consequent to release of the biocontrol agent *Cyrtobagous salviniae*.
3. Dattatraya Haribhau Kand, a Pune farmer who successfully managed the papaya mealybug with the parasitoid Acerophagus papayae supplied by MPKV, Pune and went on to extend this technology to papaya farmers in the region.
4. The farmer-scientist team in front of the sugarcane field at Motori, Dhenkanal, Bhubaneshwar where the sugarcane early shoot borer and internode borer were successfully managed by releasing *Trichogramma chilonis* supplied by OUAT, Bhubaneshwar.
5. Foreign delegates interacting with NBAII staff at the International Agricultural Exhibition COP – II at Hyderabad.
6. *Trichogramma japonicum* Ashmead
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**Cover design**: Sunil Joshi

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**3. Maize**

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**4. Coconut**

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

**5. Brinjal**

i. BIPM in brinjal (OUAT)

# 2. EXPERIMENTAL RESULTS

## 2.1. Basic Research

## 2.1.1. National Bureau of Agriculturally Important Insects

### Biosystematic studies on agriculturally important insects

### i. Taxonomic studies on parasites & predators of insect pests

*Anagyrus amnestos* Rameshkumar, Noyes & Poorani (Hymenoptera: Encyrtidae) was described in collaboration with scientists from Clemson University, US and the Natural History Museum, London, many years after it was originally collected in the US. This parasitoid is of US origin and has spread to Italy and India, probably on accidental introduction along with the host. This is the only parasitoid that has been found to be effective against the madeira mealybug (*Phenacoccus madeirensis* Green) so far, with high degree of host specificity. It was observed to occur in and around Bangalore and Mudigere in Karnataka. Even at low densities of the mealybug, *A. amnestos* has been found to be active, which is a promising trait. A new species of *Calvia* Mulsant (Coccinellidae) was described from North-east India. *Platynaspis flavoguttatus* (Gorham), a rare species of Coccinellidae from Karnataka, was redescribed and the male genitalia were illustrated for the first time. *Aspidimerus birmanicus* (Gorham), a species hitherto known from Myanmar, Thailand and China, was recorded from Meghalaya, which constitutes a new distribution record for India. Three Chinese species, *Sumnius yunnanensis* Mader (Meghalaya), *Afissula craspedotricha* Yu (Sikkim) and *Cryptogonus hainanensis* Pang & Mao (Tripura), were recorded from India for the first time.

### ii. Biodiversity of economically important Indian Microgastrinae (Braconidae)

Described 5 new Indian species of parasitic wasps in 2013-14

*Buluka horni* Gupta, 2013
*Dolichogenidea cinnarae* Gupta *et al*., 2013
*Glyptapanteles clanisae* Gupta, 2013
*Glyptapanteles trilochae* Gupta, 2013
*Parapanteles echeriae* Gupta *et al*., 2013

Five species of parasitic wasps associated with hesperiids from peninsular India are documented along with the description of a new species of gregarious endoparasitoid, *Dolichogenidea cinnarae* Gupta *et al*. 2013, (Hymenoptera: Braconidae) parasitic on caterpillar of *Borbo cinnara* (Wallace) (Lepidoptera: Hesperiidae). The gregarious larval parasitoid, *Cotesia erionotae* (Wilkinson) (Braconidae) and solitary pupal parasitoid *Charops plautus* Gupta & Maheshwary (Ichneumonidae) were bred from the host *Udaspes folus* (Cramer) on the host plant *Hedychium coronarium* J. Koenig. *Udaspes folus* is the new host record for the parasitic wasp genus *Charop*s. *Cotesia erionotae* was bred from *U. folus* caterpillars from three states: Maharashtra, Karnataka and Kerala. An encyrtid wasp *Ooencyrtus papilionis* Ashmead was bred from eggs of *Bibasis jaina* (Moore) on the host plant *Hiptage benghalensis* (L.). This is the first documentation of a parasitic wasp from the genus *Bibasis*. *Leptobatopsis indica* (Cameron) (Ichneumonidae), often associated with *Parnara guttatus* (Bremer & Grey), was recorded from the Andaman Islands.

A new species of gregarious endoparasitoid, *Parapanteles echeriae* Gupta, Pereira & Churi, 2013 bred from *Abisara echeria* Stoll (Lepidoptera: Riodinidae) on host plant *Embelia* sp. (Myrsinaceae), was described and illustrated from Mumbai, Maharashtra, India. *Abisara echeria*, commonly known as plum judy, is a small striking butterfly prevalent in Asia. This is the first ever record of a parasitic wasp associated with *Abisara*. A key to the Indian species of *Parapanteles* was also published.

***Glyptapanteles clanisae* Gupta 2013,** a gregarious endoparasitoid, was bred from the caterpillar of *Clanis phalaris* Cramer (Lepidoptera: Sphingidae) on the host plant *Pongamia pinnata* (L.) (Leguminosae) along with a hyperparasitoid, *Eurytoma* sp. (Eurytomidae).

***Glyptapanteles trilochae* Gupta 2013,** was reared from parasitized caterpillar of *Trilocha varians* (Walker) (Lepidoptera: Bombycidae) on the host plant *Ficus racemosa* L. (Moraceae) along with a hyperparasitoid, *Paraphylax* sp. (Ichneumonidae: Cryptinae).

***Buluka horni* Gupta 2013,** was collected from solitary cocoons of an indeterminate caterpillar feeding on *Mangifera indica* L. leaves.

At NBAII, a Web portal on "Indian fauna of Pteromalidae" for NBAII website with species identification fact sheets. http://www.nbaii.res.in/Pteromalidae/index.php was developed

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

Surveys were conducted for Platygastroidea in three states viz., Meghalaya (Umiam and Umran), Orissa (Bhubhaneshwar, Jaraka and Cuttack) and different part of Karnataka.

A total of 1500 parasitoids were collected, curated and preserved for future studies. So far 52 genera under five subfamilies were recorded from India and an additional five genera are added (**Table** 1) raising the total to 57 genera.

The genus *Phanuromyia* (Telenominae) is reported for the first time from India. The genus *Amitus*, parasitoids of whiteflies, was recorded only from Bihar, now it is reported for the first time from South India and Sikkim. The genus *Nixonia* which was recorded only from Uttaranchal was reported for the first time from South India.

So far only three genera viz., *Telenomus*, *Baryconus* and *Platyscelio* were reported from the state of Odisha. Recent surveys conducted in Bhubhaneshwar and Cuttack revealed the presence of thirty two more genera under five subfamilies.

Nine new species of Platygastroids *viz*. *Mantibaria kerouaci* (Scelioninae), *Allotropa gundlupetensis* (collected from Madeira mealybug, *Phenacoccus madeirensis*), *Allotropa vanajae, Allotropa nigra, Amblyaspis fabrei, Amblyaspis panhalensis, Amblyaspis charvakae, Amblyaspis ashmeadi* and *Amblyaspis tippusultani* were described.

**iv. Biosystematics of Trichogrammatoidea (Hymenoptera)**

Surveys were conducted in the South (Tamil Nadu: Ooty, Kotagiri; Karnataka: Tumkur, Chikkaballapur, Chintamani, Mandya, Maddur, Hessarghatta, Attur), East (Odisha: Bhubaneswar, Cuttack) and Northeast (Meghalaya: Umiam, Umran) of India for the collection of Trichogrammatidae. Ten genera of Trichogrammatidae were collected. Of these, *Lathromeroidea* is new record for South India while Paratrichogramma is a new record for Karnataka. *Trichogrammatoidea nana* collected from Meghalaya is the first record of the genus from Northeast India. *Trichogramma cuttackensis* was collected from Bhubaneshwar which though contiguous is the only place that it is known from outside its type locality. This species does not multiply on the eggs of *Corcyra cephalonica* but can be reared on the eggs of Sphingidae. This is also the first species of Indian *Trichogramma* for which pseudogenes were detected.

*Megaphragma* which were known earlier from Karnataka and Uttar Pradesh were collected for the first time from Orissa and Meghalaya. A distinct but closely related taxon collected from Meghalaya is being studied.

**v. Biodiversity of aphids, coccids and their natural enemies**

- A total of 109 field surveys were made and 2541 insect specimens collected.

- Specimens thus collected were processed by making slides. 2640 slides were prepared by following standard procedure.

- 1630 specimens of aphids, coccids, diaspidiids, and pseudococcids were identified.

- Identification services for 390 species of aphids and coccids were extended for SAUs, ICAR institutes and private organizations.

- Nine species of Mealybugs, twenty species of aphids, four predators and nine parasitoids were identified and submitted to Molecular Biology laboratory for DNA barcoding and other studies.

- *Metaceronema japonica* (Maskell), *Stictacanthus azadirachtae* (Green), *Shivaphis celti* Das and *Odonaspis greenii* Cockerell were recorded for the first time from Karnataka.

- *Planococcus bendovi* Williams, *Ctenochiton olivaceum* Green, *Macrosiphum euphorbiae* (Thomas) and *Milviscutulus mangiferae* (Green) were recorded for the first time from South India.

- *Marsipococcus iceryoides* (Green), *Ceronema fryeri* Green, *Maacoccus piperis* (Green), *Trijuba oculata* De Lotto, *Protopulvinaria longivalvata* Green, *Paralecanium ovatum* Morrison, *Paralecanium vacuum* Morrison, *Paralecanium mancum* (Green), *Eriococcus coccineus* Cockerell, *Duplaspidiotus claviger* (Cockerell), *Exallomochlus philippinensis* Williams and *Astegopteryx pallida* van der Goot were recorded for the first time from India.

- Twenty nine species of parasitoids were recorded from 43 species of coccids out of these one parasitoid species was a new record from India; eight were new records from Karnataka and four were new host associations.

**vi. Molecular characterization and DNA barcoding of some agriculturally important insect pests**

From different parts of the country, more than 500 insect species belonging to different groups were collected. Specimens were kept in -70°C as well as in 95% alcohol for DNA extraction. After morphological identification, generally one leg was taken for DNA isolation except for specimens which were minute. Extracted DNA was kept in -20°C until used and process employed was as per protocol for PCR work for obtaining products for sequencing. These insect belonged to 162 species, in 9 orders, *viz*., Hemiptera, Diptera, Lepidoptera, Coleoptera, Hymenoptera, Araneae, Ixodida, Mantodea and Isoptera and a total of 63 families. All sequences agreed with Folmer's region, >550 bp with complete species information for 46 species for which Barcodes were generated. The percentage wise characterization of 162 species was Hemiptera (29.6%), Lepidoptera (22.2%), Diptera (16.7%), Coleoptera (12.3%), Hymenoptera (11.7%), Araneae (2.5%), Ixodida (1.9%), Mantodea (1.9%) and Isoptera (1.2%).

**vii. Molecular Characterization and DNA barcoding of Agriculturally Important Parasitoids and Predators**

Molecular characterization using cytochrome oxidase 1 region (CO1) the following parasitoids namely *Aprostocetus gala* (KF817576), (KF958278), *Tetrastichus schoenobii* (KJ 627790), *Chelonus blackburnii* (KF 365461), *Bracon hebetor* (KJ 627789), *Quadrastichus mendeli* (KF879806), *Sceliocerdo viatrix* (KF 938928), *Pseudleptomastix mexicana* (KF365460), *Leptomastix nigrocincta* (KJ 489424); pollinators namely *Apis florea* (KF 817578), *Apis cerana indica (*KF 861941), *Megachile anthracina* (KF 861940), *Apis dorsata* (KJ 513470); predators namely *Amphiareus constrictus* (KF 817577), *Xylocoris flavipes* (KF 365462), *Blaptostethus pallescens* (KF365463), *Buchananiella indica* (KF 383326), *Cardiastethus affinis* (KF 383326), *Scymnus nubilus* (KF861939), *Isoliaindica* (KJ489423), *Cheilomenes sexmaculata* (KF998579) and weed killer *Teleonemia scrupulosa* (KF 817579) was done and GenBank Acc. Nos. obtained.

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

The commonly recorded anthocorids were *Cardiastethus exiguus* Poppius, *Blaptostethus pallescens* Poppius, *Cardiastethus affinis* Poppius and *Orius tantillus* (Motschulsky). Additionally, *Buchananiella crassicornis* Carayon on *Lagestromia*, *Orius shyamavarna* Muraleedharan and Ananthakrishnan on *Butea monosperma*, *Physopleurella* sp. from flour mill, *Buchananiella indica* Muraleedharan on Crossandra, *Amphiareus constrictus* (Stal.) on sugarcane, *Orius maxidentex* Ghauri on *Wedelia* and *Anthocoris muraleedharani* Yamada on *Ficus* sp. were collected. *B. indica, A. muraleedharan* and *A. constrictus* were amenable to rearing on alternate laboratory hosts. Two new species of *Orius* (*Orius* sp. nov. and *Orius* sp. nr. *O. pallidicornis*) were collected from *Hibiscus* and *Butea,* respectively.

*Orius amnesius* Ghauri collected on rose and *Buchananiella pacificus* Herring are first records for India. Genbank accession numbers were obtained for *Buchananiella indica:* (KF383325), *Cardiastethus affinis:* (KF383326), *Xylocoris flavipes*: (KF365462) and *Blaptostethus pallescens*: (KF365463). For the first time, *A. constrictus*, recorded earlier as a predator of hoppers (BPH and GLH) on rice in Mandya, could be reared continuously on laboratory host eggs (rice moth) and biology was studied. The incubation period was 4.2 days; nymphal period 14.0 days and total developmental period 16.4 days. Male longevity was 55.7 days and female longevity was 55.3 days and fecundity was 84.7 eggs per female. Percent hatching was 100 and per cent adult emergence from the hatched nymphs was 96.5%. The biology of *B. indica* (which could be reared on *Corcyra* eggs), originally collected from Crossandra dry flowers was studied. - - Incubation period: 4-5 days; nymphal period 15-17 days; 100% hatching; 100% nymphal survival; mean male longevity: 30 days; mean female longevity: 31 days and fecundity: 33 eggs per female. The morphometrics of the above two anthocorids were also studied. The effect of temperature on the warehouse pirate bug *Xylocoris flavipes* was studied. Considering the nymphal survival and fecundity, constant temperatures of 17 and 36°C are not suitable for rearing *X. flavipes* and 22 and 27°C are the optimum temperatures. The developmental threshold temperatures for incubation, nymphal and total development were recorded as 7.85, 12.28 and 11.8, respectively and upper threshold temperatures 37.6, 31.5 and 32.08, respectively indicating that the egg stage of this predator is least heat sensitive. Indigenous predatory mites were evaluated in net house studies against thrips infesting chilli. In the treated plants, there was a clear reduction in the thrips population per leaf and in percent curling, while the plant height was distinctly more in the treated plants in comparison to control.

### ix. Studies on *Trichogramma brassicae* and *Cotesia vestalis* (*plutellae*) interaction with their host in cabbage

Gut microflora in different geographical populations of the parasitoid *Cotesia vestalis* (a parsitoid of the diamond back moth) were isolated, identified and characterized. All sequences were submitted to Genbank and accession numbers obtained. Phylogeny of these endosymbionts were determined. *Wolbachia*, a symbiont altering reproductive physiology and sex was detected in the parasitoid populations from different regions. The role of *Wolbachia* in feminization was determined. Degradation of insecticides by the bacterial endosymbionts, *Bacillus* sp and *Enterobacter cancerogenus* was established through minimal media and LCMS studies. Variations in the geographical populations based on the heat shock proteins (Hsps) were studied. *Hsp*s contributing to the sustenance of the parasitoid under stressed conditions were detected in the populations from Bhubaneshwar, Oddanchatram, Rajahmundry, Tirupathi and Varanasi. The *Hsp*70 was detected at abrupt temperature of 28, 30 and 32$^0$C and ramping temperature from 28-34$^0$ C.

### x. Insecticide resistance monitoring studies

Brinjal shoot and fruit borer, *Leucinodes orbonalis* is one of the most destructive pests on brinjal in India and other South and Southeast Asian countries. It has reportedly developed high level of resistance against many synthetic insecticide used in brinjal. For insecticide resistance monitoring in *L. orbonalis*, the filter paper residue assay was found simple, precise and consistent. Three populations of *L. orbonalis* collected from Almora, Nagpur and Varanasi are being maintained on potato tubers and a modified semi synthetic diet for conducting insecticidal bioassays. Insecticide resistance bioassays against emamectin benzoate, phosalone and fenvalerate revealed high level of resistance against Phosalone and Fenvalerate in Nagpur and Varanasi populations. Enhanced midgut carboxylesterase activity was noticed in these two resistant populations. Under NAIP International training at University of Kentucky, US, the mRNA expression of four families of metabolic genes from 16 bedbug populations were characterized for their role in insecticide resistance.

**xi. Microflora associated with insecticide resistance in cotton Leafhoppers**

Culturable gut microflora associated with *Amrasca biguttula biguttula*, *Nilaparvata lugens*, *Empoasca* spp, *Nephotettix nigropictus*, *Bothrogonia* spp. of various crops were characterized through morphological and molecular methods. 24 culturable bacteria associated with *Amrasca biguttula biguttula*, 2 culturable bacteria associated with *Nilaparvata lugens*, 7 bacteria associated with *Nephotettix nigropictus*, 2 bacteria associated with *Empoasca* spp and one bacterium associated with *Bothrogonia ardalahua* Young were characterized and identified. The predominant bacterial genera associated with these leafhoppers were *Enterobacter spp.*, *Stenotrophomonas maltophilia*, *Bacillus* spp. *Micrococcus* spp., *Lysinibacillus fusiformis*, *Microbacterium*, *Agrococcus* and *Staphylococcus*. The bacteria *Enterobacter cloacae* and *Bacillus pumilus* showed the tolerance towards Acephate insecticide under various concentrations when they were tested under *in vitro.*

**xii. Role of microbial flora of aphids in insecticide resistance**

Live population of aphids belonging to *Aphis gossipii*, *A. craccivora* and *Myzus persicae* were collected from Gabbur and Hebballi from Dharwad district, Raibag, Banahatti and Harugeri of Belgaum, Karnataka from different crop plants. A total of 9 bacteria were identified based on 16S rDNA sequences and sequence homology search as *Bacillus aryabhattai*, *B. cereus*, *B. firmus*, *B. horikoshii*, *B. jeotgali*, *B. massiliensis*, *B. subtilis*, *Exiguobacterium indicum*, *Moraxella osloensis* and *Paenibacillus lautus.* A total of 30 *i*dentified bacterial 16S rDNA sequences were deposited at GenBank and accession numbers KC465366, KC603539-KC603546 and KC707524-KC707552 were obtained. Phylogenetic affiliation of the microflora of aphids was accomplished using MEGA 4.0 software using 1000 pseudoreplications and including some reference sequences of the isolates from NCBI.

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

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

Survey for invasive insects in South India revealed the occurrence of *P. jackbeardsleyi* in Tamil Nadu, and Karnataka. It was found associated with papaya mealybug on papaya at Ravindranath Tagore Nagar in Bangalore. Other plants in the area like *Cordyline terminalis* (Agavaceae) an ornamental plant native to Southeast Asia, Australia, New Zealand were found to harbour *P. jackbeardsleyi*. The nymphs were found scattered on the leaves singly. Similarly it was found on flowers of custard apple (*Anonna squamosa),* Purple martin (*Streptocarpus*sp.), Jasmine (*Jasminum multiform*) in pure form. Along with papaya mealybug *Paracoccus marginatus* Williams and Granara de Willink, it was found in papaya, tapioca, chrysanthemum and Indian spinach (*Basella alba*). It is associated with *Phenacoccus solenopsis* on parthenium and chrysanthemum. In some crops it was associated with aphids and spiralling whiteflies as in case of basil, chrysanthemum and jasmine.

**b. Interaction of indigenous and the introduced parasitoid of eucalyptus gall wasps**

Interaction of indigenous and the introduced parasitoid of eucalyptus gall wasps was studied and it was found that the resource utilization by both the parasitoids were mutually exclusive. *Quadrastichus mendeli* preferred young larvae of *L. invasa* which were within the green galls, whereas the local parasitoid, *Megastigmus viggianii* selected larvae within the older pink and brown galls

**c. Erythrina Gall wasp management**

Erythrina Gall wasp *Quadrastichus erythrinae* was found to be severe in Mandya and Chamarajnagar districts in beetle wine stake plants *Erythrina indica*. *Aprostocetus gala* was found to be the major parasitoid of *Q. erythrinae* 25-46% parasitization observed in field. It was clearly established that *Aprostocetus gala* is not a gall former in *Erythrina* plants but a very good parasitoid of *Quadrastichus erythrinae. Aprostocetus gala* was unable to parasitize *Leptocybe invasa* both in Net house and field release studies.

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

*Chromolaena* weed biocontrol agent, C. *connexa* released at different places have got established. 9-12 galls were observed per 5 minutes search in 450 m around the released spot. New releases were made in Jharkhand in collaboration with Directorate of Weed Science research.

**xiv. Genetic Diversity, Biology and Utilization of Entomopathogenic Nematodes (EPN) against Cryptic Pests**

- Genomes and transcriptomes of four Indian strains of bacterial symbionts associated with EPN were accomplished first of their kind for enhancing the existing efficacy of EPN against Lepidopteran and Coleopteran insect pests; genes and pathways related to their virulence and pathogenesis against insects identified during NABG-NAIP overseas training on genomics and transcriptomics at WSU, Pullman.

- Worked out LC & LT values for 2-4 instar grubs of *Anomala ruficapilla*, *Holotrichia serrata, H. consanguinea, Phyllophaga, Oyxcetonia versicolor, Protesia* sp., *Coelosterna scabrator, Sthenias grisator*.

- Demonstrated whitegrubs control in redgram and fodder grass using EPN. Organized 8 days MTC Hands-on training on eco-friendly management of whitegrubs using EPN for officers of Agriculture and Horticulture departments.

- Licensed and transferred two technologies on production, down-stream processing and development of WP formulations of EPN and *Pochonia chlamydosporia* to Allwin Industries, Indore and Rs. 3.5 lakhs revenue generated.

- Thirty five EPN & bacteria molecular identified.
- EPN strains of NBAII including *Heterorhabditis indica*, *Steinernema carpocapsae*, *S. abhasi* were screened against *Lepidiota mansueta* in Majouli Island in groundnut and vegetables.
- Evaluated EPN formulations against white grubs, cutworms and termites through AINP centre at Jorhat, Assam.
- Supplied EPN formulations to centres of AICRP Biological Control and AINP on whitegrubs and other soil arthropods across the country.

**xv. Biosystematics and diversity of entomogenous nematodes in India.**

- A total of 172 soil samples were collected from Mulberry fields of Pampore, Tral, Bandipora and Yor Khusi Pora (Y. K. Pora) villages of Jammu and Kashmir, forest vegetation of Monughat (Dhalali, Tripura) and coffee, arecanut, sugarcane, vegetable fields of UAS, Dharwad, Mugad, Narendra, Gamanagatti, Garag villages of Karnataka.
- One sample was intercepted with a EPN (most likely belong to *Steinernema* sp.) when analyzed by soil baiting technique using wax moth, *Galleria mellonella.*

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

Cry2A CDS (2.2 kb) obtained from eight isolates and cloned for further studies. This gene has dual toxicity to lepidoptera and diptera and when formulated, it will be useful in combating the pests of Lepidoptera and Diptera. The full length gene sequencing of 1.9 kb cry3a (coleopteran specific gene) was done and cloned in TA vector. The 2.37 kb Vip3A (lepidopteran specific gene) and 3.686 kb cry1Ac (lepidopteran specific gene) was done using primer walking. The sequences were then sub cloned into *E. coli* expression system. This will enable formulation of these toxins for field use. The dipteran toxic *cry*2A, *cry*17A, *cry*4A and *cry*44Ba were identified through PCR analysis. The identification of cry44Ba is a first report from India.

Seven isolates expressing the coleopteran specific *cry3A* gene were tested against the coleopteran pest *Sitophilus oryzae*, (stored grain pest) along with the international standard strain (4AA1). The isolate *Bt*AN4 was comparable with the standard strain and was the most toxic among the indigenous isolates tested. *Bt*An4 showed the least $LC_{50}$ value of 89.65µg/ml and the standard strain showed LC50 value of 85.26µg/ml. It was followed by TrBt10 which showed an $LC_{50}$ value of 96.16 µg /ml. The *Bt*AN4 strain was used for cloning studies.

**xvii. Effect of entomofungal pathogens on *Bemisia tabaci* infestation in tomato and capsicum under protected cultivation**

Evaluation of entomofungal pathogens on *Bemisia tabaci* infestation in tomato (variety, NS501) and capsicum (var. Indria) was carried out in the polyhouse at NBAII Farm, Attur with nine isolates of entomopathogenic fungi (*B. bassiana* Bb-9, Bb-36, & Bb-68, *M.*

*anisopliae* Ma-6, Ma-41& Ma-42 and *L. lecanii* Vl-8, Vl-12 & Vl-32) during February-May, 2013 (summer). The trial was laid out in RBD with three replications for each treatment with 24 plants for each treatment. Four rounds of foliar sprays with oil formulations of fungal pathogens at a spore dose of $1x10^8$ spores /ml were applied at 15 days intervals during March-April, 2013.

**Tomato:** Among the nine entomofungal pathogens tested, *L. lecanii* (Vl-8 isolate) and *B. bassiana* (Bb-9 isolate) showed significantly lower white fly population in tomato (15.29 & 17.21 whiteflies/plant respectively) compared the higher whitefly population in the untreated control (48.24 whiteflies/plant in tomato) indicating reduction of 68.30 & 64.32% in tomato. With regard to yield, Vl-8 treated plants showed significantly higher yield (5.06kg/plant) compared to untreated control plants (3.42kg/plant). The yields recorded in the plants treated with other fungal pathogens were on par with control.

**Capsicum:** Among the nine entomofungal pathogens tested, *L. lecanii* (Vl-8 isolate) and *B. bassiana* (Bb-9 isolate) showed significantly lower white fly population in capsicum (6.47 & 6.98 whiteflies/plant respectively) compared the higher whitefly population in the untreated control (28.12 whiteflies/plant) indicating reduction of 77.00 & 75.12% respectively. With regard to yield, statistically significant differences in the yield were not observed in entomofungal pathogen treated plants and untreated control plants.

**Field evaluation of entomofungal pathogens on cabbage aphid (*Brevicoryne brassicae*)**

The field trial for evaluation of entomofungal pathogens cabbage aphid (*Brevicoryne brassicae*) in cabbage (var. Saint) was carried out at NBAII Farm Attur during kharif season July-November, 2013 with nine isolates of entomopathogenic fungi (*B. bassiana* Bb-5a, Bb-9, Bb-68, *M. anisopliae* Ma-42, Ma-41, Ma-6 and *L. lecanii* Vl-8, Vl-12 & Vl-32) in RBD design with three replications for each treatment and with a plot size 2x3mfor each replication. Three rounds of foliar sprays of oil formulations of fungal pathogens at a spore dose of $1x10^8$ cfu /ml were applied at monthly intervals during August, September & October 2013. Pre-treatment observations on number of aphids per leaf were recorded in August and the post-treatment observations were recorded in September, October & November 2013. Yield of cabbage was recorded treatment wise. Among the nine fungal pathogen isolates tested, Bb-5a, Ma-6 and Vl-8 isolates showed significantly low aphid population/leaf (4.62, 5.82 & 5.06 respectively) with a reduction of 60.0-68.25% over control were statistically on par with each other. With regard to yield, statistically significant differences in the yield were not observed in entomofungal pathogen treated plants and untreated control plants.

**xviii. Diversity of Non Apis pollinators in different agroclimatic regions**

Over 200 specimens of Non Apis bees belonging to megachilidae, apidae, halictidae, xylocopidae were collected and preserved for further studies.

**xix. Influence of elevated levels of carbon dioxide on the tritrophic interactions in some crops**

The influence of elevated levels of carbon dioxide and temperature was studied in Open Top Carbon dioxide chambers (OTC) at Yelahanka farm of NBAII. Tomato plants were grown inside the OTC chambers at ambient temperature and $CO_2$, 500 ppm of $CO_2$ and ambient temperature, 500 ppm of $CO_2$ and two degrees above ambient respectively. The incidence of pests were monitored at weekly intervals. Though, some minor pests were noticed, the incidence of leafminer (*Liriomyza trifoill*) was significantly varying between the various levels of $CO_2$ and temperature. Higher incidence of *L. trifolii* was noticed in the chambers with higher $CO_2$ and temperature compared to ambient conditions (Fig.1).

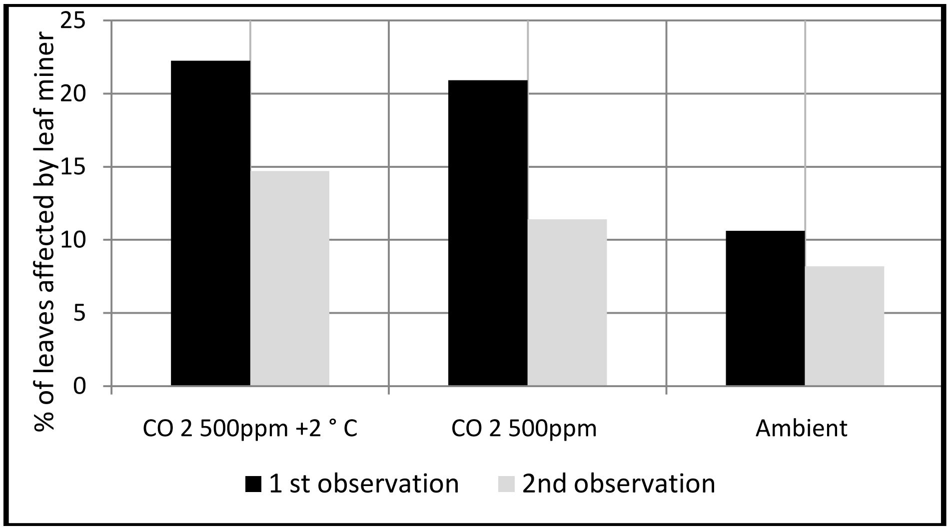


**Fig. 1: Incidence of *Liriomyza trifolii* on tomato plants grown under different levels of carbon-dioxide and temperature**

**xx. Influence of infochemical diversity on the behavioural ecology of some agriculturally important insects**

A plant based attractant was developed which was evaluated for the attraction of *Bactrocera dorsalis* in the mango orchards. The dispensers were developed in wooden blocks and kept in fruit fly traps with water and the number of fruit flies captured was monitored for longer period. The dispenser attracted more fruit flies than the standard check methyl eugenol (Fig. 2), mainly *B. dorsalis* than other species such as *B. correcta* and *B. zonata.*

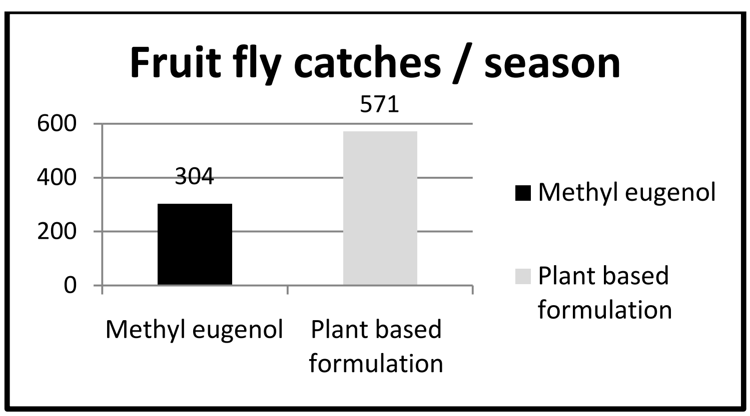


**Fig. 2: Number of fruit flies captured per season in methyl eugenol check and in plant based attractant.**

## 2.1.2 Indian Agricultural Research Institute, New Delhi

**I. Diversity of biocontrol agents from various agro-ecological zones**

1. **Survey and collection of *Trichogramma* strains from different agro-climatic zone of India.**

Surveys were conducted in Punjab, Haryana and Bihar to collect local strains of Trichogrammatids by using *Corcyra cephalonica* egg cards. Eggs of the prevalent insect pest species of different crops grown in the region were also collected. The samples were brought to laboratory and incubated for parasitoid emergence. The emerged Trichogrammatids were reared under laboratory conditions on *C. cephalonica* eggs.

**2. Evaluation of collected *Trichogramma* strains for searching efficiency, temperature tolerance and fecundity.**

All the populations could tolerate temperatures as high as 30$^{o}$C under laboratory conditions. Populations of Trichogrammatids collected from different nearby villages were pooled and allowed to interbreed to obtain a sizable population under laboratory conditions. They were reared continuously for 9 generations and then isofemale lines were generated and maintained. These were than evaluated for fecundity. It was found that the isofemale lines have relatively lower fecundity, viz., Sirsa, Haryana (61), Ballabhgarh, Haryana (85), Nawanshahr, Punjab (98), Morinda, Punjab (98) and Silao, Bihar (46) (**Table 1**). Ten pairs of each population were collected and fecundity was estimated. No significant differences in fecundity was observed among the populations collected from each Taluk, however, significant differences were observed amongst the population of different Taluks. Searching efficiency of the strains could not be estimated under laboratory/net-house conditions. We believe, the searching efficiency would be better because these were collected from field.

**Table 1: Fecundity of Trichogrammatids collected in villages from Punjab, Harayana and Bihar.**

| Village | Average Fecundity* | Average |
|---|---|---|
| **Sirsa, Haryana** | | |
| Chakarian | 60 | 61 |
| Handi Khera | 62 | |
| Baidwala | 61 | |
| Sikandarpur | 64 | |
| Bajekan | 58 | |
| **Ballabhgarh, Haryana** | | |
| Khera | 80 | 85 |
| Machgarh | 90 | |
| Sotai | 85 | |
| Panhera Khurd | 82 | |
| Dayalpur | 88 | |
| **Nawanshahr, Punjab** | | |
| Gujjarpur Kalan | 100 | 98 |
| Mahalon | 96 | |

| | | |
|---|---|---|
| Mehandpur, | 98 | |
| Durgapur | 96 | |
| Kulam | 100 | |
| **Morinda, Punjab** | | |
| Bamnara | 101 | 98 |
| Dholan Majra | 100 | |
| Kanjla, | 98 | |
| Kishanpur | 96 | |
| Ranjian | 95 | |
| **Silao, Bihar** | | |
| Nanad | 44 | 46 |
| Chorsua | 49 | |
| Sipah | 48 | |
| Sohsarai | 44 | |
| Silao | 45 | |

*Average fecundity of ten pairs

### 3. Breeding the better performing strains under laboratory conditions

The field collected strains were maintained under laboratory conditions using *C. cephalonica* eggs. The better performing strains were used for further crossings. The following crosses were made and breeding performance has been presented.

**Following crosses were made**

TCS – 31(male) x TFC (female) at 27˚ C
TCS – 31(female) x TFC (male) at 27˚ C
TCS – 31(male) x TFC (female) at 30˚ C
TCS – 31(female) x TFC (male) at 27˚ C
TFC (male) x TCSHF (female) CA at 27˚ C
TFC (female) x TCSHF (male) CB at 27˚ C
TFC (male) x TCSHF (female) CA at 30˚ C
TFC (female) x TCSHF (male) CB at 30˚ C
TFC (male) x TCSHF (female) CA at 32˚ C
TFC (female) x TCSHF (male) CB at 32˚ C
TRA (female) x TCS 31 (male) EA at 27˚ C
TRA (male) x TCS 31 (female) EB at 27˚ C

In the crosses with TFC (female) x TCSHF (male) CB at 27˚ C, in all the pairs parasitism was observed (**Table 2**). The higher fecundity was selected for higher temperature i.e. 30˚C. in F4 generations 12 pairs were selected and shifted to 30˚ C. in the cross between TFC (male) x TCSHF (female) CA at 30˚C, out of 14 pairs selected there was no para sitism in 10 sets because of arrhenotoky (**Table 3**). Similarly arrhenotoky was evident in the crosses between TFC (male) x TCSHF (female) CA at 32˚ C and TFC (female) x TCSHF (male) CB at 32˚ C.

**Table 2: TFC (female) x TCSHF (male) CB 27°C**

| TFC (female) x TCSHF (male) CB 27°C | | | | | |
|---|---|---|---|---|---|
| | No. of adults emerged | F1 | F2 | F3 | F4 |
| 1 | 78 | Par. | Par. | Par. | Par. |
| 2 | 86 | Par. | Par. | Par. | Par. |
| 3 | 105 | Par. | Par. | Par. | Par. |
| 4 | 108 | Par. | Par. | Par. | Par. |
| 5 | 111 | Par. | Par. | Par. | Par. |
| 6 | 65 | Par. | Par. | Par. | Par. |
| 7 | 90 | Par. | Par. | Par. | Par. |
| 8 | 84 | Par. | Par. | Par. | Par. |
| 9 | 72 | Par. | Par. | Par. | Par. |
| 10 | 98 | Par. | Par. | Par. | Par. |
| 11 | 27 | Par. | Par. | Par. | Par. |
| 12 | 62 | Par. | Par. | Par. | Par. |

In all the pairs parasitization was there. The higher fecundity set was selected for higher temperature i.e. 30°C. In F4 generations 12 pairs were selected and shifted to 30°C

**Table 3: TFC (male) x TCSHF (female) CA 30°C.**

| TFC (male) x TCSHF (female) CA 30°C | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of adults emerged | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 |
| 1 | 47 | Arrhenotoky | | | | | | | | |
| 2 | 98 | Arrhenotoky | | | | | | | | |
| 3 | 75 | Arrhenotoky | | | | | | | | |
| 4 | 41 | Arrhenotoky | | | | | | | | |
| 5 | 59 | Par. | Par. | Par. | Par. | Par. | Par. | Par. | Par. | Par. |
| 6 | 83 | Arrhenotoky | | | | | | | | |
| 7 | 42 | Par. | Par. | Par. | Par. | Par. | Par. | Par. | Par. | Par. |
| 8 | No parasitization | | | | | | | | | |
| 9 | 104 | Arrhenotoky | | | | | | | | |
| 10 | 48 | Arrhenotoky | | | | | | | | |
| 11 | 79 | Arrhenotoky | | | | | | | | |
| 12 | 67 | Arrhenotoky | | | | | | | | |
| 13 | No parasitization | | | | | | | | | |
| 14 | No parasitization | | | | | | | | | |

Out of 14 pairs selected there was no parasitization in three pairs but in F2 generation there was no parasitization in 10 sets, because of arrhenotoky. The higher fecundity set was selected in F10 generation and shifted to 32°C.

## 2.1.3. Biodiversity of Biocontrol Agents from various Agro Ecological Zones

**1. Survey, collection and diversity analysis of biocontrol agents from various agro ecological zones** (AAU-A, AAU-J, ANGRAU, KAU, MPKV, PAU, SKUAST, TNAU, YSPUHF, CAU, UAS R, IARI, CTRI, CISH, Dir. Sorghum Res and Dir. Rice Res.)

**AAU-A**

**Location** **:** Anand, Kheda, Baroda and Ahmedabad districts

**1. *Trichogramma*:** Sentinal Trichocards with eggs of *Corcyra cephalonica* were placed in cotton, maize, tomato, groundnut and castor fields for parasitism by *Trichogramma* in different geographical areas and collected after 3 days from the fields and observed in the laboratory for emergence of *Trichogramma*. Similarly, eggs of host insects were collected at fortnightly intervals from cotton (*H. armigera*), paddy and castor (*Achaea janata*) crops. *Trichogramma chilonis* was the only *trichogramatid* recorded as evident from **Table 4**. As the numbers of *Trichogramma* collected was very low they were each separately multiplied in the laboratory and few samples were sent to NBAII.

**Table 4: Biodiversity of *Trichogramma chilonis* around Anand in different Crops**

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

**2. *Chrysoperla:*** Green lacewings were collected from different geographic locations. *Chrysoperla zastrowi sillemi* (Esben-Peterson) was found in all the populations.

**3. Coccinellids:** Diversity of coccinellids from various crop ecosystem of the region was also studied. *Cryptolaemus***:** The natural population of *C. montrouzieri* was observed throughout the year. More ever, peak population was rich when the incidence of host was higher.

**4. Spiders:** 207 Spider specimens were collected both by pitfall trapping as well as by general collection from paddy ecosystem. Samples were sent to NBAII.

**5. EPNs from soil:** Two hundred and sixty one samples were collected from 53 locations of Chotaudaipur and 50 soil samples were collected from 10 locations in Bhavnagar – both in middle Gujarat. These soil samples were from cultivated areas with 17 different crops. No EPNs were recovered from the Bhavnagar samples while a sample each were recovered from pigeonpea fields in Zaz and Puniyavant and from cotton fields in Puniyavant and Gathboriyal.

**6. Isolation of native *Bt* isolates from soil:** Isolation of *B.thuringiensis* was done according to the method prescribed from the soil samples collected from the same places as on EPNs. Fried egg like colonies were selected and suspension of each isolate was prepared and observed under phase contrast for presence of parasporal bodies. Among 261 samples from 22 villages of Vadodara district *Bt* isolates were found in 17 samples. Of the 50 samples from Bhavnagar district *Bt* could be isolated from only 4 places.

**7. Anthocorids:** Regular surveys were carried out for anthocorid predators on thrips and mites infested plants. No predators were found.

**AAU-Jorhat**

**Locations:** Jorhat, Golaghat, Sivsagar, Sonitpur and Dibrugarh districts

**1. *Trichogramma* :** Sentinel egg cards of *Corcyra cephalonica* were placed in rice, sugarcane, castor , tea maize and vegetables (okra, brinjal, tomato, and cole crops) from July to January, 2013-14 for parasitisation by *Trichogramma* in different geographical areas. The cards were collected after 2 days from the fields and observed in the laboratory for the emergence of trichogrammatid spp. The recovery of trichogrammatid spp. (unidentified) was made only from rice and tea. But no parasitoid recovered from okra, brinjal, bean, cole crops and tomato, However, the recovery of *Trichogramma sp*. from tea and castor as reported earlier is still in progress in biocontrol Laboratory, AAU, Jorhat. The live culture of trichogrammatids recovered from tea and castor will be sent to NBAII for confirmation.

**2. *Chrysoperla:*** survey for chrysopids were undertaken in sugarcane, papaya, cabbage and okra fields in Golaghat, and Jorhat districts. The field collected populations of chrysopids from papaya and sugarcane have been sent to NBAII, Bangalore for identification.

***3. Cryptolaemus:*** Five geographical locations were surveyed for collection of *Cryptolaemus* sp. in different crops like papaya, sugarcane and in *kharif* as well as *rabi* vegetables during 2013-2014. But natural populations of *Cryptolaemus* were not observed in any location.
Other coccinellids collected from different *rabi* vegetables infested by aphids and whiteflies were *Coccinella septempunctata*, *Coccinella transversalis Micraspis* sp. *Brumoides* sp. and *Cheilomenes sexmaculatus*.

**4. Entomopathogens:** The cadavers of *Spodoptera* collected from cabbage infected by entomopathogens have been collected from Horticulture farm Jorhat and were identified as *Beauveria bassiana*, by Department of Plant pathology, AAU, Jorhat.

**5. Spiders:** Thirty spiders collected from different habitats such as grasses, moist places, under stones , pebbles, dead leaves, humus, bushes, on the bark and branches of trees, houses and huts have been sent to NBAII, Bangalore for identification.

**6. Insect derived EPN:** Soil samples were collected from different geographical locations to isolate local EPN. Insects (*Corcyra* larvae) suspected to be affected by EPN were isolated and placed in 50 cc soil in polythene bags and will be sent to NBAII, Bangalore, for identification in May, 2014. Efforts are being made to isolate local EPN's with the help of Department of Nematology.

**7. Anthocorids:** No anthocorid predators could be detected from thrips and mite infested plants particularly chilli, okra, and French bean.

**ANGRAU - Hyderabad**

Bio Control Agents from various crop ecosystems like cotton, red gram, sugarcane, sunflower, sorghum, maize, brinjal, tomato and rice were collected as per the standard protocols provided by NBAII (**Table 5**).

As a part of the survey, collection and diversity studies, 22 batches of *Trichogramma*, 9 batches of *Chrysoperla*, 5 batches of *Chelonus blackburnii*, 12 batches of Coccinellids, and 19 batches of spiders were collected from Southern Telangana. Microbial slants cultured from different crop rhizospheres (cotton, pigeonpea, groundnut, rice, sunflower, tomato, brinjal, maize and jowar).

**Table 5: Bioagents collected from different crop ecosystems**

| **Rice** | **Red gram** | **Castor** | **Maize** | **Sunflower** | **Brinjal** | **Papaya** |
|---|---|---|---|---|---|---|
| *Tetrastichus* sp | *Campoletis* | *Trichogramma* | *Trichogramma* | *Trigona laeviceps* | *Trichogramma* | *Acerophagus* |
| *Telenomus* sp | *Odontomyia laeviceps* | *Snellenius maculipennis* | Anthocorids | Ichneumonid | *Chrysopa* | *Anagyrus* |
| *Trichogramma* sp | Syrphids | *Euplectrus* | *Braconid* | *Brachymeria* | *Campoletis chloridae* | |
| Mirids | *Gryon* sp. | *Cremastus* | *Cheilomenes* | *Paederus* | *Bracon* | |
| Coccinellids | *Apanteles* | Bracon | *Paederus* | | *Coccinella sp* | |
| *Brachymeria* | *Cotesia* | *Diastatrix papilio* | *Brachymeria* | | | |
| Coccinellids | Bracon | Mirids | | | | |
| *Trichomalopsis* | Spiders | *Telenomus* | | | | |
| *Paederus* | *Eucelatoria bryani* | | | | | |
| *Ophioneae* | | | | | | |
| *Xanthopimpla* | | | | | | |

**KAU - Thrissur**

Survey and collection of natural enemies of banana weevil and banana aphid, pollu beetle and root mealybug of pepper.

**1. Banana pseudostem weevil - *Odoiporus longicollis* (Oliv.):** Surveys were carried out in Thrissur, Ernakulam, Palakkad, Wayand and Kasargode districts. Pest incidence was noticed in almost all locations. The earwigs collected from the outer layer of pseudostem were brought to the lab and were found feeding on the eggs of pseudostem weevil. The earwigs were sent to Zoological Survey of India, Calcutta for identification. The earwig is identified as *Auchenomus hincksi* Ramamurthi (Dermaptera: Labiidae)

**2. Banana rhizome weevil-*Cosmopolites sordidus* Germ**. Survey was carried out for the natural enemies of rhizome weevil. Earwigs were collected as predators. The earwigs were sent to Zoological Survey of India, Calcutta for identification. The earwigs were identified as

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

**3. Banana aphid - *Pentalonia nigronervosa* Coq:** Survey on natural enemies of banana aphid was carried out in Thrissur and Ernakulam districs and coccinellids were collected. The coccinellids collected were identified as *Pseudaspidimerus trinotatus* (Thunberg), *Scymnus pyrocheilus* (Mulsant), *Jaurovia soror* Weise, *Scymnus* spp., *Cheilomenes sexmaculata* (Fab.) and *Sticholitis* sp. A hemerobid predator was also collected from the aphid colonies.

**4. Pepper pollu beetle- *Lanka ramakrishnae*:** Surveys were carried out in different pepper growing areas of Thrissur, Ernakulam, Wayanad and Kasaragod for spiders. The spiders present in these areas were *Bavia kairali* (Salticidae), *Oxyopes javanus* (Oxyopidae) and *Oxyopes swetha* (Oxyopidae) spiders present.

**5. Pepper root mealybug - *Formicoccus polysperes* Williams:** Survey was carried out in pepper growing areas of Kerala mainly in Wayanad district. Mealybug incidence was observed in Mullankolly and Pulpally areas of Wayanad district. The infestation was observed in main field and in nursery plants. Th mealybugs were identified as *Formicoccus polysperes* Williams.

No natural enemies were collected during the period.

**6. Entomopathogens:** Diseased rice bugs were collected from paddy fields at Vellanikkara, Thrissur. The fungus causing infection was isolated in the lab and sent to National Center of fungal taxonomy for identification. The fungus was identified as *Acremonium lioliae* Latch.

**Collection of insect biocontrol agents from the agro ecosystems**

a) The insects collected from different agro ecosystems of Kerala were sent to NBAII, Bangalore during the months of July, August, October, November and March of 2013-14. Net sweepings were made from paddy fields and the parasitoids collected were sent to NBAII, Bangalore. Aeulophid parasitoid, *Paraphylax* sp. (Eulophidae) was identified from these collections.

Natural enemies collected from parasitized insect pests were also sent to NBAII for identification. The parasitoids collected were egg parasitoids of *Scirpophaga incertulus,* larval parasitoids of *Cnaphalocrocis medinalis,* larval parasitoid of *Diaphania indica,* and a parasitoid of *Phenacoccus solenopsis.*

b) *Trichogramma*: Sentinel cards of eggs of *Corcyra cephalonica* were placed in vegetable fields. They were taken back after 24 h of field exposure and observed for parasitism. Live parasitoids along with UV treated Corcyra eggs were sent to NBAII, Bangalore.

c) *Goniozus* and Braconid species: Cocoons of the parasitoids were collected from *Opisina arenosella* infested plots and the adults were sent to NBAII, Bangalore.

d) Spiders: Spiders were collected from vegetable fields using pit fall trap. The spiders were identified as *Lycosa pseudoannulata, Gasteracantha germinate, Hyllus* sp. and *Plexippus petersi.*

e) Insect derived EPNs: Soil samples were taken from Banana Research Station, Kannara, Thrissur where EPN experiments were conducted in the previous years and sent to NBAII, Bangalore.

f) Soil samples for isolation of antagonistic organisms: Soil samples were taken from rice fields of Thrissur and sent to NBAII, Bangalore for isolation of antagonistic organisms.

**MPKV - Pune**

The natural enemies including parasitoids, predators and micro-organisms associated with insect pests of crops were collected from field and horticultural crops around Pune in western Maharashtra as per the protocol given in the technical programme of 2013-14. The specimens were brought to the laboratory, reared to adult emergence, identified locally and maintained for record, whereas unidentified specimens of bioagents are sent to NBAII, Bangalore for identification.

**1. *Trichogramma***

Sentinel cards with the eggs of *Corcyra cephalonica* (100 eggs /card) were displayed at seven locations in a cropped area for 24 hrs in cotton, pigeon pea, sugarcane, maize, soybean, tomato, and pomegranate and repeated at fortnight intervals during pest activity. The parasitized cards were maintained for *Trichogramma* emergence. On emergence of adult parasitoids, these were supplied with freshly laid UV treated eggs of *Corcyra.* The parasitized eggs and dead adults of *Trichogramma* preserved in 70% alcohol were sent for identification.

**2. *Chrysoperla***

At least 25 live individuals (eggs/ larvae/ adults) were collected from five geographic locations in cotton, pigeon pea, maize, French bean, brinjal and *rabi* jowar.

**3. *Cryptolaemus***

Live individuals (larvae/ adults) were collected from one location in custard apple.

**4. Spiders**

Adults were collected in cotton, sugarcane, pigeon pea, maize, soybean, *rabi jawar*, brinjal, ladies finger, French bean, papaya and mango fields. The specimens were preserved in 70% ethyl alcohol in screw cap vials.

**5. Entomopathogens**

The cadavers of *Spodoptera litura* and *Helicoverpa armigera* infected by entomopathogens were collected in dry sterile vials and the pathogens were isolated in the laboratory.

The natural enemies recorded were coccinellids *Coccinella septempunctata* Linn., *Menochilus sexmaculata* (F.), *Scymnus coccivora* Ayyer, *Encarsia flavoscutellum, Dipha* *aphidivora* Meyrick, *Micromus igorotus* Bank., syrphids on SWA in sugarcane, *Coccinella transversalis* F., *M. sexmaculata, Brumoides suturalis* (F.), *Scymnus coccivora* Ayyar, and *Triomata coccidivora* in mealy bug colonies on custard apple, *Acerophagus papayae* N. and S. and *Pseudleptomastix mexicana* N. and S. and *Mallada boninensis* Okam. and *Spalgis epius* on papaya mealy bug. The chrysopid, *Chrysoperla zastrowi sillemi* (Esben-Petersen) in cotton, spiralling white fly on papaya. The predator of lac insects, *Eublemma amabilis* on ber and a lady bird beetle with black spots on elytra, a parasitoid of sugarcane scales was also recorded.

The parasitism of *Trichogramma* was attempted to record in crops like cotton, pigeon pea, sugarcane, maize, soybean, tomato and pomegranate in Pune region through display of sentinel egg-cards of *Corcyra* but it was not observed. The chrysopid, *Chrysoperla zastrowi sillemi* Esb. was recorded in cotton, maize, pigeon pea, french bean, rabi jowar and brinjal while *Mallada boninensis* Okam on cotton, French bean, sunflower, mango and papaya,. and *M. boninensis* on papaya, pomegranate and mango. The *Cryptolaemus* grubs were collected from the pre-released plots of custard apple. The specimens of spiders collected from 9 field crops and 2 orchard crops are sent for identification. The entomopathogens particularly the cadavers of *S. litura* and *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae*, *Sl*NPV, *Ha*NPV were collected from soybean, potato, pigeon pea, chickpea, capsicum, tomato, potato and army worm larva infected with NPV in rabi *jawar* and fungus infected sugarcane woolly aphids were also collected from farmers field (**Table 6**).

**Table 6: Natural enemies recorded from western Maharashtra**

| Sr. No. | Natural Enemies | Crop | Remarks /Natural enemies identified |
|---|---|---|---|
| 1 | *Trichogramma* | Cotton, pigeon pea sugarcane, soybean, maize, tomato pomegranate | Sentinel cards of *Corcyra* eggs for *Trichogramma* were displayed in the fields from April 2013 to November, 2013 at various crop stages and prevalence of caterpillar pests, but parasitoids were not recovered. |
| 2 | Chrysopid<br>*Chrysoperla zastrowi sillemi* Esben-Petersen<br>*Mallada boninensis* Okam. | Cotton, pigeon pea, maize, rabi *jawar*, brinjal, French bean<br><br>Cotton, French bean, sunflower papaya and mango | The eggs, grubs and adult stages were collected, identified locally and also sent for identification to the NBAII, Bangalore.<br>The species recorded from aphid colonies on French beans and identified locally also sent for identification to the NBAII, Bangalore. |
| 3 | *Cryptolaemus montrouzieri* Mulsant | Custard apple | The grubs were collected from the pre-released fields for the control of mealy bugs during August-September, 2013. Recovery of *Cryptolaemus* was observed near trial plot of custard apple |

| | | | |
|---|---|---|---|
| 4 | Spiders | Cotton, sugarcane, pigeon pea, maize, soybean, papaya, rabi *jawar*, brinjal, lady's finger, French bean, mango | The specimens were collected and sent for identification to the NBAII, Bangalore. |
| 5<br>(a)<br><br><br>(b)<br><br>(c)<br><br>(d)<br><br>(e) | **Entomopathogens**<br>*Nomuraea rileyi*<br>*Metarhizium anisopliae*<br>*Sl*NPV<br><br>*Ha*NPV<br><br>NPV of armyworm<br><br>Green muscardine fungus *Metarhizium anisopliae* | Soybean, potato, pigeon pea<br>Mango<br><br>Potato, capsicum<br><br>Tomato, pigeon pea, chickpea<br><br><br>*Rabi jawar*<br><br><br>Sugarcane | *Nomuraea rileyi* and *Sl*NPV diseased cadavers of *S. litura*, *Ha*NPV infected larvae of *H. armigera* and mango hoppers infected with *M. anisopliae* were collected and isolated the pathogens in laboratory.<br><br>Infected larvae of *H. armigera*<br><br>Infected larvae of armyworm, *Mythimna separata* is collected and confirmed after inoculating fresh larvae<br>Sugarcane wooly aphids infected with *M. anisopliae* were collected and isolated the pathogens in laboratory. |

**PAU - Ludhiana**

**Collection of *Trichogramma* spp. from different crops.**

A survey was conducted in sugarcane, maize and cotton fields for the natural recovery of *Trichogramma*. For this, sentinel cards of *Corcyra* eggs were stapled in the fields regularly for natural parasitization as per protocol mentioned in the technical programme. These cards were monitored in the laboratory for the emergence of *Trichogramma*.

During the survey, egg masses of early shoot borer, *Chilo infuscatellus* and top borer, *Scirpophaga excerptalis* were collected from the fields of sugarcane All these egg masses were brought to the laboratory for the emergence of *Trichogramma*. Egg parasitoids emerged from the egg masses of top borer, which were identified as *Trichogramma japonicum*.
*Trichogramma* were also recovered from the maize fields during the survey in the districts Hoshiarpur and Ludhiana in the months of July, August and September, 2014. Ten sentinel cards bearing 100 *Corcyra* eggs each were stapled on the leaves in ten different spots in maize fields. After 24 hours they were brought to the laboratory to observe for natural parasitization. It was observed that 7.5 to 35.85 per cent eggs on these sentinel cards were parasitized (**Table 7**). As per the protocol mentioned in the technical programme of 2013-14 & 2014-15, *Trichogramma* emerged from naturally parasitized sentinel cards of maize have been sent to NBAII Bangalore for identification and confirmation (**Table 9**).

**Table 7: Rate of natural parasitization of sentinel cards of *Corcyra* eggs by *Trichogramma* collected from the fields of maize**

| Date | Percent natural parasitization | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **R1** | **R2** | **R3** | **R4** | **R5** | **R6** | **R7** | **R8** | **R9** | **R10** | **Mean** |
| 25-07-13 | 13 | 06 | 09 | 10 | 12 | 16 | 21 | 31 | 08 | 07 | **13.3** |
| 07-08-13 | - | 08 | 03 | 20 | 04 | 08 | - | 09 | 12 | 15 | **9.875** |
| 04-09-13 | 42 | 25 | 27 | 30 | 34 | 70 | 23 | - | - | - | **35.85** |
| 09-09-13 | 10 | 12 | 09 | 08 | 15 | 11 | 13 | 07 | 09 | 07 | **10.1** |
| 12-09-13 | 12 | 08 | 11 | 07 | 08 | 09 | 05 | 04 | 06 | 05 | **7.5** |

**Collection of natural enemies from cole crops**

In cole crops, the population of diamondback moth, cabbage butterfly, cabbage head borer, aphids was monitored along with their natural enemies in vegetable growing areas of Ludhiana. The incidence of cabbage butterfly, *Pieris brassicae* was reported in cauliflower. About 200 larvae of cabbage butterfly collected from two fields of cauliflower of PAU campus were brought to the laboratory for observing natural parasitization (**Table 8**). It has been observed that out of 200 larvae, 139 pupated. The remaining 61 were found parasitized with larval parasitoid, *Cotesia glomerata* and 628 cocoons of this parasitoid were collected from these parasitized larvae of *P. brassicae*. About 337 adults of *C. glomerata* emerged from these cocoons. The specimens of cocoons and the adults of *C. glomerata* have been sent to NBAII Bangalore for identification and confirmation (**Table 9**).

**Table 8: Natural parasitization of Cabbage butterfly, *Pieris brassicae* with larval parasitoid, *Cotesia glomerata***

| Field | Number of *P. brassicae* larvae collected | Number of *P. brassicae* pupae formed | Number of *P. brassicae* larvae parasitized | Number of cocoons of *C. glomerata* formed | Number of adults of *C. glomerata* emerged |
|---|---|---|---|---|---|
| **I** | 100 | 64 | 36 | 374 | 177 |
| **II** | 100 | 75 | 25 | 254 | 160 |
| **Total** | 200 | 139 | 61 | 628 | 337 |

**Table 9: The detail of the specimens of bio agents sent to NBAII Bangalore for identification**

| S. No. | Bioagent | Pest | Crop | Location | Remarks |
|---|---|---|---|---|---|
| 1. | *Trichogramma* sp. (Adults and parasitized *Corcyra* card) | Early shoot borer | Sugarcane | Jalandhar | Sent in the month of June 2013 |
| 2. | *Trichogramma* sp. (Adults and parasitized *Corcyra* card) | Sentinel cards | Maize | Hoshiarpur and Ludhiana | Sent in March, 2014 |
| 3. | *Cotesia glomerata* (Adults) | *Pieris brassicae* | Cauliflower | Ludhiana | Sent in the month of June, 2013 and got identified |
| 4. | *Cotesia glomerata* (Adults and cocoons) | *Pieris brassicae* | Cauliflower | Ludhiana | Sent in March, 2014 |
| 5. | Entomopathogenic fungi *Beauveria* | Sugarcane borer | Rice, sugarcane and maize | Pathankot, Jalandhar and Hoshiarpur | Sent in March, 2014 |
| 6. | *Bacillus* isolates | - | Radish and moong bean | Jalandhar and Pathankot | Sent in March, 2014 |

**SKUAST - Srinagar**

A study on survey and collection of natural enemy complex of pests of apple, apricot, plum, pear, peach, cherry, walnut and almonds was carried out in different districts of J & K during 2013. Forty species of natural enemies of 16 temperate fruit pests were recorded from Kashmir. Among 40 species of natural enemies, 17 species were parasitoids and 23 species were predators. During the survey of temperate fruit pests, 17 species of parasitoids were recorded. These were *Ablerus* sp., *Aphelinus mali*, *Aphytis proclia*, *Azotus* sp., *Encarsia perniciosi*, *Marietta* sp., *Scymnus* sp., *Trichomalopsis sp.* and unidentified species of aphelinid, braconid, chalcid, eulophid ichneumonid, trichogrammatid, associated with San Jose scale, wooly aphid, apple leaf miner and codling moth. *Aphidus* sp. recorded from an aphid, *Aphis spiraecola* Patch and *Trioxys* sp. from the walnut aphid, *Calipteras juglandis* (Goetze). Twenty three predators of temperate fruit pests include Coccinellids (*Chilocorus infernalis* Mulsant, *Priscibrumus uropygialis* (Mulsant), *Chilocorus rubidus* Hope, *Aiolocaria hexaspilota* (Hope), *Propylea luteopustulata* (M.), *Coccinella septempunctata* L., *Harmonia dimidiata* (F.), *Harmonia eucharis* (Mulsant), *Adalia tetraspilota* (Hope), *Hippodamia variegata*, *Calvia punctata* (Mul.); Chrysopids (*Chrysoperla zastrowi sillemi*, Chrysoperla sp.); spiders (*Neoscona theisi* (Walckenaer), *Neoscona mukerjei* Tikader, *Leucauge celebesiana* (Walckenaer), *Theridion* sp.); syrphid flies (*Episyrphus balteatus*(De Geer), *Eristalinus aeneus* (Scopoli), *Syrphus* sp., *Eristalis tenax* (Linnaeus), *Scaeva pyrastri* (Linneaus) and an unidentified anthocorid bug.

**TNAU - Coimbatore**

The natural enemies *viz*., *Trichogramma*, *Chrysoperla*, *Cryptolaemus*, and parasitoids of pulse pod borer and bruchid collected in Tamil Nadu were sent to NBAII.

**YSPUHF - Solan**

Different cropping systems in all the four agro-climatic zones spanning subtropical to dry temperate zones were surveyed for the collection of *Trichogramma, Chrysoperla,* coccinellids, mites, spiders, bugs, thrips, parasitoids, entomopathogens, EPNs, etc. Natural enemies were collected from vegetable, fruit, ornamental and weed crops. Sampling was done from neglected as well as managed orchards. Natural enemies were collected, reared up to adult stage (if collected immature) for identification and further study. Specimens were sent to NBAII, Bengaluru.

**CAU - Pasighat**

**1. Biodiversity of Bio-control agents from various agro ecological zones.**

i. 96 isolates of *Pseudomonas fluorescens* were isolated from soil samples collected from different places of East Siang District, Arunachal Pradesh. The isolates were screened using polymerase chain reaction (PCR) based molecular methods along with a set of primers PS 16 r and PS 16 f. Among the 96 isolates, 51 are found to be *Pseudomonas fluorescens* and the screened isolates were characterized for their potential as plant growth promoting rhizobacteria (PGPR). BOX PCR using BOX A1R primer was employed to study the closeness of screened isolates. Among the isolates Pf 14 was found to produce the highest amount of Indole Acetic Acid (IAA) in the absence of L- Tryptophan followed by Pf 15, Pf 12 and Pf 11.

ii. 15 species of ladybird beetles were collected from different parts of East Siang District of Arunachal Pradesh.

**2. Collection of spider fauna from the rice ecosystem.**

Ten species of spiders were collected from different rice eco- systems and they were preserved in 95% ethyl alcohol. The same was submitted to the Bureau for molecular characterization.

**UAS Raichur**

Collection of *Trichogramma* in cotton and rice ecosystems has been done. The experiment is in progress. Recently in cotton ecosystem encountered the incidence of flower midge and the specimens were identified by Dr. Virakthmath as *Dasineura gossypii* Felt and the associated parasitiod was identified by Dr. Poorni as *Ecrizotomorpha*.

**IARI**

Surveys and collection of *Trichogramma* strains from Uttarkhand state could not be carried out due to paucity of funds in the Division as advised by the Head of the Division.

**CTRI**

**Survey and collection of spiders and parasitoids in tobacco intercropping systems**

Intercrops were not grown due to two months delay of FCV tobacco crop. Hence, the survey was taken up on the diversity of arthropod fauna in FCV tobacco monocrop fields and tobacco nurseries planted with trap crop castor at CTRI farm and farmer's field at Katheeru. The observations were taken during January to march 2014. The sampling activity was initiated three weeks after transplanting and seven weekly observations were taken.The samples of arthropods from plant canopy were collected using insect net with 20 doubled swings. Samples of arthropods on the ground were collected from near the plant base manually. The samples were preserved in alcohol and identified with reference collections and software. The data were put in to an observation table and separated the arthropod species based on order and ecological function in Virginia tobacco field and nursery.They were further analysed by using Shannon index and evenness with the following formula.

Locations

1. CTRI farm Katheru.
2. Farmers field Katheru

Methodology

The research was conducted during January to March 2014. The sampling was carried out in Virginia tobacco fields in CTRI farm Katheru (**Table 11**) and nearby farmers fields (**Table 10**) in Katheru. The plot size is three hectares Virginia tobacco field. The sampling activity was initiated three weeks after transplanting. Seven weekly observations were taken.

The samples of arthropods from plant canopy were collected using insect net with 20 doubled swings. Samples of arthropods on the ground were collected from near the plant base manually. The samples were preserved in alcohol and identified with reference collections and web based identification aids.

The data were put into an observation table and the arthropod species were separated based on order and ecological function in Virginia tobacco field and nursery. They were further analysed by using Shannon index and evenness with the following formula.

Shannon index $H = € _{(} n_i \div N \log_{2(} n_i \div N _{)}$

Where $n_i$ = number of particular species

N = Total number of species

Evenness is calculated as Shannon index ÷ Total number of species. Shannon index represents the diversity and evenness indicates the evenness of inter species arthropods.

**Farmers Field**

Observations at the farmers' field (**Table 10**) showed intermediate species diversity with Shannon index of 2.83. The evenness was 0.18 indicating low inter species evenness, the individual number of species was much different from one to another. Total number of species were 15. The phytophgages were dominated by Lepidoptera (3) followed by Odonata (2).There were more phytophage than entomophages. The total number of phytophages were

196 and the total number of natural enemies were 112. The phytophages were dominated by *Myzus nicotianae* and the natural enemies were dominated by *Nesidiocoris tenuis.*

**Table 10: Number of arthropod species based on order and ecological function.(Framers field)**

| Order | Phytophage | Predator | Parasitoid | Decomposer | Pollinator | Others |
|---|---|---|---|---|---|---|
| Hymenoptera | - | 1 | - | - | 1 | 1 |
| Coleoptera | - | 1 | - | - | - | - |
| Diptera | - | - | - | - | - | - |
| Lepidoptera | 3 | - | - | - | - | - |
| Hemiptera | 1 | 1 | - | - | - | - |
| Homoptera | 2 | - | - | - | - | - |
| Odonata | - | 2 | - | - | - | - |
| Araneae | - | 1 | - | - | - | - |
| Orthoptera | 1 | - | - | - | - | - |

**List of arthropod species**.
*Spodoptera litura, Helicoverpaarmigera, Scrobipalpa heliopa, Nezara virudula, Myzus nicotianae, Bemisia tabaci, Acrida* sp., *Polystes, Cheilomenes sexmaculata, Harpactor costalis, Phyothemes variegate*, *Phyothemes* sp, *Oxyopes* sp., bumble bee and *Apis* sp.

In the Katheru farm (**Table 11**), the Shannon index showed value of 2.03 which indicates intermediate diversity.The evenness was 0.10 indicating very low inter species evenness, the individual number of species was much different from one to another. Total number of species were 20.The phytophgages were dominated by Lepidoptera (3) followed by Coleoptera (2).There were equal number of phytophage species and entomophages. The total number of phytophages were 246 and the total number of natural enemies were 103.The phytophages were dominated by *M. nicotianae* and the natural enemies were dominated by *Nesidiocoris tenuis.*

**Table 11: Number of arthropod species based on order and ecological function (Katheru farm)**

| Order | Phytophage | Predator | Parasitoid | Decomposer | Pollinator | Others |
|---|---|---|---|---|---|---|
| Hymenoptera | - | 1 | 1 | - | 1 | - |
| Coleoptera | 1 | 3 | - | 1 | - | - |
| Diptera | - | 2 | - | - | | - |
| Lepidoptera | 3 | - | - | - | - | - |
| Hemiptera | 1 | 1 | - | - | - | - |
| Homoptera | 2 | - | - | - | - | - |
| Odonata | - | 1 | - | - | - | - |
| Araneae | - | 1 | - | - | - | - |
| Orthoptera | 1 | - | - | - | - | - |

List of arthropod species

*Mesomorphus villiger,Spodoptera litura, Helicoverpa armigera, Scrobipalpa heliopa, Nezara virudula, Myzus nicotianae, Bemisia tabaci, Acrida*sp.*, Polystes, Cheilomenes sexmaculata,Coccinella repanda,Verania vincta, Xanthogramma scutellare, Paragus serratus, Harpactor costalis, Phyothemes variegate, Oxyopes* sp.*, Apelinus* sp., dung beetle, bumble bee and *Apis* sp.

**Study of Biodiversity in tobacco nurseries**

List of arthropod species
*Polystes sp, Chelonus formosanus,Apanteles sp,Apis dorsata,Apis sp,Holotrichia sp,Cheilomenes sexmaculata, Coccinella repanda, Verania vincta,* dung beetle, *Spodoptera litura, Plusia signata, Nezara virudula* and *Harpactor costalis, Bemisia tabaci, Myzus nicotianae, Phyothemes variegata, Phyothemis sp, Oxyopes sp, Clubonia sp,* mole cricket, *Acrida sp.*

In the active nursery, the Shannon index showed value of 3.22 which indicates good diversity. The evenness was 0.16 indicating very low inter species evenness, the individual number of species was much different from one to another. Total number of species were 20.The phytophgages were dominated by Lepidoptera (2), Coleoptera (2) and Homoptera.There were eight number of entomophage species. The total number of phytophages were 105 and the total number of natural enemies were 27. The phytophages were dominated by *S.litura* and the natural enemies were dominated by *Prebeae orbata and Cheilomenes sexmaculata* (**Table 12**).

**Table 12: Number of arthropod species based on order and ecological function.(Active Nursery)**

| order | Phytophage | Predator | Parasitoid | Decomposer | Pollinator | Others |
|---|---|---|---|---|---|---|
| Hymenoptera | - | 1 | 2 | - | 1 | - |
| Coleoptera | 2 | 3 | - | - | - | - |
| Diptera | - | - | 2 | - | - | - |
| Lepidoptera | 2 | - | - | - | - | - |
| Hemiptera | 1 | 1 | - | - | - | - |
| Homoptera | 2 | - | - | - | - | - |
| Odonata | | 2 | - | - | - | - |
| Araneae | | 2 | - | - | - | - |
| Orthoptera | 2 | - | - | - | - | - |

List of arthropod species
*Polystes sp, Chelonus formosanus, Apanteles sp, Apis dorsata, Apis sp, Holotrichia sp, Cheilomenes sexmaculata, Coccinella repanda, Verania vincta,* dung beetle, *Spodoptera litura Plusia signata,* castor butterfl*y, Achoea janata. Hymenia recurvalis, Nezara virudula* and *Harpactor costalis, Bemisia tabaci, Myzus nicotianae,* spittle bug*, Phyothemes variegata, Phyothemis sp, Oxyopes sp, ,* Mole cricket*, Acrida sp.*

In the left over nursery, the Shannon index showed value of 4.33 which indicates greater diversity. The evenness was 0.16 indicating very low inter species evenness, The individual number of species was much different from one to another. Total number of species were 20.The phytophgages were dominated by Lepidoptera (There were 12 number of entomophage species). The total number of phytophages were 65 and the total number of natural enemies were 36.The phytophages were dominated by *S.litura* and the natural enemies were dominated by *Prebeae orbata* and *Cheilomenes sexmaculata* (**Table 13**).

**Table 13: Number of arthropod species based on order and ecological function. (Left over Nursery)**

| order | Phytophage | Predator | Parasitoid | Decomposer | Pollinator | Others |
|---|---|---|---|---|---|---|
| Hymenoptera | - | 1 | 2 | - | 2 | - |
| Coleoptera | 2 | 3 | - | 1 | - | - |
| Diptera | - | - | 2 | - | - | - |
| Lepidoptera | 5 | - | - | - | - | - |
| Hemiptera | 1 | 1 | - | - | - | - |
| Homoptera | 2 | - | - | - | - | 1 |
| Odonata | - | 2 | - | - | - | - |
| Araneae | - | 1 | - | - | - | - |
| Orthoptera | 2 | - | - | - | - | - |

**CISH**

A roving survey was conducted in mango growing belts of Uttar Pradesh. During the survey four districts were covered viz., Lucknow, Faizabad, Sitapur and Unnao. About 25 species of natural enemies were collected from the mango ecosystem, which included both parasitoids and predators. Predators are mainly coccinellids, syrphids and spiders, whereas parasitoids belonged to three major families *viz*., ichnuemoniids, braconids and chalcidids. Detailed identification of the collected natural enemies is yet to be ascertained.

**Directorate of Sorghum Research**

Preliminary survey was conducted at DSR, research farm during Kharif 2913. The salient achievements are:

1. About 15-20% larval parasitization due to *Coetesia* on *Chilo partellus* was recorded at DSR, Research farm during July 2013.
2. About 20-23% egg parasitization due to *Trichogramma chilonis* recorded on shoot fly, *Atherigona soccata* on sorghum at research farm during August- September, 2013.

**Directorate of Rice Research**

**Survey and collection of natural enemies of rice pests**

Survey was made in different rice fields of Pattambi, Kerala to record pests and natural enemies. Samples were collected from sweep net and light trap. A total of 117 species belonging to 8 orders, 63 families of insects and spiders were collected and identified, of which 45 were pest species, 44 predators, 24 parasitoids and 4 in neutral or saprophagous group (**Table** 14). Three stem borer species were observed in the field, the yellow stem borer, *Scirpophaga incertulus*, the white stem borer, *Scirpophaga fusciflua* and the pink stem borer, *Sesamia inferens*. Three speices of egg parasitoids were observed on eggs of *S. incertulus* and

*S. fusciflua viz., Tetrastichus schoenobii, Trichogramma japonicum* and *Telenomus* spp. The yellow hairy caterpillar *Psalis pennatula* was found in large numbers and 10 per cent larvae were parasitized by *Brachymeria* sp.

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

**Table 14: Natural enemies collected from Pattambi, Kerala**

| S. no | Order | Family | Genus | Ecological role |
|---|---|---|---|---|
| | Diptera | Sciomyzidae | *Sepedon* | Parasitoid |
| 1 | Diptera | Tachinidae | *Argyrophylax* | Parasitoid |
| 2 | Hymenoptera | Braconidae | *Apanteles* sp. | Parasitoid |
| 3 | Hymenoptera | Braconidae | *Bracon chinensis* | Parasitoid |
| 4 | Hymenoptera | Braconidae | *Chelonus blackburnii* | Parasitoid |
| 5 | Hymenoptera | Braconidae | *Cotesia angustibasis* | Parasitoid |
| 6 | Hymenoptera | Braconidae | *Cotesia flavipes* | Parasitoid |
| 7 | Hymenoptera | Braconidae | *Macrocentrus philippinensis* | Parasitoid |
| 8 | Hymenoptera | Braconidae | *Stenobracon nicevillei* | Parasitoid |
| 9 | Hymenoptera | Braconidae | *Tropobracon hyati* | Parasitoid |
| 10 | Hymenoptera | Chalcidae | *Brachymeria* sp | Parasitoid |
| 11 | Hymenoptera | Dryinidae | UID | Parasitoid |
| 12 | Hymenoptera | Eulophidae | *Tetrastichus schoenobii* | Parasitoid |
| 13 | Hymenoptera | Ichneumonidae | *Charops bicolor* | Parasitoid |
| 14 | Hymenoptera | Ichneumonidae | *Xanthopimpla flavolineata* | Parasitoid |
| 15 | Hymenoptera | Ichneumonidae | *Xanthopimpla punctata* | Parasitoid |
| 16 | Hymenoptera | Platygastridae | *Platygaster oryzae* | Parasitoid |
| 17 | Hymenoptera | Pteromaildae | *Trichomalopsis apanteloctena* | Parasitoid |
| 18 | Hymenoptera | Platygastridae | *Gryon nixoni* | Parasitoid |
| 19 | Hymenoptera | Platygastridae | *Telenomus dignus* | Parasitoid |
| 20 | Hymenoptera | Platygastridae | *Telenomus* sp. | Parasitoid |
| 21 | Hymenoptera | Platygastridae | *Trissolcus* | Parasitoid |
| 22 | Hymenoptera | Trichogrammatidae | *Trichogramma japonicum* | Parasitoid |
| 23 | Araenae | Araeidae | *Araneus inustus* | Predator |
| 24 | Araenae | Araeidae | *Argiope catenulata* | Predator |
| 25 | Araenae | Araeidae | *Neoscona* | Predator |
| 26 | Araenae | Clubionidae | *Clubiona* sp. | Predator |
| 27 | Araenae | Lycosidae | *Lycosa psuedoannulata* | Predator |

| | | | | |
|---|---|---|---|---|
| 28 | Araenae | Oxyopidae | *Oxyopes lineatus* | Predator |
| 29 | Araenae | Oxyopidae | *Oxyopes javanus* | Predator |
| 30 | Araenae | Salticidae | *Bianor* sp. | Predator |
| 31 | Araenae | Tetragnathidae | *Tetragnatha maxillosa* | Predator |
| 32 | Araenae | Tetragnathidae | *Tetragnatha* sp | Predator |
| 33 | Araenae | Thomisidae | *Thomisus* sp. | Predator |
| 34 | Coleoptera | Carabidae | *Ophionea* sp. | Predator |
| 35 | Coleoptera | Carabidae | *Ophionea nigrofaciatus* | Predator |
| 36 | Coleoptera | Coccinellidae | *Brumoides suturalis* | Predator |
| 37 | Coleoptera | Coccinellidae | *Cocinella septumpunctata* | Predator |
| 38 | Coleoptera | Coccinellidae | *Cocinella transversalis* | Predator |
| 39 | Coleoptera | Coccinellidae | *Harmonia octomaculata* | Predator |
| 40 | Coleoptera | Coccinellidae | *Menochilus sexmaculatus* | Predator |
| 41 | Coleoptera | Coccinellidae | *Micraspis* sp. | Predator |
| 42 | Coleoptera | Coccinellidae | *Propylea dissecta* | Predator |
| 43 | Coleoptera | Coccinellidae | *Scymnus* sp. | Predator |
| 44 | Coleoptera | Hydrophilidae | *Berosus* sp. | Predator |
| 45 | Coleoptera | Staphylinidae | *Paederus fuscipes* | Predator |
| 46 | Diptera | Dolichopodidae | *Condylostylus* sp. | Predator |
| 47 | Hemiptera | Anthocoridae | *Orius* sp. | Predator |
| 48 | Hemiptera | Corixidae | *Micronecta* sp. | Predator |
| 49 | Hemiptera | Corixidae | *Notonecta* sp. | Predator |
| 50 | Hemiptera | Gerridae | *Gerris* sp. | Predator |
| 51 | Hemiptera | Gerridae | *Limnogonus* sp. | Predator |
| 52 | Hemiptera | Hydrometridae | *Hydrometra* sp. | Predator |
| 53 | Hemiptera | Lygaeidae | *Geocoris flavipes* | Predator |
| 54 | Hemiptera | Lygaeidae | *Geocoris erythrocephalus* | Predator |
| 55 | Hemiptera | Mesoveliidae | *Mesovelia vittigera* | Predator |
| 56 | Hemiptera | Microveliidae | *Microvelia atrolineata* | Predator |
| 57 | Hemiptera | Miridae | *Cyrtorrhinus lividipennsis* | Predator |
| 58 | Hemiptera | Pentatomidae | *Andrallus spinidens* | Predator |
| 59 | Hemiptera | Reduviidae | *Scipinia horrida* | Predator |
| 60 | Hemiptera | Reduviidae | *Polytoxus fuscovittatus* | Predator |
| 61 | Odonata | Coenagrionidae | *Ishneura arora* | Predator |
| 62 | Odonata | Coenagrionidae | *Ceriagrion coromandelianum* | Predator |
| 63 | Odonata | Libellulidae | *Orthetrum sabina sabina* | Predator |
| 64 | Odonata | Libellulidae | *Pantala flavescens* | Predator |
| 65 | Orthoptera | Tettigonidae | *Anaxipha longipennis* | Predator |

## 2. Mapping of EPN diversity (AAU-A, PAU)

### PAU - Ludhiana
### Mapping of EPN diversity in Punjab and Haryana

Ten soil samples were collected during wet season from different areas of state at root zone depth and placed in plastic containers with lid and processed for isolation of EPN. For isolation of EPN five healthy $5^{th}$ instar *Galleria* larvae were placed at the bottom of containers before filling the samples. These larvae were daily examined for their mortality for 7 days. The suspected EPN infected cadavers which did not putrify and rot were separated from soil. Out of twelve samples tested, the samples collected from vegetable fields of radish and ridge gourd in village Paddi Khalsa (District Jalandhar), where no insecticide was sprayed, caused mortality of *Galleria* larvae, but no EPN was isolated (**Table** 15).

### Isolation of entomopathogens from soil samples

a) Twenty one soil samples were collected from different fields of various districts of Punjab. All these soil samples were processed for isolation of entomopathogens as per protocol (**Table** 16). From these soil samples, three entomopathogenic fungi of *Beauveria* were isolated. These fungi were isolated from soil samples collected from the fields of rice, sugarcane and maize in the districts of Pathankot, Jalandhar and Hoshiarpur, respectively.

b) All these soil samples were processed for isolation of *Bacillus thuringiensis* as per protocol. From these samples two *Bacillus* isolates were isolated on T3 media. The bacteria were isolated from soil samples collected from the fields of radish and green *Moong* bean from districts of Jalandhar and Pathankot respectively.

All the isolates of entomopathogenic fungi and bacteria have been sent to NBAII, Bangalore by post on 19.3.14 and slip No is A CP105734068IN, for identification and confirmation.

**Table 15: Soil samples screened for isolation of EPN by *Galleria* bait method**

| Location | District | Common name of pest | Scientific name of insect | Distance from HQ | Month of survey | Host crop | Stage of crop | GIS data | Pesticides used |
|---|---|---|---|---|---|---|---|---|---|
| PAU Entomology Farm | Ludhiana | Jassid and spotted Bollworm | *Amrasca biguttula biguttula* and *Earias vitella* | 0 Km | August 2013 | Okra | Fruiting | 30.90 N 75.81 E | Malathion 50 EC |
| Paddi Khalsa | Jalandhar | No pest | - | 62 Km | August 2013 | Ramtori | Flowering | $30.9^0$ N $75.9^0$E | No spray |
| Hissar University Farm | Hissar | Brinjal shoot & fruit borer | *Leucinodes orbonalis* | 162 Km | August 2013 | Brinjal | - | 29° 5'5"N 75° 45'55"E | - |
| PAU Entomology Farm | Ludhiana | Brinjal shoot & fruit borer | *Leucinodes orbonalis* | 0 Km | August 2013 | Brinjal | Fruiting | 30.90 N 75.81 E | Malathion 50 EC (Spray as recommended) |
| Paddi Khalsa | Jalandhar | No pest | - | 62 Km | September 2013 | Radish | One month old | $30.9^0$ N $75.9^0$E | No spray |
| Janichak | Pathankot | No pest | - | 174 Km | September 2013 | Rice | Ear stage | 32.26° N 75.64° E | No information |
| Gopal pur | Pathankot | Hairy caterpillar | *Spilosoma obliqua* | 174 Km | October 2013 | Green Moong bean | Flowering and fruiting | 32.26° N 75.64° E | No information of spray |
| PAU Entomology farm | Ludhiana | No pest | - | 0 Km | November 2013 | Capsicum | One month old | 30.90 N 75.81 E | Sprayed as per university recommendation |
| Saholi | Nabha | No pest | - | 72 km | December 2013 | Capsicum | Two month | 30.37° N 76.15° E | No information |
| Paddi Khalsa | Jalandhar | No pest | - | 64 km | March 2014 | Musk melon | One month old crop | $30.9^0$ N $75.9^0$E | No information |

*Farmers were not sure about the names of pesticides which they used. They were spraying the crop after every week with a number of pesticides purchased from local markets.

** As *Galleria* was not available so limited soil sample were screened for its isolation.

**Table 16: Screening of soil/insect samples collected from various field crops for isolation of entomopathogens**

| Location | District | Common name of pest | Scientific name of insect | Distance from HQ | Month of survey | Host crop | Stage of crop | GIS data | Pesticides used |
|---|---|---|---|---|---|---|---|---|---|
| Janichak | Pathankot | No pest | - | 174 Km | September 2013 | Rice | Ear stage | 32.26° N 75.64° E | No information |
| Saholi | Nabha | No pest | - | 72 km | December 2013 | Capsicum | Two month | 30.37° N 76.15° E | No information |
| Paddi Khalsa | Jalandhar | No pest | - | 62 Km | September 2013 | Radish | One month | $30.9^0$ N $75.9^0$E | No spray |
| PAU Entomology farm | Ludhiana | Jassid and spotted Bollworm | - | 0 Km | August 2013 | Okra | Fruiting | 30.90 N 75.81 E | Malathion 50 EC |
| PAU Entomology farm | Ludhiana | Brinjal shoot and fruit borer | *Leucinodes orbanalis* | 0 Km | August 2013 | Brinjal | Fruiting | 30.90 N 75.81 E | Malathion 50 EC (Spray as recommended) |
| Paddi Khalsa | Jalandhar | No pest | - | 62 Km | August 2013 | Ramtori | Flowering | $30.9^0$ N $75.9^0$E | No spray |
| Paddi Khalsa | Jalandhar | No pest | - | 64 Km | March 2014 | Musk melon | One month old crop | $30.9^0$ N $75.9^0$E | No information |
| PAU Entomology farm | Ludhiana | No pest | - | 0 Km | November 2013 | Capsicum | One month old | 30.90 N 75.81 E | Sprayed as per university recommendation |
| Hissar University farm | Hissar | Brinjal shoot and fruit borer | *Leucinodes orbanalis* | 162 Km | August 2013 | Brinjal | Flowering | 29° 5'5''N 75° 45'55''E | No information |
| Gopal pur | Pathankot | Hairy caterpillar | *Spilosoma obliqua* | 174 Km | October 2013 | Green Moong bean | Flowering and fruiting | 32.26° N 75.64° E | No information of spray |
| Porshian (Rajputhana) | Amritsar | Jassid and Mealy bug | *Amrasca biguttula* and *Maconellic* | 142 Km | July 2013 | Okra | Fruiting | $31.63^0$N $74.87^0$E | No information |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *occus hirsutus* | | | | | | |
| Channo | Sangrur | No pest | - | 77 Km | December 2013 | Pea | Fruiting | 30.55$^{0}$N 75.96$^{0}$E | No information |
| Shabridran (Malerkotla) | Amritsar | Jassid and Red cotton bug | *Amrasca biguttula* and *Dysdercus cingulatus* | 138 Km | July 2013 | Okra | Fruiting | 31.63$^{0}$N 74.87$^{0}$ E | No information |
| Pucka village | Faridkot | No pest | - | 123 Km | July 2013 | Tori | Fruit and flowering | 30.11$^{0}$ N 74.75$^{0}$ E | No spray |
| Malerkotla | Sangrur | No pest | - | 58 Km | Feb2014 | Cabbage | Fruiting | 30.55$^{0}$N 75.96$^{0}$E | Heavy spray |
| Machakikalan | Faridkot | No pest | - | 125 Km | August 2013 | Cucumber | Fruiting | 30.11$^{0}$ N 74.75$^{0}$ E | No spray |
| PaddiKhalsa | Jalandhar | Early shoot borer | *Diatraea saccharalis* | 62 Km | September 2013 | Sugarcane | Two month old | 30.9$^{0}$ N 75.9$^{0}$E | No spray |
| MahalKhurd | Barnala | No pest | - | 76 Km | August 2013 | Okra | Fruiting | 30.38 $^{0}$N 75.52$^{0}$ E | Heavy spray* |
| Research farm | Ludhiana | No pest | - | 0 Km | March 2014 | Wheat | Ear | 30.90 N 75.81 E | Sprayed as per university recommendation |
| Karewala | Bathinda | No pest | - | 142 Km | August 2013 | Cotton | Ball formation | 30.11$^{0}$ N 75.00$^{0}$ E | Heavy spray |
| Bahowal | Hoshiarpur | Maize borer | *Chilo partellus* | 77.7 Km | August 2013 | Maize | cobs | 31.53°N 75.92° E | No information |

### 3. Surveillance for alien invasive pests in vulnerable areas (all centres)

**AAU-A**

Periodic surveys were carried out but none of the invasive pests listed above was recorded.

**AAU-J**

Periodic surveys were carried out from August, 2013 in the district of Jorhat, Sonitpur, Dibrugarh and Golaghat, Assam for alien invasive pests. Except *Paracoccus marginatus* infesting papaya and ornamental plants (marigold, croton, hibiscus, ornamental tapioca etc.) none of the invasive pests listed above were found.

In different homestead papaya gardens of Sonitpur district the survey revealed that the infestation of *P. marginatus* varied from 20-80%. But in some locations of Jamugurihat area under Sonitpur district 100 per cent infestation of *P. marginatus* was observed .In Jorhat and Dibrugarh district the infestation varied from 20-60% as against 0-30% was recorded in Golaghat district during survey period of 2013-14. (Table 17). The mealy bug was found to have disappeared from the papaya plants from January and February, 2014 and reappeared again in March, 2014. One lepidopteran predator, *Spalgius epius* was found feeding on *P. marginatus* everywhere. Moreover other predators *Menochilus sexmaculatus*, spider (unidentified) and green lace wing (unidentified) were also found predating on this pest.

**Table 17: Observations of *Paracoccus marginatus* on papaya plant**

| **Month of survey** | **Infestation of *P. marginatus* (%)** | | | |
|---|---|---|---|---|
| | **Jorhat district** | **Golaghat district** | **Sonitpur district** | **Dibrugarh district** |
| July’2013 | 40 | 20 | 40 | 30 |
| August’2013 | 50 | 20 | 80 | 60 |
| September’2013 | 60 | 30 | 60 | 50 |
| October’2013 | 30 | 10 | 20 | 30 |
| November’2013 | 20 | 10 | 20 | 30 |
| December’2013 | 0 | 0 | 0 | 20 |
| January’2014 | 0 | 0 | 0 | 0 |
| February’2014 | 0 | 0 | 0 | 0 |

**KAU - THRISSUR**

Mealybugs were collected from different crops and were identified by Dr. Sunil Joshi, NBAII, Bangalore. No invasive pests have been reported.

i. *Phenacoccus solenopsis* Tinsley (Host: Bhendi)
ii. *Phenacoccus solenopsis* Tinsley (Host: Brinjal)
iii. *Phenacoccus solenopsis* Tinsley (Host: Beet root)
iv. *Geococcus coffeae* Green (Host: Coleus) (Plate)
v. *Rastrococcus iceryoides* (Green) (Host: Cowpea)

**MPKV - Pune**

Field crops, horticultural crops and ornamental plantations were surveyed in western Maharashtra covering five agro-ecological zones. The fields and orchards in Pune region were frequently visited for the record of pests species *viz.*, coconut leaf beetle *Brontispa longissima*, spiraling white fly *Aleurodicus dugessi*, mealy bugs *Phenacoccus manihoti*, *Paracoccus marginatus*, *Phenacoccus madeirensis* and other alien invasive pests. The stages of *Paracoccus marginatus* W. and G. and *Phenacoccus solenopsis* Tinsley were collected for record of natural enemies. Infested fruits and vegetables were collected from city market yards and investigated in the laboratory for alien invasion of pest species and natural enemies.

Amongst the target pests, *Pseudococcus jackbeardsleyi* was recorded on custard apple in the vicinity of Pune. Papaya mealy bug *Paracoccus marginatus* W. and G. was observed in the papaya orchards on main host papaya and pigeon pea as well as weed plant velvet leaf locally called *pethari* (*Abution indicum* L.) in the vicinity of papaya orchards in ten districts (Pune, Satara, Sangli, Kolhapur, Solapur, Ahmednagar, Dhule, Jalgaon, Nashik and Nandurbar) of western Maharashtra along with the encyrtid parasitoid *Acerophagus papayae* N. and S. and *Pseudleptomastix mexicana* N. and S. in Pune region. The pest specimens were sent to NBAII, Bangalore for identification. The spiralling white fly (*Aleurodicus dispersus*) was recorded on papaya, cotton, pomegranate, acalypha, wild almond, ashoka and teak.

**CTRI**

Invasive pests were not found in black soil tobacco agro-ecosystem

**TNAU - Coimbatore**

During the study period the following species of mealybugs were recorded.

1. Papaya mealybug *Paracoccus marginatus*
2. Jack Beardsley mealy bug *Pseudococcus jackbeardsleyi*

The following alien invasive insect pests were not recorded during the year 2013-14.

- *Brontispa longissima*
- *Aleurodicus dugesii*
- *Phenacoccus manihoti*
- *Phenacoccus madeirensis.*

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

**1. Development of cost-effective WP/EC based *Trichoderma* (Th-14) formulations and delivery system to increase their longevity and efficacy under field conditions (GBPUAT).**

**a. Evaluation of various factors during mass production of *Trichoderma* to obtain higher CFUs**

**i). Effects of incubation period on growth and sporulation of *T. harzianum* (Th14)**

Very thick mycelial growth and very good sporulation (Table 18) was observed in PDB at 15 DAI ($3.49x10^8$) followed by 10 DAI ($2.87x10^8$) in stationary incubated culture.

**Table 18: Effect of different incubation days on growth and sporulation of *T. harzianum* (Th14)**

| Days after incubation (DAI) | Growth characters | Sporulation ($x10^8$ spores/ml) |
|---|---|---|
| 5 | Thin mycelia mat, very less sporulation | 1.61 |
| 7 | Thick mycelial mat, good sporulation | 2.16 |
| 10 | Thick mycelial mat, very good sporulation | 2.87 |
| **15** | **Thick mycelial mat, very good sporulation** | **3.49** |
| CD (0.05) | | 0.33 |
| CV (%) | | 8.01 |

**ii). Effect of shake and stable culture incubation on sporulation of *T. harzianum***

Optimum mycelial growth was observed in both shake and stable culture and in their combination at 15 DAI. However, significantly higher sporulation (spores/ml) was observed in stable culture ($1.3x10^8$) followed by stable and shake culture ($1.3x10^7$) and shake and stable culture incubation ($2.0x10^3$). No sporulation was observed in shake culture (Table 19).

**Table 19: Effect of shake and stable culture incubation on sporulation of *T. harzianum* in potato dextrose broth (PDB)**

| Treatment | Growth characters | Sporulation ($x10^6$ spores/ml) |
|---|---|---|
| Stable culture | Thick mycelia mat, good sporulation | **130.6** |
| Shake culture | Mycelial growth with no sporulation | 0.00 |
| Stable and shake culture | Mycelial mat, with less sporulation | 13.1 |
| Shake and Stable culture | Good mycelial growth with very less sporulation | 0.002 |
| **CD (0.05)** | | **56.5** |
| **CV (%)** | | 91.02 |

**iii.) Evaluation of solid and liquid media for growth and sporulation of *Trichoderma harzianum* (Th14)**

Different liquid (*Trichoderma* selective medium-TSM, jaggery medium, potato dextrose broth-PDB and potato broth) and solid media (Jhangora grains alone and Jhangora grains amended with 5 per cent jaggery) were tested for their effect on sporulation. Significantly maximum sporulation (Table 20) was observed in solid media i.e. Jhingora grains amended with 5 per cent jaggery ($4.2x10^{10}$ spores/g) as compared to Jhingora grains alone ($2.16x10^{10}$/g). Among different liquid media, significantly higher sporulation was observed in jaggery medium ($4.94x10^{8}$/ml) followed by PDB ($3.26x10^{8}$/ml).

**Table 20: Effect of different solid and liquid media on growth and sporulation of *Trichoderma harzianum* (Th14) at 10 DAI**

| **Medium** | **Growth Characters** | **Sporulation ($x10^{6}$ spores/ml/g)** |
|---|---|---|
| | **5 DAI*** | **15 DAI** |
| **Liquid medium** | | |
| *Trichoderma* selective medium | Thin mycelia mat , less sporulation | 32.2 |
| Jaggery medium | Thick mycelia mat, very good sporulation | **494.1** |
| Potato dextrose broth | Thick mycelia mat, good sporulation | 326.2 |
| Potato broth | Thin mycelia mat very less sporulation | 3.9 |
| **Solid medium** | | |
| Jhingora grains | Very good sporulation | 21641.0 |
| **Jhingora grains + Jaggery (5%)** | **Very good sporulation** | **42042.2** |
| **CD (0.05)** | **1091.0** | |
| **CV(%)** | 8.68 | |

**iv). Effect of different carbon sources on sporulation of *T. harzianum***

Good mycelial growth was observed in potato broth amended with jaggery, sugar, sucrose, fructose, mannitol, glucon-D and dextrose as carbon sources. There was a significant effect of carbon sources on sporulation of *Trichoderma*. Among different carbon sources, jaggery gave significantly higher sporulation ($1.57x10^{9}$spores/ml) than other carbon sources followed by mannitol ($1.3x10^{9}$) which was at par with sucrose ($1.2x10^{9}$) at 15 DAI. However, minimum sporulation (spores/ml) was observed in fructose ($9.1x10^{8}$) which was at par with glucon-D ($9.4x10^{8}$). Good sporulation was observed with all the carbon sources with increasing days after inoculation at 15 DAI (**Table 21**).

**Table: 21: Effect of different carbon sources on sporulation of *T. harzianum***

| Carbon source (2%) | Growth characteristics | Sporulation ($x10^8$ spores /ml) | | |
|---|---|---|---|---|
| | | Days after incubation | | |
| | | **5** | **10** | **15** |
| Fructose | Thick mycelia mat with dark green sporulation | 3.4 | 7.7 | 9.1 |
| **Jaggery** | **Thick mycelia mat with dark green sporulation** | **6.0** | **12.0** | **15.7** |
| Sucrose | Thick mycelia mat with dark green sporulation along with aerial white mycelium | 4.3 | 9.2 | 12.3 |
| Manitol | Thick mycelia mat with dark green sporulation along with aerial whitish green mycellium | 3.1 | 9.7 | 13.3 |
| Sugar | Thick mycelia mat with dark green sporulation along with aerial whitish green mycellium | 6.4 | 10.0 | 13.7 |
| Glucon D | Thick mycelia mat with dark green sporulation | 6.4 | 8.2 | 9.4 |
| Dextrose | Thick mycelia mat with dark green sporulation | 2.3 | 7.9 | 13.0 |

| | **days** | **carbon sources** | **days x carbon sources** |
|---|---|---|---|
| **CD (0.05)** | **1.1** | **1.5** | **2.7** |
| **CV(%)** | 19.37 | | |

**v). Effect of different nitrogen sources on sporulation of *T. harzianum***

Different nitrogen sources viz., ammonium nitrate, sodium nitrate, potassium nitrate, l-alanine, ammonium sulphate at two different concentrations (0.01 and 0.03%) evaluated in basal medium of PDB for growth and sporulation of *T. harzianum*. Results (Table 22) revealed good mycelial growth and optimum sporulation (spores/ml) with all nitrogen sources at both the concentrations. Significantly higher sporulation was observed in $NH_4SO_4$ ($1.49x10^9$) and ($2.73 x10^9$) while minimum in $NaNO_3$ ($1.07x10^9$) and ($1.16x10^9$) at 0.01 and 0.03 per cent respectively as compared to standard check-PDB ( $6.1x10^8$) and ($8.1x10^8$) at 0.01 and 0.03 per cent respectively at 15 DAI.

**vi). Effect of different pH on growth and sporulation of *Trichoderma***

Results in the present study (**Table 23**) revealed that among different pH (5.0, 5.5, 6.0 and 6.5) level of PDB, significantly high sporulation (spores/ml) was observed at pH 5.5 ($8.0x10^8$) which is on par with pH 6.0 ($6.7x10^8$). However, minimum sporulation was observed at a pH of 6.5 ($3.6x10^8$).

**Table 22: Effect of different nitrogen sources on sporulation of *T. harzianum***

| Nitrogen source | Growth Characteristics | Spore concentration ($x10^8$ spores/ml) 0.01 per cent Days after incubation | | | 0.03 per cent Days after incubation | | |
|---|---|---|---|---|---|---|---|
| | | 5 | 10 | 15 | 5 | 10 | 15 |
| $NaNO_3$ | Thick mat with dark green sporulation | 3.1 | 8.7 | 10.7 | 5.4 | 11.0 | 11.6 |
| **$NH_4SO_4$** | **Thick Mat with whitish growth and dark green sporualtion** | **4.3** | **14.8** | **14.9** | **10.7** | **26.3** | **27.3** |
| $KNO_3$ | Thick mat with whitish cottony growth and little dark green and light green sporulation | 2.7 | 9.0 | 12.0 | 10.1 | 11.7 | 16.7 |
| Alanine | Thick mat with dark green sporualtion | 2.5 | 9.5 | 14.3 | 7.9 | 12.7 | 17.4 |
| $NH_4NO_3$ | Thick mat with dark green sporulation | 2.2 | 6.0 | 11.4 | 6.9 | 6.6 | 17.6 |
| Check (PDB) | Thick mat with dark green sporulation | 1.7 | 3.6 | 6.1 | 5.2 | 6.8 | 8.1 |

| | days (a) | conc. (b) | nitrogen (c) | bxc | axc | axbxc |
|---|---|---|---|---|---|---|
| **CD(0.05)** | **2.1** | **1.7** | **2.9** | **5.1** | **4.1** | **7.2** |
| **CV(%)** | 4.4 | | | | | |

**Table 23: Effect of different pH levels on growth and sporulation of *Trichoderma***

| pH | Growth characteristics | Sporulation ($x10^8$ spores/ml) |
|---|---|---|
| 5.0 | Thick mycelia mat with dark green sporulation | 5.5 |
| **5.5** | **Thick mycelia mat with dark green sporulation** | **8.0** |
| **6.0** | **Thick mycelia mat with dark green sporulation** | **6.7** |
| 6.5 | Thick mycelia mat with dark green sporulation | 3.6 |
| **CD (0.05)** | | 1.8 |
| **CV (%)** | | 16.3 |

**vii). Effect of $MgSO_4$ and NaCl as sources of micronutrient on sporulation of *Trichoderma***

Results: (Table 24) revealed that sporulation was significantly increased with $MgSO_4$ (0.05%) and NaCl (0.1%) added in PDB as micronutrient along with nitrogen source viz. $NH_4SO_4$, $KNO_3$ and l- alanine (0.01%) as compared to PDB amended only with nitrogen source and PDB alone. Significantly maximum sporulation (spores/ml) was observed with $MgSO_4$+NaCl+$NH_4SO_4$ ($1.73x10^9$) followed by $MgSO_4$+NaCl+l-alanine ($1.63x10^9$) and

$MgSO_4$+NaCl+$KNO_3$ ($1.28x10^9$) which were at par with each other but significantly different from $NH_4SO_4$ ($9.3x10^8$), l-alanine ($8.5x10^8$) and $KNO_3$ ($7.5x10^8$) as compared PDB alone ($4.5x10^8$) at 15 DAI.

**Table 24: Effect of $MgSO_4$ and NaCl on sporulation of *Trichoderma***

| Treatment | Sporulation ($x10^8$ spores/ml) | | |
|---|---|---|---|
| | Days after incubation | | |
| | 5 | 10 | 15 |
| **PDB+$MgSO_4$ +NaCl +$NH_4SO_4$** | **10.2** | **11.3** | **17.3** |
| PDB+$MgSO_4$ +NaCl +$KNO_3$ | 6.4 | 8.7 | 12.8 |
| **PDB+$MgSO_4$ +NaCl +l-Alanine** | **8.6** | **13.3** | **16.3** |
| PDB+$NH_4SO_4$ | 6.0 | 8.6 | 9.3 |
| PDB+$KNO_3$ | 4.1 | 6.5 | 7.5 |
| PDB+l-Alanine | 5.3 | 7.7 | 8.5 |
| PDB | 2.3 | 3.5 | 4.5 |
| | **Days (d)** | **nitrogen (n)** | **d x n** |
| **CD(0.05)** | **2.03** | **2.87** | **4.97** |
| **CV (%)** | 24.04 | | |

**viii). Sporulation of *Trichoderma* in modified media**

In the present study PDB and jaggery medium with a pH of 5.5 amended with sugar (2%) as carbon and $NH_4SO_4$ (0.01%) as nitrogen sources along with $MgSO_4$ (0.05%) and NaCl (0.1%) as a source of micronutrients were evaluated for the sporulation (spores/ml) of *Trichoderma*. These modified media i.e. Jaggery and PDB significantly increased the sporulation by $1.2x10^{10}$ and $1.06x10^{10}$ as compared to the jaggery medium ($7.8x10^9$) and PDB ($6.4x10^9$) alone (Table 25).

**Table 25: Effect of modified media on sporulation of *Trichoderma***

| Medium | Sporulation ($x10^9$spores/ml) |
|---|---|
| PDB | 6.4 |
| **PB +dextrose +$NH_4SO_4$+ $MgSO_4$+NaCl** | **10.6** |
| PB + Jaggery | 7.8 |
| **PB+ Jaggery +$NH_4SO_4$+ $MgSO_4$+NaCl** | **12.0** |
| **CD(0.05)** | **3.0** |
| **CV (%)** | 17.9 |

**b. Methods of talc-based preparations of *Trichoderma* to obtain higher CFU/g powder**

In this study (Table 26) modified Jaggery liquid medium and Jhingora grains (amended with 5% jaggery) as solid substrate were used for the mass production of *Trichoderma*. The *Trichoderma* colonized Jhingora grains ($2.2x10^{10}$ spores/g) were properly mixed with *Trichoderma* colonized liquid modified Jaggery medium ($1.2x10^{10}$ spores /ml) in different ratio viz. 1:1, 1:3 and 1:4 (w/v) to obtain higher CFUs. The *Trichoderma* culture filtrate thus obtained showed significantly higher CFUs in all the combinations as compared to alone. The 1:1 ratio showed significantly higher spore concentration ($8.1x10^{13}$) as compared to 1:3 ($5.8x10^{12}$) and 1:4 ($3.2x10^{12}$), which was at par with each other.

The *Trichoderma* culture filtrate obtained as above (1:1, 1:3, 1:4) was mixed properly with talc powder (1:1 v/w) to prepare talc based preparation. Significantly maximum CFUs/g was observed in the talc-based preparation prepared by mixing *Trichoderma* culture filtrate with talc powder in 1:1 ($1.14x10^{13}$) as compared to 1:3 ($3.27x10^{12}$) and 1:4 ratio ($3.13x10^{12}$) which was at par with each other (Table 26). As 1:4 ratio is cost effective it will be used during preparation of different WP/EC based formulations in the next year, 2014-15 to increase the longevity during storage and efficacy of the *Trichoderma* during application in the field .

**Table 26: Spore concentration of talc-based preparations.**

| **Mixing of *Trichoderma* colonized jhangora grains and liquid medium (w/v)** | **Spore concentration of *Trichoderma* culture filtrate ($x10^{12}$ spores/ml)** | **CFU in talc based preparation ($x10^{11}$/g powder)** |
|---|---|---|
| **1:1** | **81.0** | **114.3** |
| 1:3 | 5.8 | 32.7 |
| 1:4 | 3.2 | 31.3 |
| **CD(0.05)** | **7.5** | **18.2** |
| **CV (%)** | 12.6 | 15.4 |

**2. Identification, evaluation and exploitation of ISR activity of PGPR against spot blotch of wheat under controlled conditions (GBPUAT).**

Soil samples from the rhizosphere of different wheat varieties were collected. Fluorescent pseudomonads were isolated on Kings B medium by soil dilution method incubated at 28ºC. Purified bacterial cultures were confirmed by fluorescence under UV rays. Some bacterial isolates which showed inhibition of growth of other bacteria on soil dilution plates but not produce fluorescence were also isolated and purified. A total of 126 rhizobacterial isolates ($G^-$ and 52 $G^+$) were isolated, purified and identified as $G^-$ (74 no.) and $G^+$ (52 no.) bacteria.

The fungal pathogen collected from infected wheat leaves showing brown spots was isolated, purified and identified as *Bipolaris sorokiniana* based on morphological characteristics. The pure culture was maintained on PDA slants stored at $4^0$C. Talc based preparation of different rhizobacterial isolates (126 no.) having a cfu count of $10^7$cfu/g were applied as seed treatment @ 10g /kg seed at the time of sowing and as soil application by drenching (30 ml suspension/pot) one month after sowing. The wheat variety (UP 262) susceptible to spot blotch was used in the study. Ten seeds were sown in each pot (15 cm dia.).

The spore suspension ($10^4$spores/ml) of the pathogen was properly sprayed on foliage of each plant in each pot 4 days after soil drenching with rhizobacteria. Optimum temperature of about $22^0$C with a RH of about 80 per cent was maintained at least 48 hrs. after inoculation.

The observations on disease severity was measured at 15 and 30 days after pathogen inoculation using double-digit (DD, 00-99) system, a modification of Saari and Prescott's (Eyal *et al.*, 1987).

**Results**

The wheat plans treated with inducer rhizobacteria (seed and soil treatment) artificially inoculated with the pathogen (*Bipolaris sorokiniana*) showed less disease severity as compared to control (Table 27). Maximum decrease in disease severity was observed in the Pfa-50 (51.3%) followed by N-38 (46.7%), N-24 (46.6%), Pfa-2 (38.9%), Pfa-37 (38.8%), N-18x (37.5%) and Pfa-65 (34.7%). Among these seven isolates Pfa-2, Pfa-37, Pfa-50 and Pfa-65 were gram negative fluorescent Pseudomonads, while N-24, N38 and N18x were gram positive rhizobacteria. The decrease in disease severity may be due to the induction of ISR activities as rhizobacteria were applied as seed treatment and as soil treatment 25 days after sowing and 4 days before pathogen inoculation (foliar application). Biochemical evidences of the defense mechanism of these seven isolates will be confirmed during the next year, 2014-15 by estimating various biochemical parameters related to ISR activities viz. Proline content, Hydrogen peroxide ($H_2O_2$), total phenolics, peroxidase activity, polyphenol Oxidase activity (PPO), phenylalanine ammonia lyase activity (PAL) and superoxide dismutase.

**Table 27: Efficacy of different rhizobacterial isolates against spot blotch of wheat in glasshouse**

| Sl. No. | Rhizobacteria isolate | Disease Severity (%) | | Reduction in disease severity(%) |
|---|---|---|---|---|
| | | Days after inoculation | | |
| | | 15 | 30 | 30 |
| T1 | **N-38** | **11.5** | **43.8** | **46.7** |
| T2 | **Pfa -50** | **10.5** | **40.1** | **51.3** |
| T3 | **Pfa-2** | **18** | **50.3** | **38.9** |
| T4 | N-36 | 24.7 | 75.1 | 8.8 |
| T5 | N-61 | 27.4 | 78.2 | 5.8 |
| T6 | N-4 | 24.7 | 68.7 | 16.6 |
| T7 | Nx2 | 28.2 | 70.3 | 14.6 |
| T8 | N-5 | 28.3 | 75.9 | 7.8 |
| T9 | N-3 | 26.8 | 73.2 | 11.1 |
| T10 | N-99 | 28.2 | 71.5 | 13.2 |
| T11 | Pfa-41 | 37.4 | 75.1 | 8.8 |
| T12 | N-40x | 28.3 | 73.2 | 11.2 |
| T13 | N-34 | 26.2 | 70.5 | 14.4 |
| T14 | N-60 | 30.6 | 73.1 | 11.3 |
| T15 | T-15 | 30.0 | 70.6 | 14.2 |
| T16 | T-16 | 27.9 | 71.7 | 13.0 |
| T17 | N-88 | 30.7 | 73.5 | 10.7 |
| T18 | N-87 | 29.4 | 72.3 | 12.2 |
| T19 | N-47 | 29.5 | 71.9 | 12.7 |
| T20 | N-35 | 26.9 | 72.3 | 12.3 |
| T21 | N-86 | 30.4 | 73.4 | 10.9 |

| | | | | |
|---|---|---|---|---|
| T22 | Pfa-35 | 28.1 | 68.4 | 16.9 |
| T23 | T-23 | 29.8 | 72.3 | 12.2 |
| T24 | Pfa-46 | 26.5 | 72.3 | 12.2 |
| T25 | Pfa-27 | 34.9 | 77.7 | 5.7 |
| T26 | N-92 | 25.2 | 72.4 | 12.1 |
| T27 | N-82 | 22.1 | 66.3 | 19.5 |
| T28 | N-83 | 20.2 | 69.9 | 15.1 |
| T29 | Pf-25 | 20.7 | 73.4 | 10.9 |
| T30 | Pfa-38 | 26.7 | 73.1 | 11.3 |
| T31 | Pfa44 | 27.6 | 73.7 | 10.5 |
| T32 | **N-24** | **10.0** | **43.9** | **46.6** |
| T33 | **Pfa-37** | **10.3** | **50.3** | **38.8** |
| T34 | Nx-1 | 28.0 | 73.0 | 11.4 |
| T35 | Pfa-40 | 26.0 | 80.1 | 2.7 |
| T36 | T-36 | 29.6 | 78.9 | 4.2 |
| T37 | N-90 | 41.5 | 76.1 | 7.6 |
| T38 | N-77 | 42.8 | 76.3 | 7.4 |
| T39 | N-81 | 26.7 | 70.1 | 14.9 |
| T40 | Pf28 | 22.9 | 71.9 | 12.7 |
| T41 | T-41 | 24.1 | 69.3 | 15.9 |
| T42 | N-79 | 38.5 | 76.1 | 7.5 |
| T43 | N-76 | 30.8 | 75.9 | 7.8 |
| T44 | Pf6 | 33.8 | 75.4 | 8.4 |
| T45 | N-75 | 31.3 | 78.6 | 4.6 |
| T46 | N-36x | 30.6 | 65.0 | 21.0 |
| T47 | N-35x | 26.5 | 63.3 | 23.1 |
| T48 | N-31 | 33.3 | 75.8 | 7.9 |
| T49 | N-38x | 27.3 | 68.9 | 16.4 |
| T50 | N-63 | 17.5 | 78.1 | 5.2 |
| T51 | Pfa-36 | 25.4 | 67.9 | 17.5 |
| T52 | N-62 | 42.4 | 76.3 | 7.3 |
| T53 | N-2 | 39.7 | 75.7 | 8.0 |
| T54 | N-37 | 38.1 | 76.1 | 7.5 |
| T55 | T-55 | 38.1 | 70.1 | 14.8 |
| T56 | N-80x | 47.1 | 74.6 | 9.4 |
| T57 | T-57 | 32.3 | 71.9 | 12.7 |
| T58 | T-58 | 33.1 | 74.5 | 9.6 |
| T59 | Pfa-51x | 32.1 | 66.0 | 19.9 |
| T60 | **N-18x** | **10.5** | **51.4** | **37.5** |
| T61 | T-61 | 23.6 | 65.9 | 19.9 |
| T62 | Pfa-34 | 32.6 | 78.5 | 4.7 |
| T63 | N-11 | 35.9 | 72.6 | 11.9 |
| T64 | Nx | 38.3 | 79.2 | 3.8 |
| T65 | N-66 | 32.9 | 76.6 | 7.0 |
| T66 | N-68 | 35.9 | 79.4 | 3.6 |
| T67 | T-67 | 44.1 | 74.7 | 9.3 |
| T68 | N-67 | 32.1 | 73.8 | 10.3 |
| T69 | N-69 | 30.3 | 74.7 | 9.3 |

| | | | | |
|---|---|---|---|---|
| T70 | **Pfa-65** | **15** | **53.8** | **34.7** |
| T71 | Nx-3 | 29.2 | 72.8 | 11.6 |
| T72 | N-22x | 32.9 | 72.5 | 12.0 |
| T73 | N-22 | 32.8 | 73.8 | 10.3 |
| T74 | N-71 | 31.1 | 69.2 | 16.0 |
| T75 | N-23x | 28.9 | 77.3 | 6.2 |
| T76 | N-23 | 25.1 | 66.0 | 19.9 |
| T77 | T-77 | 29.3 | 75.4 | 8.5 |
| T78 | N-13 | 31.0 | 76.1 | 7.5 |
| T79 | Pfa-53 | 32.1 | 82.0 | 0.5 |
| T80 | N-70 | 35.3 | 71.7 | 12.9 |
| T81 | Pfa-51x | 43.7 | 81.0 | 1.7 |
| T82 | N-101 | 38.9 | 70.9 | 13.9 |
| T83 | N-19 | 34.6 | 78.3 | 4.9 |
| T84 | Pfa-26 | 43.2 | 74.7 | 9.3 |
| T85 | N-33 | 40.1 | 77.9 | 5.4 |
| T86 | N-25 | 45.3 | 78.3 | 4.9 |
| T87 | N-28 | 52.1 | 78.1 | 5.2 |
| T88 | N-10 | 39.3 | 74.9 | 9.1 |
| T89 | N-18 | 30.2 | 66.0 | 19.9 |
| T90 | Pfa-52 | 38.6 | 76.8 | 6.7 |
| T91 | Pfa-25 | 30.4 | 64.2 | 22.1 |
| T92 | Pfa-42 | 33.8 | 76.6 | 7.0 |
| T93 | Pa-43 | 43. | 77.6 | 5.8 |
| T94 | Pfa-45 | 29.3 | 73.9 | 10.2 |
| T95 | Pfa-32 | 27.3 | 71.4 | 13.2 |
| T96 | Pfa-33 | 27.4 | 79.8 | 3.2 |
| T97 | Pfa-26 | 34.1 | 78.0 | 5.3 |
| T98 | Pfa-30 | 43.9 | 77.6 | 5.81 |
| T99 | T-99 | 33.1 | 67.0 | 18.6 |
| T100 | Pfa-39 | 35.7 | 73.3 | 1.1 |
| T101 | T-101 | 38.9 | 79.3 | 3.7 |
| T102 | T-102 | 37.6 | 79.8 | 3.1 |
| T103 | T-103 | 27.1 | 72.2 | 12.3 |
| T104 | T-104 | 28.9 | 76.1 | 7.6 |
| T105 | T-105 | 35.4 | 75.1 | 8.8 |
| T106 | T-106 | 28.3 | 76.7 | 6.9 |
| T107 | T-107 | 32.1 | 73.8 | 10.4 |
| T108 | T-108 | 29.5 | 73.7 | 10.5 |
| T109 | T-109 | 30.6 | 73.6 | 10.7 |
| T110 | T-110 | 30.9 | 72.4 | 12.0 |
| T111 | T-111 | 31.4 | 73.9 | 10.2 |
| T112 | T-112 | 33.5 | 73.1 | 11.3 |
| T113 | T-113 | 33.1 | 75.0 | 8.9 |
| T114 | T-114 | 32.6 | 73.0 | 11.3 |
| T115 | T-115 | 30.8 | 72.4 | 12.1 |
| T116 | T-116 | 31.4 | 73.2 | 11.1 |
| T117 | T-117 | 30.9 | 73.4 | 10.9 |

| | | | | |
|---|---|---|---|---|
| T118 | T-118 | 30.8 | 73.2 | 11.1 |
| T119 | T-119 | 30.7 | 72.0 | 12.6 |
| T120 | T-120 | 29.0 | 71.8 | 12.8 |
| T121 | T-121 | 31.6 | 74.9 | 9.0 |
| T122 | T-122 | 31.7 | 72.6 | 11.8 |
| T123 | T-123 | 32.7 | 72.1 | 12.4 |
| T124 | T-124 | 30.6 | 73.8 | 10.4 |
| T125 | PF-12 | 31.2 | 73.7 | 10.5 |
| T126 | PF-11 | 27.6 | 71.5 | 13.1 |
| C-1 | Cont-1 | 39.9 | 82.4 | - |
| **CD (0.05)** | | **6.5** | **10.4** | |
| **CV(%)** | | 13.2 | 8.9 | |

**3. Selection and promotion of plant growth promoting *Trichoderma* isolates for crop health under sustainable agriculture (Crop: wheat, chickpea and rice).**

A total of 78 *Trichoderma* isolates were isolated (Table 28) from rhizosphere and rhizoplane of rice (27 no.), wheat (27 no.) and chickpea (24 no.) for their growth promoting effects on the crops. Based on cultural characteristics, 52 *Trichoderma* isolates were selected for their growth promotion effect in their respective crops viz. wheat (19 no.) rice (17 no.) and chickpea (16 no.) *in vitro* (paper towel method) and *in vivo* ( in pots under glasshouse).

**Table 28: *Trichoderma* isolates isolated from different crops**

| Crop | *Trichoderma* isolate isolated | | Selected *Trichoderma* isolates | |
|---|---|---|---|---|
| | Rhizosphere (RS) | Rhizoplane (RP) | Rhizosphere (RS) | Rhizoplane (RP) |
| Rice | 17 | 10 | 9 | 8 |
| Wheat | 18 | 9 | 11 | 8 |
| Chickpea | 15 | 9 | 9 | 7 |

***In vitro* screening (Towel paper method)**

Seeds of wheat, chickpea and rice were treated with the prepared formulations of respective *Trichoderma* isolates (10g/kg seed) isolated from respective crops. Thirty seeds of each crop were placed on moist towel papers. Folded towel papers were placed in a tray and incubated at 24±1°C for 14 days (rice), 8 days (wheat) and 10 days (chickpea). Proper moisture was maintained by adding sterilized distilled water. Seeds without any treatment served as check. Three replications of each treatment were maintained. The observations on seed germination, radical and plumule length and weight were recorded.

***In vivo* screening (in pots under glasshouse)**

Plastic pots (8 kg capacity) were filled with sterilized well pulverized natural sandy loam soil collected (upper 0-15 cm soil layer) from Crop Research Centre, G.B.P.U.A.&T, Pantnagar. Each pot was amended with 200 g vermicompost mixed with respective *Trichoderma* isolates. The seeds (rice var. Govind, wheat var. PBW 343 and chickpea var. PG

168) bio-primed with the preparations of respective *Trichoderma* isolates were sown in the pots (10 seeds /pot). The plastic pots filled with the sterilized soil and vermicompost alone (without *Trichoderma*) sown with the seeds (untreated) were served as control. Maintain optimum level of moisture by regular watering. After germination (seedlings) 5 plants were maintained in each pot. The observations on seed germination, root and shoot length and weight were recorded 45 DAS.

**Results:**

Different crop specific *Trichoderma* isolates were tested in their respective crops *in-vitro* and *in vivo* for their growth promoting effects on their native crop. Based on their performance 7 *Trichoderma* isolates from wheat-Wh (out of 19), and chickpea-Ch (out of 16), while 6 *Trichoderma* isolates from Rice-Rc (out of 17) were selected for further studies *in vitro* and *in vivo.*

**a. Wheat**

***In vitro* screening (Towel paper method)**

Of the seven crop native *Trichoderma* isolates, TRS Wh 8 and TRS Wh 4 were found significantly most effective in promoting plumule length (16.0 &14.42 cm) plumule weight (0.8 & 0.78 g), root length (22.18 & 20.85 cm) and root weight (0.46 & 0.45 g) respectively as compared to standard check (Th14) and check (12.73 & 10.31cm, 0.7 & 0.51 g ; 19.68 & 16.93cm, 0.30 & 0.20 g) in promoting shoot length & weight and root length & weight respectively (Table 29).

**Table 29: Efficacy of *Trichoderma* isolates on plant vigour of wheat *in vitro***

| ***Trichoderma* isolate** | **Plumule length (cm)** | **Plumule weight (g)** | **Radicle length (cm)** | **Radicle weight (g)** |
|---|---|---|---|---|
| TRS Wh 2 | 10.19 | 0.64 | 16.81 | 0.28 |
| TRS Wh 3 | 10.21 | 0.61 | 14.74 | 0.21 |
| TRS Wh 4 | 14.42 | 0.78 | 20.85 | 0.45 |
| TRS Wh 7 | 11.65 | 0.66 | 17.49 | 0.29 |
| TRP Wh 3 | 10.24 | 0.58 | 15.84 | 0.26 |
| TRP Wh 6 | 14.26 | 0.69 | 18.81 | 0.31 |
| TRP Wh 8 | 16.00 | 0.80 | 22.18 | 0.46 |
| Th-14 | 12.73 | 0.70 | 19.68 | 0.30 |
| Check | 10.31 | 0.51 | 16.93 | 0.20 |
| **CD (0.05)** | **1.33** | **0.22** | **1.89** | **0.18** |
| **CV (%)** | 6.5 | 1.97 | 5.08 | 2.9 |

***In vivo* screening (in pots under glasshouse)**

Of the seven native *Trichoderma* isolates, TRP Wh 8 and TRS Wh 4 were found significantly most effective in promoting shoot length (41.6 & 40.3 cm) shoot weight (21.6 &

20.9 g), root length (51.3 & 51.6 cm) and root weight (30.6 & 29.8 g) respectively as compared to standard check (Th14) and check (36.1 & 33.0 cm, 20.7 & 16.0 g ; 48.6 & 38.3 cm, 26.9 & 19.1 g) in promoting shoot length & weight and root length & weight respectively (**Table 30**).

**Table 30: Efficacy of *Trichoderma* isolates on plant vigour of wheat *in vivo***

| ***Trichoderma* isolate** | **Germination (%)** | **Shoot length (cm)** | **Shoot weight (g)** | **Root length (cm)** | **Root weight (g)** |
|---|---|---|---|---|---|
| TRS Wh 2 | 90 | 34.6 | 20.8 | 37.3 | 21.8 |
| TRS Wh 3 | 93 | 33.6 | 17.5 | 35.3 | 22.9 |
| TRS Wh 4 | 96 | 40.3 | 20.9 | 51.6 | 29.8 |
| TRS Wh 7 | 90 | 36.0 | 15.8 | 42.3 | 22.8 |
| TRP Wh 3 | 96 | 34.0 | 11.2 | 41.0 | 21.9 |
| TRP Wh 6 | 93 | 38.5 | 13.4 | 41.6 | 18.7 |
| TRP Wh 8 | 96 | 41.6 | 21.6 | 51.3 | 30.6 |
| Th-14 | 96 | 36.1 | 20.7 | 48.6 | 26.9 |
| Check | 92 | 33.0 | 16.0 | 38.3 | 19.1 |
| **CD (0.05)** | **-** | **2.70** | **0.92** | **2.1** | **1.18** |
| **CV (%)** | - | 4.61 | 3.08 | 2.8 | 2.9 |

Based on the performance of different wheat *Trichoderma* isolates on the plant vigour of wheat *in vitro* and *in vivo* two best isolates **TRS Wh 8 and TRP Wh 4** were selected to evaluate their growth promoting effects on other crops viz. rice and chickpea.

### b. Chickpea

#### *In vitro* screening (Towel paper method)

Of the seven native *Trichoderma* isolates, TRP Ch4 and TRP Ch3 were found significantly most effective in promoting plumule length (27.68 & 25.92 cm), plumule weight (0.49 & 0.48 g), radicle length (29.75 & 28.97 cm) and radicle weight (0.36 & 0.32 g) respectively as compared to standard check (Th14) and check (23.85 & 14.74 cm, 0.47 & 0.0.31 g; 28.05 & 20.51 cm, 0.17 & 0.15 g) in promoting plumule length & weight and radicle length & weight respectively (**Table 31**).

**Table 31: Efficacy of *Trichoderma* isolates on plant vigour of chickpea *in vitro***

| ***Trichoderma* isolate** | **Plumule length (cm)** | **Plumule weight (g)** | **Radicle length (cm)** | **Radicle weight (g)** |
|---|---|---|---|---|
| TRS Ch 5 | 22.28 | 0.38 | 26.18 | 0.18 |
| TRS Ch 7 | 13.95 | 0.43 | 18.13 | 0.17 |
| TRP Ch 3 | 25.92 | 0.48 | 28.97 | 0.32 |
| TRP Ch 4 | 27.68 | 0.49 | 29.75 | 0.36 |
| TRP Ch 5 | 14.43 | 0.39 | 23.49 | 0.14 |
| TRP Ch 6 | 14.73 | 0.41 | 13.64 | 0.15 |
| TRP Ch 7 | 15.73 | 0.41 | 19.41 | 0.14 |
| Th-14 | 23.85 | 0.47 | 28.05 | 0.17 |
| Check | 14.74 | 0.31 | 20.51 | 0.15 |
| **CD (0.05)** | **1.26** | **0.15** | **1.84** | **0.16** |
| **CV (%)** | 3.83 | 2.13 | 4.65 | 4.17 |

***In vivo* screening (in pots under glasshouse)**

Of the seven native *Trichoderma* isolates, **TRP Ch4 and TRP Ch3 were found significantly most effective in promoting shoot length (39.66 & 38.33 cm), shoot weight (13.03 & 12.00 g), root length (32.00 & 31.66 cm) and root weight (6.06 & 5.70 g)** respectively as compared to standard check (Th14) and check (37.33 & 29.00 cm, 13.33 & 9.53 g; 26.66 & 27.00 cm, 4.46 & 4.26g) in promoting shoot length & weight and root length & weight respectively (**Table 32**).

**Table 32: Efficacy of *Trichoderma* isolates on plant vigour of chickpea *in vivo***

| ***Trichoderma* isolate** | **Germination (%)** | **Shoot length (cm)** | **Shoot weight (g)** | **Root length (cm)** | **Root weight (g)** |
|---|---|---|---|---|---|
| TRS Ch 5 | 96 | 31.33 | 10.76 | 20.00 | 3.96 |
| TRS Ch 7 | 95 | 31.00 | 11.03 | 24.33 | 4.10 |
| **TRP Ch 3** | **90** | **38.33** | **12.00** | **31.66** | **5.70** |
| **TRP Ch 4** | **93** | **39.66** | **13.03** | **32.00** | **6.06** |
| TRP Ch 5 | 93 | 27.33 | 10.80 | 21.33 | 4.40 |
| TRP Ch 6 | 93 | 32.06 | 9.93 | 20.00 | 3.90 |
| TRP Ch 7 | 96 | 30.00 | 10.00 | 23.66 | 4.53 |
| Th-14 | 96 | 37.33 | 13.33 | 26.66 | 4.46 |
| Check | 96 | 29.00 | 9.53 | 27.00 | 4.26 |
| **CD (0.05)** | - | **5.20** | **2.26** | **4.10** | **1.37** |
| **CV (%)** | - | 4.05 | 3.2 | 3.4 | 4.35 |

Based on the performance of different chickpea *Trichoderma* isolates on the plant vigour of chickpea *in vitro* and *in vivo*, two best isolates TRP Ch 4 and TRP Ch 3 were selected to see their growth promoting effects on other crops viz. wheat and rice.

**c. Rice**

***In vitro* screening (Towel paper method)**

Of the seven native *Trichoderma* isolates, **TRS Rc 8 and TRS Rc 4 were found significantly most effective in promoting plumule length (16.96 & 13.92 cm) plumule weight (0.36 & 0.30 g), radicle length (22.10 & 20.68 cm) and radicle weight (0.56 & 0.53 g)** respectively as compared to standard check (Th14) and check (12.60 & 9.60 cm, 0.28 & 0.25 g; 19.99 & 19.18 cm, 0.40 & 0.23 g) in promoting plumule length & weight and radicle length & weight respectively (**Table 33**).

**Table 33: Efficacy of *Trichoderma* isolates on plant vigour of rice *in vitro***

| ***Trichoderma* isolate** | **Plumule length (cm)** | **Plumule weight (g)** | **Radicle length (cm)** | **Radicle weight (g)** |
|---|---|---|---|---|
| TRS Rc 3 | 8.54 | 0.22 | 16.46 | 0.26 |
| TRS Rc 4 | 13.92 | 0.30 | 20.68 | 0.53 |
| TRS Rc 8 | 16.96 | 0.36 | 22.10 | 0.56 |
| TRS Rc 9 | 13.64 | 0.24 | 19.67 | 0.43 |
| TRP Rc 4 | 9.80 | 0.24 | 12.81 | 0.26 |
| TRP Rc 7 | 6.99 | 0.23 | 18.01 | 0.26 |
| Th-14 | 12.60 | 0.28 | 19.99 | 0.40 |
| Check | 9.60 | 0.25 | 19.18 | 0.23 |
| **CD (0.05)** | **0.95** | **0.10** | **0.99** | **0.93** |
| **CV (%)** | 4.79 | 4.64 | 3.09 | 4.65 |

***In vivo* screening (in pots under glasshouse)**

Of seven native *Trichoderma* isolates, TRS Rc 8 and TRS Rc 4 were found significantly most effective in promoting shoot length (16.66 & 15.33 cm) shoot weight (0.80 & 0.76 g), root length (27.66 & 26.66 cm) and root weight (2.23 & 2.20 g) respectively as compared to standard check (Th14) and check (14.33 & 11.33 cm, 0.56 & 0.53 g; 26.00 & 22.00 cm, 2.00 & 1.80 g) in promoting shoot length & weight and root length & weight respectively (Table 34).

**Table 34: Efficacy of *Trichoderma* isolates on plant vigour of rice *in vivo***

| ***Trichoderm*a isolate** | **Germination (%)** | **Shoot length (cm)** | **Shoot weight (g)** | **Root length (cm)** | **Root weight (g)** |
|---|---|---|---|---|---|
| TRS Rc 3 | 96 | 12.00 | 0.63 | 22.00 | 1.10 |
| **TRS Rc 4** | **95** | **15.33** | **0.76** | **26.66** | **2.20** |
| **TRS Rc 8** | **90** | **16.66** | **0.80** | **27.66** | **2.23** |
| TRS Rc 9 | 93 | 11.33 | 0.50 | 20.66 | 1.66 |
| TRP Rc 4 | 93 | 14.00 | 0.53 | 14.33 | 1.56 |
| TRP Rc 7 | 93 | 13.66 | 0.53 | 19.00 | 1.10 |
| Th-14 | 96 | 14.33 | 0.56 | 26.00 | 2.00 |
| Check | 96 | 11.33 | 0.53 | 22.00 | 1.80 |
| **CD (0.05)** | - | **1.61** | **0.10** | **1.41** | **0.17** |
| **CV (%)** | - | 5.04 | 4.29 | 3.66 | 5.23 |

Based on the performance of different rice *Trichoderma* isolates on the plant vigour of rice *in vitro* and *in vivo,* two best isolates TRS Rc 8 and TRS Rc 4 were selected to see their growth promoting effects on other crops viz. wheat and chickpea.

**Efficacy of selected *Trichoderma* isolates on plant vigour on their respective crop and vice versa *in vitro* (Towel paper method)**

The study was done to demonstrate that either the crop specific *Trichoderma* isolates have a better growth promotion effects on their respective crop or on other crops. The two *Trichoderma* isolates from each crop viz. wheat, rice and chickpea were selected based on their performance *in vitro* and *in vivo* screening test for their growth promotion effects in their respective crops. Each selected isolates were tested *in-vtro* (paper towel method) in each crop for their growth promotion effects. The data recorded in table 35 revealed that crop specific *Trichoderma* isolates were found significantly better in increasing plant vigour in their respective crop as compared to other crops. The *Trichoderma* isolates from wheat were found significantly better in increasing plant vigour of wheat as compared to chickpea and rice isolates as well as standard check (Th14) and check. Similarly *Trichoderma* isolates from chickpea were found significantly better in increasing plant vigour of chickpea as compared to wheat and rice isolates and *Trichoderma* isolates from rice were found significantly better in increasing plant vigour of rice as compared to wheat and chickpea. Further confirmation of the results will be done in pots under glasshouse conditions during the next year, 2014-15. The antagonistic activity of these selected isolates against important plant pathogens of selected crops will also be done *in vitro* and in vivo during the next year, 2014-15.

**Table 35: Efficacy of selected *Trichoderma* isolates on plant vigour on their respective crops & other crops**

| | **Wheat** | | | | **Chickpea** | | | | **Rice** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Trichoderma* isolate** | **Plu. (cm)** | **Plu. g)** | **Rad. (cm)** | **Rad. (g)** | **Plu. (cm)** | **Plu. (g)** | **Rad. (cm)** | **Rad. (g)** | **Plu. (cm)** | **Plu. (g)** | **Rad. (cm)** | **Rad. (g)** |
| TRP Wh 8 | 16.63 | 0.84 | 22.02 | 0.45 | 16.56 | 0.38 | 17.46 | 0.27 | 10.47 | 0.38 | 20.93 | 0.27 |
| TRS Wh 4 | 14.06 | 0.62 | 21.60 | 0.39 | 18.83 | 0.40 | 18.80 | 0.29 | 10.33 | 0.25 | 21.38 | 0.28 |
| TRP Ch 4 | 13.70 | 0.41 | 17.66 | 0.15 | 27.60 | 0.66 | 25.43 | 0.42 | 9.86 | 0.27 | 22.36 | 0.36 |
| TRP Ch 3 | 10.83 | 0.32 | 17.20 | 0.14 | 25.53 | 0.55 | 22.43 | 0.38 | 9.88 | 0.30 | 22.65 | 0.49 |
| TRS Rc 4 | 10.76 | 0.40 | 15.10 | 0.17 | 19.53 | 0.42 | 21.33 | 0.35 | 13.26 | 0.40 | 23.42 | 0.56 |
| TRS Rc 8 | 13.54 | 0.42 | 18.96 | 0.20 | 15.43 | 0.30 | 17.80 | 0.26 | 15.55 | 0.53 | 25.60 | 0.65 |
| Th-14 | 12.96 | 0.47 | 20.46 | 0.14 | 22.36 | 0.48 | 21.66 | 0.35 | 11.86 | 0.36 | 22.36 | 0.34 |
| Check | 10.10 | 0.34 | 17.97 | 0.10 | 15.90 | 0.32 | 16.00 | 0.27 | 9.66 | 0.19 | 20.06 | 0.34 |
| **CD (0.05)** | 2.05 | 0.39 | 0.87 | 0.32 | 1.20 | 0.18 | 2.10 | 0.17 | 0.59 | 0.22 | 3.10 | 0.29 |

**4. Field evaluation of promising *Trichoderma* isolates for the management of soil-borne and foliar diseases (GBPUAT).**

**1. Rice (Kalanamak-3131)**

A field experiment was conducted at organic farming block of Breeder Seed Production Center of G.B.P.U.A&T., Pantnagar to evaluate the some new promising isolates of *Trichoderma* (19 no.) on rice (Kalanamak-3131) for plant health and yield. Some of the isolates were identified by using the plate reader BiOLOG microstation system (Version 4.2, GEN II) as TCMS 4 (*Trichoderma viride),* TCMS 5 (*T. koningii),* TCMS 14a (*T. viride),* TCMS14b (*T. koningii),* TCMS 16 (*T. harzianum),* TCMS 15 *(T. viride),* TCMS 36 (*T. harzianum),* TCMS 43 (*T. harzianum),* TCMS 65 (*T. harzianum).*Nursery was laid on June 13, 2013 and the transplanting was done on July 26, 2013. The different promising *Trichoderma* isolates were applied as seedling root dip treatment (10g/lit.), soil application (1kg talc based formulation of *Trichoderma* /100 kg vermicompost) and as two foliar sprays (10 g/lit) at 30 &

60 days after transplanting. The experiment was laid in a randomized block design in three replications with a plot size of 2x3 $m^2$. Harvesting was done during 3rd week of December 2013.

Data presented in table 36 indicates low level of brown spot disease severity in isolates TCMS 5 (17.3%), TCMS 14a (18.3%), Th 14 (19.3%), Th 82 (22.7%), Th 3 (23.3) & Th 17 (24.0%), were significantly different as compared to check (48.0%) but at par with each other. Significantly low level of sheath blight disease incidence was recorded in all the *Trichoderma* isolates except TCMS 2, TCMS 4, TCMS 15 and TCMS 16. However, minimum sheath blight disease incidence was observed in TCMS 5 (8.1%), TCMS 14a (8.8%), Th-14 (9.3%), Th- 82 (10.7%), Th-3 (10.8%) & Th-17 (13.1%) as compared to check (35.0%). Occurrence of bacterial blight was very low during the course of investigation. No sheath rot disease incidence was observed. No *Trichoderma* isolate was found good in managing stem borer, grass hopper and leaf folder. Among all the isolates TCMS 5, TCMS 14a, Th-14, Th-82, Th-3 & Th-17 were found good in managing brown spot and sheath blight diseases.

Significantly maximum population of *Trichoderma* (**Table 37**) in rhizosphere and rhizoplane (45 DAS) was observed in TCMS 5 ($14x10^3$ & $11.7x10^2$ CFU/g) followed by TCMS 14a ($12.7x10^3$ & $10.7x10^2$ CFU/g) and was at par as compared to check ($4.9x10^3$ & $4.3x10^2$ CFU/g). At 90 DAS significantly maximum population of *Trichoderma* in rhizosphere and rhizoplane was found in TCMS 5 ($12.0x10^3$ & $9.0x10^2$ CFU/g) followed by TCMS 14a ($11.0x10^3$ & $7.1x10^2$ CFU/g) as compared to control ($3.3x10^3$ & $1.3x10^2$ CFU/g) respectively.

Significantly higher plant height and panicle length (**Table 38**) was observed in all the promising *Trichoderma* isolates as compared to control. Maximum increase in plant height was observed in TCMS 5 (21.8%) followed by TCMS 14a (19.1%) and Th-14 (17.5 %) over control. Significantly maximum increase in panicle length was observed in TCMS 5 (36.5%) followed by TCMS 14a (36.1%), Th 14 (26.7%), Th 82 (26.6%) and Th 17 (26.0%). Significantly maximum increase in tiller/hill was observed in TCMS 5 (116.8%) followed by TCMS 14a (100.0%) and Th 14 (85.1%). Significantly higher yield was recorded in TCMS 5 (38.9 q/ha) followed by TCMS 14a (38.3q/ha) as compared to control (25.0 q/ha). Maximum increased in yield was observed in TCMS 5 (55.4%) followed by TCMS 14a (53.1%). Among all the promising *Trichoderma* isolates evaluated under field conditions, TCMS 5 was found best in reducing brown spot and sheath blight diseases and in increasing plant vigour and yield of rice (Kalanamak-3131) followed by TCMS 14a, Th 14 and Th 82.

**Table 36: Efficacy of promising *Trichoderma* isolates against important rice diseases (Kalanamak-3131)**

| ***Trichoderma* isolate** | **Per cent disease severity / disease incidence** | | | |
|---|---|---|---|---|
| | **Brown spot** | | **Sheath blight** | |
| | **Disease severity (%)** | **decreased in disease (%)** | **Disease incidence (%)** | **decreased in disease (%)** |
| TCMS 2 | 40.7 | 15.3 | 29.1 | 16. 7 |
| TCMS 4 | 41.3 | 13.9 | 30.3 | 13.5 |
| **TCMS 5** | **17.3** | **63.9** | **8.1** | **76.8** |
| **TCMS 14a** | **18.3** | **61.8** | **8.8** | **75.0** |
| TCMS 14b | 28.3 | 41.0 | 17.6 | 49.8 |

| | | | | |
|---|---|---|---|---|
| TCMS 15 | 35.0 | 27.1 | 28.4 | 18.8 |
| TCMS 16 | 33.3 | 30.6 | 26.3 | 24.8 |
| TCMS 36 | 24.3 | 49.3 | 14.0 | 60.0 |
| TCMS 43 | 24.0 | 50.0 | **13.3** | **62.0** |
| TCMS 9 | 25.0 | 48.0 | 14.2 | 59.5 |
| TCMS 65 | 28.3 | 41.0 | 17.2 | 50.9 |
| Th 56 | 25.00 | 47.92 | 14.3 | 59.2 |
| Th 69 | 26.7 | 44.5 | 16.0 | 54.5 |
| Th 75 | 25.0 | 47.9 | 15.6 | 55.4 |
| **Th 82** | **22.7** | **52.8** | 10.7 | 69.4 |
| Th 89 | 30.7 | 36.1 | 23.8 | 32.1 |
| **Th 14** | **19.3** | **59.7** | **9.3** | **73.4** |
| **Th 3** | **23.3** | **51.4** | **10.8** | **69.1** |
| Th 17 | 24.0 | 50.0 | **13.1** | **62.5** |
| Control | 48.0 | - | 35.0 | - |
| **CD (0.05)** | **11.0** | **-** | **11.4** | - |
| **CV (%)** | 24.2 | - | 38.8 | - |

**Table 37: Population dynamics of *Trichoderma* isolates in rhizosphere & rhizoplane of rice (Kalanamak-3131)**

| ***Trichoderma* isolate** | **Population dynamics (days after transplanting)** | | | |
|---|---|---|---|---|
| | **Rhizosphere (x$10^3$ cfu/g)** | | **Rhizoplane (x$10^2$ cfu/g)** | |
| | **45** | **90** | **45** | **90** |
| TCMS 2 | 5.9 | 5.5 | 5.0 | 4.3 |
| TCMS 4 | 5.7 | 5.0 | 4.7 | 3.7 |
| **TCMS 5** | **14.0** | **12.0** | **11.7** | **9.0** |
| **TCMS 14a** | **12.7** | **11.0** | **10.7** | **7.1** |
| TCMS 14b | 6.6 | 6.4 | 7.7 | 4.7 |
| TCMS 15 | 6.2 | 5.6 | 6.3 | 4.3 |
| TCMS 16 | 6.4 | 5.6 | 6.7 | 4.3 |
| TCMS 36 | 8.0 | 7.8 | 9.7 | 5.3 |
| TCMS 43 | 8.1 | 7.9 | 10.0 | 6.0 |
| TCMS 9 | 8.0 | 7.6 | 9.3 | 5.3 |
| TCMS 65 | 6.7 | 5.0 | 7.9 | 5.0 |
| Th 56 | 7.7 | 6.4 | 9.3 | 5.0 |
| Th 69 | 7.1 | 6.7 | 8.9 | 5.0 |
| Th 75 | 7.4 | 7.1 | 9.0 | 5.0 |
| Th 82 | 10.0 | 9.3 | 10.3 | 6.0 |
| Th 89 | 6.5 | 5.9 | 7.3 | 4.7 |
| **Th 14** | **11.5** | **9.7** | **10.7** | **6.3** |
| Th 3 | 8.2 | 9.7 | 10.3 | 6.0 |
| Th 17 | 8.1 | 8.2 | 10.2 | 6.0 |
| Control | 4.9 | 3.3 | 4.3 | 1.3 |
| **CD(0.05)** | **2.4** | **2.1** | **3.0** | **2.9** |
| **CV (%)** | 18.9 | 16.7 | 21.1 | 33.5 |

**Table 38: Efficacy of promising *Trichoderma* isolates on plant vigour and yield of rice (Kalanamak-3131)**

| *Trichoderma* isolate | Plant vigour | | | | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | Plant height | Increase over check | Panicle length | Increase over check | Tiller/ hill | Increase Over check | Yield /plot (6 $m^2$) | Yield /ha | Increase over check |
| | (cm) | (%) | (cm) | (%) | (no.) | (%) | (kg) | (q) | (%) |
| TCMS 2 | 141.4 | 1.0 | 26.6 | 15.5 | 6.7 | 6.8 | 1.5 | 25.4 | 1. 7 |
| TCMS 4 | 140.8 | 0.6 | 26.2 | 13.9 | 6.7 | 5.7 | 1.6 | 25.8 | 3.2 |
| **TCMS 5** | **170.6** | **21.8** | **31.5** | **36.5** | **13.7** | **116.8** | **2.0** | **38.9** | **55.4** |
| **TCMS 14a** | **166.7** | **19.1** | **31.4** | **36.1** | **12.6** | **100.0** | **2.0** | **38.3** | **53.1** |
| TCMS 14b | 155.2 | 10.8 | 27.9 | 19.7 | 9.4 | 49.2 | 1.5 | 28.2 | 12.9 |
| TCMS 15 | 147.1 | 5.1 | 26.7 | 15.9 | 8.5 | 34.3 | 1.4 | 26.7 | 6.7 |
| TCMS 16 | 152.0 | 8.6 | 27.2 | 18.2 | 8.9 | 40.6 | 1.4 | 26.7 | 6.7 |
| TCMS 36 | 158.5 | 13.2 | 28.1 | 22.0 | 10.3 | 62.9 | 1.6 | 31.1 | 24.5 |
| TCMS 43 | 159.3 | 13.8 | 28.4 | 23.1 | 10.4 | 65.1 | 1.7 | 33.4 | 33.8 |
| TCMS 9 | 158.1 | 12.9 | 28.2 | 22.4 | 9.7 | 53.3 | 1.6 | 31.1 | 24.5 |
| TCMS 65 | 154.3 | 10.2 | 27.6 | 19.6 | 9.1 | 43.8 | 1.5 | 29.0 | 16.0 |
| Th 56 | 157.6 | 12.6 | 27.9 | 21.1 | 9.6 | 52.4 | 1.6 | 30.3 | 21.4 |
| Th 69 | 155.3 | 11.0 | 27.6 | 20.0 | 9.4 | 49.2 | 1.6 | 30.2 | 20.7 |
| Th 75 | 155.4 | 11.0 | 27.8 | 20.6 | 9.5 | 50.2 | 1.6 | 30.2 | 20.7 |
| Th 82 | 163.0 | 16.4 | 29.2 | 26.6 | 11.5 | 81.9 | 1.9 | 35.8 | 43.0 |
| Th 89 | 152.1 | 8.6 | 27.0 | 17.1 | 8.7 | 38.6 | 1.5 | 28.0 | 12.1 |
| Th 14 | 164.5 | 17.5 | 29.2 | 26.7 | 11.7 | 85.1 | 1.9 | 36.0 | 43.8 |
| Th 3 | 159.8 | 14.1 | 28.4 | 23.3 | 10.5 | 66.0 | 1.8 | 34.4 | 37.6 |
| Th 17 | 160.0 | 14.2 | 29.0 | 26.0 | 11.1 | 76.7 | 1.8 | 34.8 | 39.2 |
| Control | 140.0 | - | 23.0 | - | 6.3 | - | 1.5 | 25.0 | - |
| **CD(0.05)** | **17.3** | **-** | **3.0** | **-** | **2.1** | | **0.3** | **-** | **-** |
| **CV (%)** | 6.7 | - | 6.2 | - | 12.8 | | 23.8 | - | - |

## 2. Lentil

A field experiment was conducted at Crop Research Centre, Pantnagar during *Rabi* 2013-14 to evaluate the efficacy of potential isolates of *Trichoderma* on Lentil (PL-406) for crop health. Sowing was done on October 31, 2013. The different promising *Trichoderma* isolates were applied as soil application (1kg talc based formulation of *Trichoderma* /100 kg vermicompost/acre) as seed treatment @ 10 g/kg seeds and as two foliar sprays @10g/lit at 45 & 90 days after sowing. The experiment was laid in a randomized block design in three replications with a plot size of 3x3 $m^2$.

Data presented in **Table 39** indicates significantly maximum per cent increase in germination over control in isolate Th-17 and TCMS-5 (28.7%) followed by Th-14 (21.3%), over control. Significant difference in the mortality was observed in different isolates of *Trichoderma*. At 90 DAS least mortality was recorded with TCMS-14b (8.1%) followed by TCMS-2 (9.0%) and Th-3 (9.7 %) as compared to control (28.1%). Significantly maximum population of *Trichoderma* in rhizosphere and rhizoplane (45 DAS) was observed in TCMS 2 ($9.0x10^3$ & $31.3x10^2$ CFU/g) followed by Th 3 ($8.7x10^3$ & $18.3x10^2$ CFU/g) and TCMS 14a ($8.3x10^3$ & $15.3x10^2$ CFU/g) respectively. At 90 DAS significantly maximum population of

*Trichoderma* in rhizosphere and rhizoplane was found in TCMS 2 ($8.0x10^3$ & $26.0x10^2$ CFU/g) followed by Th 3 ($6.7x10^3$ & 18.0 $x10^2$ CFU/g). The crop was very good up to 100 DAS, but due to three heavy rains during II[nd] fortnight of Feb. at the interval of 4-5 days the crop was severely affected. The trials need to be repeated in the next year, 2014-15 for confirmation of the results.

**Table 39: Efficacy of promising *Trichoderma* isolates on disease and growth parameter of lentil crop variety PL-7**

| ***Trichoderma* Isolate** | **Plant stand (45 d)** | **Increase over check (%)** | **Plant stand (90 d)** | **Mortality (%)** | **Population dynamics: Rhizosphere population ($CFUx10^3/g$)** | | **Rhizoplane population $CFUx10^2/g$)** | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **45 DAS** | **90 DAS** | **45DAS** | **90 DAS** |
| **TCMS-2** | 1031.7 | 12.2 | 938.4 | **9.0** | **9.0** | **8.0** | **31.3** | **26.0** |
| TCMS-4 | 1066.7 | 16.1 | 925.4 | 13.2 | 4.3 | 3.3 | 4.3 | 3.7 |
| TCMS-5 | 1182.9 | **28.7** | 994.4 | 15.9 | 4.0 | 3.0 | 10.3 | 9.7 |
| **TCMS-14a** | 1050.4 | 14.2 | 934.8 | 11.0 | **8.3** | **8.0** | 15.3 | 12.7 |
| **TCMS-14b** | 924.2 | 0.54 | 849.3 | **8.1** | 4.7 | 4.0 | 8.0 | 7.3 |
| TCMS-15 | 1012.1 | 10.1 | 784.9 | 22.5 | 2.7 | 2.0 | 5.3 | 5.0 |
| TCMS-16 | 964.2 | 4.90 | 939.9 | 11.9 | 6.7 | 6.0 | 10.7 | 9.0 |
| TCMS-36 | 932.1 | 1.4 | 742.7 | 20.3 | 5.0 | 4.7 | 6.7 | 5.7 |
| TCMS-43 | 1030.8 | 12.1 | 799.1 | 22.5 | 4.3 | 3.7 | 4.3 | 3.7 |
| TCMS-9 | 970.0 | 5.5 | 829.9 | 14.4 | 6.0 | 5.0 | 7.7 | 7.0 |
| TCMS-65 | 1011.7 | 10.1 | 769.4 | 24.0 | 4.0 | 3.3 | 5.0 | 4.0 |
| Th-56 | 1042.5 | 13.4 | 873.6 | 16.2 | 6.3 | 5.7 | 14.3 | 12.3 |
| Th-69 | 989.2 | 7.6 | 804.2 | 18.7 | 4.0 | 3.3 | 10.3 | 9.0 |
| Th-75 | 987.9 | 7.4 | 840.7 | 14.91 | 4.0 | 3.0 | 8.7 | 8.0 |
| Th-82 | 986.7 | 7.3 | 848.1 | 14.0 | 4.0 | 3.0 | 3.7 | 4.0 |
| Th-89 | 987.1 | 7.4 | 828.0 | 16.1 | 5.0 | 4.7 | 3.0 | 2.0 |
| Th-14 | 1115.0 | 21.3 | 991.0 | 11.1 | 6.3 | 5.7 | 7.0 | 6.7 |
| **Th-3** | 1090.4 | 18.6 | 984.2 | **9.7** | **8.7** | **6.7** | 18.3 | 18.0 |
| **Th-17** | 1183.3 | **28.7** | 980.0 | 17.1 | 6.3 | 5.3 | 11.0 | 9.7 |
| Control | 919.2 | - | 660.8 | 28.1 | 2.3 | 1.7 | 1.0 | 1.0 |
| **CD (0.05)** | **234.36** | **--** | **173.30** | **--** | **2.0** | **1.6** | **3.2** | **2.9** |
| **CV (%)** | 13.07 | -- | 12.25 | -- | 23.3 | 22.3 | 21.1 | 22.1 |

## 3. Chickpea

A field experiment was conducted at Crop Research Centre, GBPUA&T, Pantnagar during Rabi 2013-14 to evaluate the efficacy of potential isolates of *Trichoderma* on Chickpea (PG-186) crop health. Sowing was done on October 31, 2013. The different promising *Trichoderma* isolates were applied as soil application (1kg talc based formulation of *Trichoderma* /100 kg vermicompost/acre), as seed treatment @ 10 g/kg seeds and as two foliar sprays @10 g/lit at 45 & 90 days after sowing. The experiment was laid in a randomized block design in three replications with a plot size of 3x3 $m^2$.

Data presented in **Table 40** indicates significantly maximum per cent increase in germination over control in isolates TCMS-5 (24.6%) followed by TCMS-14a (23.2%) and

Th-14 (23.0%) over control. At 90 DAS least mortality was recorded with TCMS-5 (5.9%) followed by Th-14 (6.3%) and Th-17 (7.0%) as compared to control (15.4%).

Significantly maximum population of *Trichoderma* in rhizosphere and rhizoplane (45 DAS) was observed in TCMS 2 ($13.0x10^3$ & $34x10^2$ CFU/g) followed by TCMS 4 ($11.9x10^3$ & $20.3x10^2$ CFU/g) and Th-56 ($11.7x10^3$ & $15.0x10^2$ CFU/g) respectively. At 90 DAS significantly maximum population of *Trichoderma* in rhizosphere and rhizoplane was found in TCMS 2 ($10.7x10^3$ & $29.0x10^2$ CFU/g) followed by TCMS 4 ($9.9x10^3$ & $18.3$ $x10^2$ CFU/g).

The crop was very good up to 100 DAS, but due to three heavy rains during II$^{nd}$ fortnight of Feb. at the interval of 4-5 days the crop was severely affected. The trials need to be repeated in the next year, 2014-15 for confirmation of the results.

**Table 40: Effect of selected *Trichoderma* isolates on disease and growth parameter of chick pea crop variety (PG-186)**

| ***Trichoderma* isolate** | **Plant stand (45 d)** | **Increase over check (%)** | **Plant stand (90 d)** | **Mortality (%)** | **Population dynamics** | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **R.sphere pop. CFU($x10^3$/g)** | | **R.plane pop. CFU($x10^2$/g)** | |
| | | | | | **45 DAS** | **90 DAS** | **45DAS** | **90 DAS** |
| TCMS-2 | 390.5 | 20.2 | 361.0 | 7.5 | 13.0 | 10.7 | 34.0 | 29.0 |
| TCMS-4 | 380.0 | 16.9 | 343.0 | 9.7 | 11.9 | 9.9 | 20.3 | 18.3 |
| TCMS-5 | 405.0 | 24.6 | 381.0 | 5.9 | 5.3 | 4.3 | 10.7 | 9.3 |
| TCMS-14a | 400.5 | 23.2 | 365.0 | 8.8 | 2.3 | 2.0 | 20.0 | 18.7 |
| TCMS-14b | 376.0 | 15.6 | 344.0 | 8.5 | 11.0 | 9.7 | 17.0 | 15.7 |
| TCMS-15 | 349.0 | 7.30 | 324.0 | 7.2 | 2.3 | 1.7 | 5.0 | 4.0 |
| TCMS-16 | 395.0 | 21.5 | 340.0 | 13.9 | 4.3 | 3.3 | 12.0 | 11.0 |
| TCMS-36 | 353.0 | 8.6 | 300.0 | 15.0 | 5.7 | 5.3 | 7.3 | 6.7 |
| TCMS-43 | 364.5 | 12.2 | 326.0 | 10.6 | 3.0 | 2.3 | 3.7 | 4.0 |
| TCMS-9 | 330.0 | 1.5 | 305.0 | 7.5 | 8.3 | 8.0 | 9.3 | 8.0 |
| TCMS-65 | 342.5 | 5.4 | 311.2 | 9.1 | 7.7 | 6.0 | 4.3 | 5.3 |
| Th-56 | 368.5 | 13.4 | 325.0 | 11.8 | 11.7 | 11.0 | 15.0 | 13.3 |
| Th-69 | 349.5 | 7.5 | 300.0 | 14.1 | 3.0 | 2.3 | 4.7 | 4.0 |
| Th-75 | 376.0 | 15.7 | 325.0 | 13.7 | 4.7 | 3.7 | 12.3 | 11.3 |
| Th-82 | 367.5 | 13.0 | 327.0 | 11.0 | 3.0 | 2.3 | 3.0 | 2.7 |
| Th-89 | 354.0 | 8.9 | 320.0 | 9.6 | 2.7 | 2.3 | 2.3 | 2.0 |
| Th-14 | 400.0 | 23.0 | 375.0 | 6.3 | 3.3 | 3.0 | 8.3 | 7.7 |
| Th-3 | 364.0 | 12.0 | 333.0 | 8.5 | 5.0 | 4.3 | 6.3 | 5.7 |
| Th-17 | 371.0 | 14.2 | 345.0 | 7.0 | 2.7 | 1.7 | 9.3 | 8.3 |
| Control | 325.0 | 0.00 | 275.0 | 15.4 | 1.7 | 1.3 | 0.7 | 0.3 |
| **CD (0.05)** | **64.83** | **--** | **51.81** | **--** | **2.0** | **2.1** | **3.7** | **3.1** |
| CV (%) | 14.34 | -- | 12.88 | -- | 22.8 | 27.6 | 21.8 | 20.8 |

**5. Large scale field demonstration of bio-control technologies (GBPUAT).**

**1. Rice**

During kharif season 2013 large scale field demonstration of bio-control technologies was conducted at different villages of district Nainital on the field of 31 farmers covering an area of 42 hectares with the plot size ranging from 0.25-3.0 hectares. Pant bio-agent-3 (mixture of *T. harzianum* Th-14 and *P. fluorescens* PBAP-173) was applied as soil application with FYM/vermicompost (5-10 tons/ha) colonized with PBAT-3 followed by seed treatment (10 g/kg seed), seedling dip treatment (10g/lit. water) and need-based foliar sprays of PBAT-3 (10g/lit. water). During the crop season there was major outbreak of Stem borer. Among diseases, occurrence of brown spot (*Drechslera oryzae*), sheath blight (*Rhizoctonia solani*) and bacterial blight (*Xanthomonas campstris* pv *oryzae*) has been observed.

**By adopting bio-control technologies an average yield of 45q/ha was obtained as compared to conventional farmer's practices (38 q/h).**

**2. Tomato**

Field demonstrations were laid at 60 farmers fields at village Golapar-Chorgalia, Haldwani District Nainital covering an area of about 100 acres. Pant bioagent-3 (PBAT-3) was applied as soil application with FYM/ vermicompost (5-10 tons/ha) colonized with PBAT-3, followed by seed treatment (10 g/kg seed), seedling dip treatment (10g/lit. water) and need-based 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.

**3. Pea**

During Rabi 2013-14 large scale field demonstrations of bio control technologies was conducted on pea variety Arkil, at 20 farmer's fields at Golapar-Chorgalia, Haldwani District Nainital covering an area of about 30 acres. The Pant bioagent-3 (PBAT-3) was applied as soil application with FYM/ vermicompost (5-10 tons/ha) colonized with PBAT-3 followed by seed biopriming (10 g/kg seed). During this year the farmers used bio-control agent for the management of wilt problems. Due to the successive application of bio-control the farmers got desired yield of green pea of 35-45 q/acre as compared to conventional farmers practices (25-30 q/acre).

**6. Dose response of different fungicides with biocontrol agents for seed treatment (GBPUAT).**

Nine fungicides, mancozeb (75WP), Captaf (50WP), Benomyl (50WP), Thiram (75WP), chlorothalonil (75WP), thiophanate methyl (70WP), Bayleton (25WP), copper hydroxide (46.1WP) and ipridione (50WP) were evaluated at 25, 50, 100, 250 µg a.i./ml for their compatibility with *T. harzianum*. Among tested fungicides, mancozeb, Captaf, Thiram, chlorothalonil and copper hydroxide were found compatible with the test antagonist up to 100 µg a.i. /ml, as these fungicides did not adversely affect the growth of test antagonist. The growth inhibition by these fungicides observed was from 2.3-39.1 per cent only, mancozeb was found highly compatible up to 250 µg a.i./ml, while Captaf, chlorothalonil and copper hydroxide were also found compatible at 250 µg a.i./ml, as these fungicides inhibited the *Trichoderma* growth from 45.0-56.8 per cent. However, Benomyl, thiophanate methyl, Bayleton and ipridione were found incompatible even at 25 µg a.i./ml, as they adversely inhibited the growth of the test antagonist to a greater extent, ranged from 81.5-100.0 per cent (**Table 41**). The fungicides found to be compatible with *Trichoderma* will be further tested after seed treatment. The new green fungicides will also be tested for their compatibility with *Trichoderma* in the next year, 2014-15. The fungicides found to be compatible will be tested for the management of soil borne and foliar diseases of rice and chickpea in the next year, 2014-15.

**Table 41: Compatibility of different fungicides with *T. harzianum***

| Fungicide | Concentration (μg a. i. /ml) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 25 | | 50 | | 100 | | 250 | |
| | **RG (mm) | *Inhibition (%) | **RG (mm) | *Inhibition (%) | **RG (mm) | *Inhibition (%) | **RG (mm) | **Inhibition (%) |
| Mancozeb (75 WP) | 81.0 | 4.7 | 85.0 | 0.0 | 82.0 | 2.3 | 79.6 | 6.2 |
| Captaf (50 WP) | 85.0 | 0.0 | 83.3 | 1.2 | 63.0 | 25.0 | 36.6 | 56.8 |
| Benomyl (50 WP) | 0.0 | 100.0 | 0.0 | 100.0 | 0.0 | 100.0 | 0.0 | 100.0 |
| Thiram (75 WP) | 81.6 | 8.1 | 80.3 | 5.4 | 51.6 | 39.1 | 27.6 | 39.1 |
| Chlorothalonil (75 WP) | 74.0 | 12.8 | 73.6 | 25.8 | 63.0 | 32.1 | 40.6 | 52.1 |
| Thiophanate methyl (75 WP) | 1.6 | 98.0 | 1.3 | 98.4 | 0.0 | 100.0 | 0.0 | 100.0 |
| Bayleton (25 WP) | 15.6 | 81.5 | 17.3 | 91.7 | 0.0 | 100.0 | 0.0 | 100.0 |
| Copper hydroxide (46.1 WP) | 82.6 | 1.9 | 82.3 | 3.1 | 77.6 | 8.5 | 46.6 | 45.0 |
| Ipridione (50 WP) | 33.0 | 83.1 | 28.3 | 87.0 | 8.3 | 90.1 | 1.6 | 98.0 |
| Check | 85.0 | – | 85.0 | – | 85.0 | – | 85.0 | – |

| | Fungicides | Concentrations | Fungicides x concentrations |
|---|---|---|---|
| *Per cent inhibition | | | |
| CD (0.05) | 2.9 | 1.8 | 5.9 |
| CV (%) | 8.4 | | |
| **Radial growth | | | |
| CD (0.05) | 2.8 | 1.6 | 5.0 |
| CV (%) | 7.0 | | |

**7. Efficacy of *Trichoderma* (Th-14) on threshold level of soil borne plant pathogens in glasshouse (GBPUAT).**

Three fungal pathogens viz. *Fusarium, Rhizoctonia* and *Sclerotinia* were isolated from chickpea. The fungal pathogens were purified and identified based on morphological characteristics. The pure culture of the pathogens is maintained on PDA slants stored at $4^0$C in refrigerator. The study on the efficacy of the Th-14 on threshold level of these isolated pathogens will be done during the next year, 2014-15.

**8. Evaluation of fungal and bacterial antagonists against collar rot of groundnut caused by *Aspergillus* spp. and *Sclerotium rolfsii* (AAU-A)**

The experiment was laid out on Agronomy farm during kharif 2013 as well as 2012 but adequate infection of Groundnut collar rot was not noticed in experimental plots and hence valid inference could not be drawn. Since for the past two years, the collar rot was not observed and hence, the trial may please be dropped.

## 9. Management of brinjal bacterial wilt with an isolate of *Pseudomonas florescence* (CAU)

The susceptible variety Anamika was used in the experiment. The seedlings were raised in the month of September and 30 days old seedlings were transplanted in October. The experimental field was laid out in randomized block design with a plot size of (12.6X 6.6) m and crop was transplanted at (60X60) cm spacing. A total eight treatments including an untreated control *viz*., intercropping with marigold (one row after every nine rows of brinjal and border), mustard oil cakes @ 5q per ha as soil amendments, seedlings root dip with CHF*Pf*-1 (a formulation prepared with a local strain of *Pseudomonas fluorescens* $2x10^8$ cfu per gm ) @25g / liter of water dipping for 30 minutes before transplanting, soil drenching with CHF*Pf*-1 @ 2.5g / litre of water at 20 days after transplanting (DAT), seedlings root dip + soil drenching with CHF*Pf*-1, soil drenching with streptocycline (streptomicin sulphate 90 % + tetracycline hydrochloride 10%) of Hindustan Antibiotics Ltd, Pune, India @ 400ppm at 20 DAT, soil drenching of bleaching powder of J. Industries, Guwahati, India @ 5 gm/ litre of water at 20 DAT and untreated control were evaluated. Three replications were maintained for each treatment. The observations on bacterial wilt incidence were recorded for every 10 days after transplantation. The wilted plants were first confirmed with oozed test and the confirmed plants were recorded and converted into per cent wilted plants. The plant characters i.e. plant height was recorded at 60 and 80 days after transplanting. The number of fruits and weight of the fruits in each plucking were recorded from 10 marked plants in each plot and average number and weight of fruit/plant was worked out. The yield per ha for each treatment were calculated based on the survived plants, average number and weight of fruit/plant.

All the treatments showed a significantly lower wilt incidence of bacterial wilt disease than the untreated control (**Table 42**). The lowest incidence with 14.75% wilted plant was recorded in the plot treated with seedling root dip + soil drenching with CHF*Pf*-1 and it was on par with soil drenching with CHF*Pf*-1 (18.25% wilted plants). Soil drenching with CHF*Pf*-1 was comparable with soil drenching with streptomycine (19.83% wilted plants), soil application with mustard oil cake (20.59% wilted plants), soil drenching with bleaching powder (21.00% wilted plants) and seedling root dip with CHF*Pf*-1 (23.58% wilted plants). Intercropping with marigold recorded a 42.39% wilted plants. The highest average plant height (68. 29 cm), highest average number of fruit per plant (9.14 fruits) and average fruit weight (114.58g/fruit) was recorded in seedling root dip + soil drenching with CHF*Pf*-1 and it was closely followed by soil drenching with CHF*Pf*-1 with 67.84cm plant height, 8.75 fruits and 113.26g/fruit, in terms of average plant height, average number of fruits/ plant and average weight of fruit, respectively. The highest yield per ha was recorded in treatment with seedling root dip + soil drenching with CHF*Pf*-1 (244.55q/ha) and it was comparable with soil drenching with CHF*Pf*-1 (222.14q/ha). The yield of soil application with mustard oil cake (190.60q/ha), soil drenching with CHF*Pf*-1 (185.94q/ha), soil drenching with bleaching powder (181.27q/ha) and soil drenching with streptomycine (178.67q/ha) were on par. The intercropping with marigold recorded only 96.74q/ha.

**Table 42: Bio-efficacy of *Pseudomonas fluorescens* against bacterial wilt of brinjal**

| **Treatments** | **Per cent wilt incidence** | **Plant height (cm)** | **No. of Fruits /Plants** | **Fruit weight (g)** | **Yield (q /ha)** |
|---|---|---|---|---|---|
| Marigold (after every 9 rows of brinjal and borders) | 42.39 (40.58)[c] | 64.44[e] | 6.99[d] | 108.16[de] | 96.74e |
| Mustard oil cakes @5q/ha as soil amendment | 20.59 (26.87)[b] | 67.24[abc] | 7.93[b] | 110.78[bcd] | 190.60b |
| Soil drenching with *P. fluorescens* @2.5g/litre of water | **18.25 (25.19)[ab]** | **67.84[ab]** | **8.75[a]** | **113.26[ab]** | **222.14a** |
| Seedlings root dip with *P. fluorescens* @25g/ litre of water | 23.58 (28.95)[b] | 66.64[bc] | 7.97[b] | 111.46[bc] | 185.94b |
| Seedlings root dip with *P. fluorescens* @25g/ litre of water + soil drenching with *P. fluorescens* @2.5g/litre of water at 20 DAT | **14.75 (22.40)[a]** | **68.29[a]** | **9.14[a]** | **114.58[a]** | **244.55a** |
| Streptomicin sulphate 90 % + Teracycline hydrochloride 10% @200ppm soil drenching at 20 DAT | 19.83 (26.41)[b] | 65.71[cde] | 7.44[bcd] | 109.42[cde] | 178.67b |
| Bleaching powder @ 5g/litre of water soil drenching at 20 DAT | 21.00 (27.07)[b] | 66.18[cd] | 7.69[bc] | 109.44[cde] | 181.27b |
| Untreated control | 60.17 (50.02)[d] | 64.90[de] | 7.27[cd] | 107.74[e] | 85.68c |
| SEd ± | 2.33 | 0.76 | 0.27 | 1.36 | 10.58 |
| CD at (P=0.05%) | 5.67 | 1.62 | 0.57 | 2.88 | 22.43 |
| CV (%) | 9.97 | 1.41 | 4.19 | 1.50 | 7.48 |

***Figures in parentheses are angular transformed values.**

## 2.3. Biological suppression of pests of Sugarcane

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

### ANGRAU - Hyderabad

District Agriculture Advisory and Transfer of Technology Centres (DAATTCs) were involved. As per the reports, SWA populations are rarely noticed in sugarcane belt of A.P. Sporadic incidence was noticed in Chittoor and adjoining areas of southern Andhra Pradesh.

### MPKV - Pune

The incidence of sugarcane woolly aphid (SWA) and its natural enemies (*Dipha aphidivora, Micromus igorotus, Encarsia flavoscutellum,* syrphids, and spiders) were recorded from five agro-ecological zones of western Maharashtra covering Pune, Satara, Sangli, Kolhapur, Solapur, Ahmednagar, Nashik, Nandurbar, Dhule and Jalgaon 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 from each plot during crop growth period.

The sugarcane fields the pest incidence was recorded at low lying areas near riverside and canal side in Pune region from Mulshi, Khed, Ambegaon, Junnar, Bhor, Babhulgaon and padasthal in Indapur and Malegaon in Baramati tahasils in Pune district, Vadgaon Haveli, Hamdabaj, Kidgaon, Nele in Satara. The average pest incidence and intensity were 0.88 per cent and 1.41, respectively. The natural enemies recorded in the SWA infested fields were mainly predators like *Dipha aphidivora* (0.6-2.6 larvae/leaf), *Micromus igorotus* (0.9-5.3 grubs/leaf), syrphids, *Eupoderes confractor* (0.01-0.9 larvae/leaf) and spider (0.3-0.8 per leaf) during August to November, 2013 on seven to 10 month-old canes (**Table 43**). The parasitoid, *Encarsia flavoscutellum* was observed in Pune and Satara districts. These natural enemies were found to be distributed and established well in sugarcane fields and regulated the SWA incidence in western Maharashtra.

**Table 43: Effect of natural enemies on incidence of sugarcane woolly aphids in Maharashtra**

| Districts surveyed | SWA incidence (%) | Pest intensity rating (1-6) | Natural enemies/leaf | | |
|---|---|---|---|---|---|
| | | | ***D. aphidivora*** | ***M. igorotus*** | ***E. flavoscutellum*** |
| Pune | 0.93 | 1.2 | 1.6 | 4.3 | 7.4 |
| Satara | 0.86 | 1.3 | 1.1 | 3.9 | 13.0 |
| Sangli | 0.92 | 1.2 | 2.0 | 4.2 | 10.6 |
| Kolhapur | 0.93 | 1.6 | 2.6 | 3.6 | 4.0 |
| Ahmednagar | 0.46 | 1.2 | 0.6 | 1.1 | 2.4 |
| Solapur | 2.71 | 2.5 | 0.8 | 5.3 | 30.6 |
| Jalgaon | 0.65 | 1.1 | 1.2 | 1.1 | 1.2 |
| Dhule | 0.42 | 1.2 | 0.7 | 0.9 | 0.0 |
| Nandurbar | 0.60 | 1.4 | 0.6 | 1.4 | 2.2 |
| Nashik | 0.31 | 1.3 | 1.5 | 1.7 | 0.0 |
| Average | 0.88 (0.31-2.71) | 1.41 (1.1-2.5) | 1.27 (0.6-2.6) | 2.35 (0.9-5.3) | 7.14 (1.2-30.6) |

**TNAU - Coimbatore**

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

Per cent incidence of SWA, pest intensity rating and natural enemies population on leaf at five spots and five clumps/ spot were recorded at monthly interval during crop growth period. The sugarcane woolly aphid incidence and occurrence of natural enemies were recorded from July 2013 to February 2014 from four major sugarcane growing districts of Tamil Nadu *viz.*, Coimbatore, Erode, Tiruppur and Karur.

In all the four districts surveyed, the incidence of SWA was at low intensity and a grade of 0-2 was observed during July 13 to February 14 (**Table 44 and 45**). The SWA was noticed in patches and the occurrence of *Dipha aphidivora, Micromus igorotus* and *Encarsia flavoscutellum* was observed along with the population of SWA. In general, an incidence of up to 14.8 SWA/ 6.25 sq.cm leaf area was observed during July to December 2013. Then the incidence was gradually declined to less than 4.2 SWA/ 6.25 sq.cm leaf area during February 2014.

**Table 44: Mean incidence of SWA and its natural enemies in different zones of Tamil Nadu**

| Districts surveyed | July 2013 | | | | August 2013 | | | | September 2013 | | | | October 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *SWA/ 6.25 sq.cm* | *Dipha/ leaf* | *Encarsia/ leaf* | *Micromus/ leaf* | *SWA/ 6.25 sq.cm* | *Dipha/ leaf* | *Encarsia/ leaf* | *Micromus/ leaf* | *SWA/ 6.25 sq.cm* | *Dipha/ leaf* | *Encarsia/ leaf* | *Micromus/ leaf* | *SWA/ 6.25 sq.cm* | *Dipha/ leaf* | *Encarsia/ leaf* | *Micromus/ leaf* |
| Erode | 12.6 | 1.0 | 0.0 | 1.2 | 4.8 | 0.0 | 0.0 | 0.2 | 2.4 | 0.2 | 0.0 | 0.4 | 11.2 | 0.4 | 4.2 | 1.0 |
| Tiruppur | 8.6 | 0.4 | 0.0 | 0.6 | 6.2 | 0.2 | 0.0 | 0.0 | 6.4 | 0.0 | 0.6 | 0.0 | 18.0 | 1.0 | 5.8 | 1.2 |
| Coimbatore | 12.8 | 0.2 | 0.0 | 0.4 | 9.8 | 0.6 | 0.0 | 0.2 | 8.4 | 0.0 | 0.2 | 0.8 | 5.0 | 0.2 | 0.2 | 0.0 |
| Karur | 14.2 | 0.4 | 0.0 | 0.0 | 8.2 | 0.2 | 0.0 | 0.4 | 4.6 | 0.0 | 0.6 | 0.0 | 4.0 | 0.0 | 1.2 | 0.2 |

| Districts surveyed | November 2013 | | | | December 2013 | | | | January 2014 | | | | February 2014 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SWA/ 6.25 sq.cm | Dipha/ leaf | Encarsia/ leaf | Micromus/ leaf | SWA/ 6.25 sq.cm | Dipha/ leaf | Encarsia/ leaf | Micromus/ leaf | SWA/6.25sq.cm | Dipha/ leaf | Encarsia/ leaf | Micromus/ leaf | SWA/ 6.25 sq.cm | Dipha/ leaf | Encarsia/ leaf | Micromus/ leaf |
| Erode | 16.6 | 0.6 | 2.0 | 0.6 | 18.0 | 1.2 | 3.0 | 0.8 | 6.2 | 0.2 | 0.0 | 0.4 | 2.8 | 0.0 | 0.0 | 0.0 |
| Tiruppur | 10.4 | 1.2 | 0.0 | 0.0 | 12.8 | 0.6 | 2.0 | 0.4 | 8.2 | 0.0 | 0.0 | 0.2 | 4.2 | 0.0 | 0.0 | 0.0 |
| Coimbatore | 14.8 | 0.2 | 3.6 | 0.4 | 6.4 | 0.0 | 4.8 | 1.2 | 4.0 | 0.0 | 2.0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.2 |
| Karur | 8.4 | 0.0 | 0.0 | 0.4 | 14.0 | 1.4 | 0.0 | 0.0 | 6.0 | 0.4 | 0.0 | 0.0 | 3.8 | 0.2 | 0.0 | 0.0 |

**Table 45. Mean incidence of sugarcane woolly aphid (Intensity rating) in different zones of Tamil Nadu**

| Districts surveyed | July 2013 | | August 2013 | | September 2013 | | October 2013 | | November 2013 | | December 2013 | | January 2014 | | February 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % incidence | Grade | % incidence | Grade | % incidence | Grade | % incidence | Grade | % incidence | Grade | % incidence | Grade | % incidence | Grade | % incidence | Grade |
| Erode | 12.6 | 2.0 | 4.8 | 1.0 | 2.4 | 1.0 | 11.2 | 2.0 | 16.6 | 2.0 | 18.0 | 2.0 | 6.2 | 1.0 | 2.8 | 1.0 |
| Tiruppur | 8.6 | 1.0 | 6.2 | 1.0 | 6.4 | 1.0 | 18.0 | 2.0 | 10.4 | 2.0 | 12.8 | 2.0 | 8.2 | 1.0 | 4.2 | 1.0 |
| Coimbatore | 12.8 | 2.0 | 9.8 | 1.0 | 8.4 | 1.0 | 5.0 | 1.0 | 14.8 | 2.0 | 6.4 | 1.0 | 4.0 | 1.0 | 1.4 | 1.0 |
| Karur | 14.2 | 2.0 | 8.2 | 1.0 | 4.6 | 1.0 | 4.0 | 1.0 | 8.4 | 1.0 | 14.0 | 2.0 | 6.0 | 1.0 | 3.8 | 1.0 |

**UAS-Raichur**

Roving survey was made in North Karnataka to monitor the incidence of SWA in Bidar, Gulbarga, Raichur, Bellary and Koppal district. Overall the incidence of SWA ranged from 5 to 10 per cent in Bidar, Gulbarga and Bellary district during December –March 2014, while its incidence was nil in Raichur and Koppal districts.

**2. Field evaluation of *T. chilonis* produced using Eri-silk worm eggs as factitious host against early shoot borer of Sugarcane (NBAII)**

The study was conducted during 2011 to 2013 in three trials including:

a. VC Farm Mandya (four and half month old crop of sugarcane variety CO 62175) targeting internode borer pest *Chilo sacchariphagus indicus* (8 releases at weekly intervals)
b. Farmer's (1) field at Madla (variety Mixture of CO 86032 and CO 62175 - 45 days old crop with early shoot borer incidence of 61.11% and 31.65%) targeting early shoot borer *Chilo infuscatellus* and internode borer *Chilo sacchariphagus indicus* (14 releases at weekly intervals) and
c. Farmer's (2) field at Madla (20 days old crop of variety CO 62175) targeting early shoot borer *Chilo infuscatellus* and internode borer *Chilo sacchariphagus indicus* (16 releases at weekly intervals).

**Treatment plots:**
1. Plot where *T. chilonis* reared on Eri silkworm eggs was released;
2. Plot where *T. chilonis* reared on *Corycra cephalonica* was released and
3. Control plot where no release of parasitoids were made. The different plots were 500 meters apart from each other. Field recovery of the parasitoid was measured by collecting the natural host eggs and also by using trap cards / sentinel cards.

**Observations:**

Percent clumps infested and percent plants infested per clump at 5 random spots in each subplot i.e. at 20 spots in one acre were recorded during the releases and once post release.

Destructive sampling was done and percent pest incidence, percent pest intensity and infestation index were calculated using the formula

Pest incidence (%) = No. of canes effected / Total no. of canes observed X 100

Pest intensity (%) = No. of internodes effected / Total no. of internodes observed X 100

Infestation Index = Per cent pest incidence X Per cent intensity / 100

**Statistical analysis:**

Data of Pest incidence (%), pest intensity (%) and parasitism (%) by *T. chilonis* was subjected to angular transformation. Infestation Index data was subjected to square root transformation. Transformed and pooled data was subjected to ANOVA single factor using MS Excel programme and CD values were calculated.

**Results:**

Analysis of pooled data (**Table 46**) indicated that the releases of *T. chilonis* produced (by using Eri silkworm eggs and *Corcyra cephalonica* eggs) could significantly reduce the pest incidence, pest intensity and infestation index than that in control plots. Percent parasitism recorded using sentinel card in control plot was significantly low (0.65 %) in comparison to that recorded in treatment plots, the values being 9.79 and 7.65 % respectively. Both the treatments were on par with each other.

The studies indicated that the performance of *T. chilonis* reared on eri silkworm eggs was comparable to *T. chilonis* reared on *Corcyra cephalonica* eggs. However, there are some distinct advantages by rearing *Trichogramma* on ESW eggs. When reared on ESW eggs, significantly more number of parasitoid adults (about 20) could emerge per egg, this method of rearing can be adopted for farm level production of *Trichogramma*, there was no predation of the parasitized ESW eggs, prolonged emergence of the adults from the cards enabling continuous availability of parasitoids in the field and lower production cost.

**Table 46: Pooled analysis data of Percent pest incidence, Percent pest intensity, Infestation index and Percent parasitism by *T. chilonis* in different treatments during the period 2011 – 2013.**

| Treatments | Pest incidence (%) | Pest intensity (%) | Infestation Index | Parasitism (%) |
|---|---|---|---|---|
| Control plot | 84.4 (71.35)[b] | 9.7 (18.3)[b] | 7.86 (2.81)[b] | 0.65 (5.63)[b] |
| *T. chilonis* reared on Esw eggs released plot | 60 (53.9)[a] | 5.4 (12.9)[a] | 3.09 (1.74)[a] | 9.79 (16.41)[a] |
| *T. chilonis* reared on *Corcyra* eggs released plot | 54.7 (48.3)[a] | 6.6 (13.4)[a] | 3.34 (1.66)[a] | 7.65 (15.27)[a] |
| CD at 1% | 13.8 | 3.5 | 0.6 | 2.83 |

## 2.4. Cotton

### 1. Monitoring biodiversity and outbreaks for invasive mealy bugs on cotton (ANGRAU, MPKV, PAU, TNAU).

### ANGRAU - Hyderabad

Fortnightly surveys were conducted for mealy bug incidence. Infested plant parts were brought back to the laboratory and held under caged conditions for emergence of natural enemies. Alternate host plants, if any, were also recorded.

Surveys conducted in *Kharif* season in adjoining districts of Mahaboobnagar, Adilabad, Khammam and Nalgonda revealed that cotton was mainly affected by *Phenococcus solenopsis* and *Maconellicoccus hirsutus* to certain extent (**Table 47**).

**Table 47: Incidence of mealy bugs in cotton growing areas of *Telangana* State**

| Location | Number /branch | | Predominant species |
|---|---|---|---|
| | ***Phenococcus solenopsis*** | ***Maconellicoccus hirsutus*** | |
| L1 | 74 | 42 | **Nalgonda Dt.**<br>*Phenacoccus solenopsis*<br>*Maconellicoccus hirsutus,*<br>*Paracoccus marginatus*<br>**Adilabad Dt.**<br>*Maconellicoccus hirsutus,*<br>**Mahboobnagar Dt.**<br>*Phenacoccus solenopsis*<br>*Maconellicoccus hirsutus,*<br>**Khammam Dt.**<br>*Maconellicoccus hirsutus,*<br>*Paracoccus marginatus* |
| L 2 | 89 | 36 | |
| L3 | 93 | 39 | |

### MPKV - Pune

The incidence of cotton mealy bug, *Phenacoccus solenopsis* Tinsley and occurrence of natural enemies were monitored at fortnightly interval from the day of germination till harvest on the variety Ankur Bollgard II. All the recommended crop management practices except pesticide application were followed to maintain healthy crop growth. A low incidence of mealy bug was noticed from 2$^{nd}$ fortnight of August, 2013 to December, 2013 in the experimental plot. Besides, survey was also carried out by visiting farmers' fields in cotton growing areas of western Maharashtra. The pest incidence was low in the months of November, December 2013 in Jalgaon, Dhule and Nandurbar region during late crop stage. The parasitism of *A. bambawalei* was found common on cotton, Parthenium, Hibiscus and marigold. Other natural enemies recorded were *Anagyrus* sp., *Coccinella* sp., *Menochilus* sp., *Scymnus* sp., *Chrysoperla* sp. and spiders.

**PAU - Ludhiana**

Regular survey of cotton crop was conducted during July to October, 2013. The different locations of cotton belt of Punjab were regularly visited at fortnightly interval to record incidence of mealy bug, *Phenococcus solenopsis* and its natural enemies. During the survey negligible incidence of mealy bug and its natural enemies was reported throughout the cropping period of cotton and there was no major outbreak of the pest. However, coccinellid predators such as *Brumus suturalis, C. sexmaculata, Scymnus coccivora* and green lace wing, *Chrysoperla zastrowi silliemi* were noticed and their population varied from 0.3 to 2.2 predators per plant.

**TNAU - Coimbatore**

Surveys conducted in Coimbatore, Erode, Tiruppur and Salem districts of Tamil Nadu on cotton and other host plants indicated that the incidence of four species of mealybugs *viz.*, *Paracoccus marginatus*, *Maconellicoccus hirsutus*, *Phenacoccus solenapsis* and *Ferrisia virgata* (Table 48 & 49) on cotton and other alternate host plants observed. *Maconellicoccus hirsutus* was predominant species recorded on grapevine, cotton, jatropa, *bhendi*, hibiscus and mulberry than the other three species. *Phenacoccus solenapsis* and *Ferrisia virgata* were recorded at low level on cotton. *Paracoccus marginatus* was observed on papaya, cotton, tapioca, mulberry, jatropa and other host plants (Table 48 & 49). The natural enemies *viz., Acerophagus papayae, Cryptolaemus montrouzieri, Scymnus coccivora, Spalgisepius, Coccinella septumpunctata, Mallada*sp, *Chrysoperla zastrowi sillemi* and *Menochilus sexmaculatus* were recorded on different species of mealybugs in the surveyed cotton fields (**Table 48 &49**).

**Table 48: Cotton mealybug and their natural enemies**

| Sl. No. | Species of Mealy bug | Alternate Host Plants | Natural enemies recorded |
|---|---|---|---|
| 1 | *Maconellicoccus hirsutus* | Cotton, bhendi, grapevine, guava, hibiscus, mulberry | *Scymnus coccivora* (Coleoptera: Coccinellidae)<br>*Cryptolaemus montrouzieri* (Coleoptera: Coccinellidae)<br>*Mallada*sp (Neuroptera: Chrysopidae)<br>*Spalgis epius*(Lycaenidae: Lepidoptera) |
| 2 | *Phenacoccus solenapsis* | cotton, sunflower, bhendi, and parthenium, | *Cryptolaemus montrouzieri* (Mulsant)<br>*Coccinella septumpunctata* (Coleoptera: Coccinellidae)<br>*Chrysoperla zastrowi sillemi* Esben- Peterson (Neuroptera: Chrysopidae)<br>*Spalgis epius* (Lycaenidae: Lepidoptera) |
| 3 | *Ferrisia virgata* | Cotton, tapioca, custard apple, guava, | *Scymnus coccivora* Ayyar (Coleoptera: Coccinellidae)<br>*Cryptolaemus montrouzieri* Mulsant<br>*Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae)<br>*Mallada* sp (Neuroptera: Chrysopidae) |
| 4 | *Paracoccus marginatus* | Cotton, Papaya, tapioca, *Jatropha curcas*, mulberry, ladies finger, sunflower, hibiscus, marigold, teak and parthenium, | *Acerophagus papayae* Noyes & Schauff (Hymenoptera: Encyrtidae)<br>*Chrysoperla zastrowi sillemi* Esben- Peterson (Neuroptera: Chrysopidae)<br>*Spalgis epius* Westwood (Lepidoptera: Lycaenidae)<br>*Cryptolaemus montrouzieri* Mulsant<br>*Scymnus coccivora* Ayyar (Coleoptera: Coccinellidae)<br>*Menochilus sexmaculatus* (Fabricius) |

**Table 49: Incidence of mealybugs on various crops and their natural enemies**

| Places surveyed | Crop | Mealybug incidence (%) | | | | Natural Enemy/5 leaves | | |
|---|---|---|---|---|---|---|---|---|
| | | ***Phenacoccus solenapsis*** | ***Paracoccus marginatus*** | ***Ferrisia virgata*** | ***Maconellicoccus hirsutus*** | ***A .papayae*** | ***Cryptolaemus montrouzieri*** | ***Spalgis epius*** |
| Coimbatore | Mulberry | - | 0-6.5 | 0.0 | 2.5-19.0 | 0 – 1.5 | 0 – 2.0 | **1** |
| | Tapioca | - | 4.5-8.5 | 3.0-9.0 | 0.0 | 1.5 - 3 | 1.0 -4.0 | **2** |
| | Cotton | 0.5-3.0 | 0.0-1.5 | 0.0 | 1.5-3.0 | 0 | 0.5-1.5 | **-** |
| | Grapevine | - | 0.0 | 0.0 | 8.5-20.0 | 0 | 3.5 -7.5 | **-** |
| | Jatropa | - | 0.5-4.0 | 0.0 | 2.5-5.5 | 1.0 – 2.0 | 1.0 -2.5 | **-** |
| | Tomato | - | 1.5-4.0 | 0.0 | 0.0 | 0 – 1.5 | 2.0 -2.5 | **-** |
| Tiruppur | Mulberry | - | 3.0-8.5 | 0.0 | 5.0-13.5 | 1.0 -4.0 | 0.5 – 4.5 | **2** |
| | Tapioca | - | 6.5-11.0 | 5.5-12.0 | 0.0-1.5 | 2.5 – 5.5 | 1.0 – 2.5 | **1** |
| | Cotton | 2.5-4.5 | 0.0 | 0.0 | 1.5-3.5 | 0.0 | 0.5 -1.0 | **-** |
| | Bhendi | - | 0.0 | 0.0 | 2.5-5.5 | 0.0 | 0.0 | **-** |
| Erode | Mulberry | - | 1.5-6.0 | 0.0 | 3.5-13.0 | 3.0 -5.5 | 1.0 – 6.5 | **3** |
| | Tapioca | - | 4.0-8.5 | 5.5-14.0 | 1.0-2.5 | 5. 7.5 | 1.5 – 4.5 | **1** |
| | Cotton | 1.0-2.0 | 1.0-3.0 | 0.0-1.5 | 2.5-4.0 | 0 -2.5 | 0.0 -1.0 | **-** |
| | Bhendi | - | 0.0-1.5 | 0.0 | 3.0-8.0 | 0.0 | 0.0 | **-** |
| Salem | Mulberry | - | 1.5-5.0 | 0.0-1.5 | 5.5-18.0 | 3.5 - 6 | 2.5 -6.5 | **-** |
| | Tapioca | - | 3.0-10.5 | 4.5-12.5 | 2.0-3.5 | 3.0 -7.5 | 0.0 – 3.5 | **1** |
| | Cotton | 0.0-1.5 | 3.0-4.5 | 1.5-3.0 | 5.5-7.0 | 1.0 - 2 | 0.5 – 1.5 | **-** |
| | *Bhendi* | - | 1.0-2.5 | 0.0 | 2.0-6.5 | 0.5 – 1.5 | 0.0 – 0.5 | **1** |
| | Jatropa | - | 1.5-4.5 | 0.0 | 3.5-7.5 | 1.0 -3.0 | 1.5 – 3.5 | **2** |

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

**MPKV - Pune**

The *Bt* cotton var. Ankur Bollgard II was raised at the research farm of College of Agriculture, Pune. All the recommended agronomic practices were followed except pesticide application. The sucking pests and natural enemies were recorded from randomly selected but tagged 25 plants from the plot at fortnightly interval. The pest population was recorded from three leaves (top, middle and lower portion) per plant. Similarly, mirids and natural enemies were also recorded on the plant (**Table 50**).

The incidence of aphids was recorded from 2$^{nd}$ fortnight of August 2013 (33$^{rd}$ MW), whereas jassids, thrips and white flies were observed during 1$^{st}$ week of September 2013 (36$^{th}$ MW). Mites were noticed from 4$^{th}$ week of September 2013 (39$^{th}$ MW). Initially, the pests' population was low but its build-up was observed gradually from 40$^{th}$ MW. The peak incidence of jassids and thrips was recorded during 2$^{nd}$ week of November 2013 (46$^{th}$ MW) and white flies in subsequent fortnight (47$^{th}$ and 48$^{th}$ MW). The aphid population was noticed maximum during 3$^{rd}$ week of November 2013 (47$^{th}$ MW). The low incidence of mealy bug was observed in October- November 2013. The natural enemies coccinellids *Menochilus sexmaculata* Fab., *Coccinella septempunctata* Linn. and spiders were recorded from 1st week of October 2013 and their population recorded maximum during 2nd and 3rd week of November 2013 (46th and 47th MW). The chrysopid *Chrysoperla zastrowi sillemi* Esb. observed from the last week of September (39th MW). All these predators were recorded till harvest of the crop. Besides, the farmers' plots were also surveyed from September to December 2013 but the incidence of all these sucking pests was comparatively low in *Bt* cotton plots.

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

| Date of record | Average population / 3 leaves / plant | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Aphids | Jassids | Thrips | White flies | Mealy bug | Mites | Chrysopid | Coccinel lids | Spiders |
| 19/8/2012 | 0.17 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.23 | 0.0 |
| 2/9/2013 | 0.84 | 1.34 | 0.26 | 0.12 | 0.0 | 0.0 | 0.0 | 0.12 | 0.47 |
| 17/9/2013 | 1.21 | 1.85 | 1.92 | 0.26 | 0.8 | 0.0 | 0.8 | 0.33 | 0.83 |
| 30/9/2013 | 2.60 | 2.13 | 1.66 | 0.09 | 0.0 | 0.46 | 1.26 | 0.68 | 1.26 |
| 14/10/2013 | 4.93 | 4.90 | 1.48 | 0.26 | 0.0 | 0.65 | 0.69 | 1.20 | 1.32 |
| 28/10/2013 | 8.69 | 9.52 | 2.47 | 1.49 | 2.09 | 1.51 | 0.42 | 0.48 | 1.22 |
| 11/11/2013 | 13.27 | 12.06 | 3.61 | 1.73 | 1.72 | 1.70 | 1.06 | 1.42 | 1.16 |
| 25/11/2013 | 14.36 | 6.24 | 2.70 | 2.68 | 1.61 | 2.62 | 0.70 | 1.68 | 1.72 |
| 9/12/2013 | 12.93 | 3.57 | 1.88 | 1.44 | 0.97 | 1.68 | 0.36 | 1.18 | 0.83 |
| 23/12/2013 | 4.5 | 1.23 | 0.90 | 0.41 | 0.0 | 0.54 | 0.35 | 0.25 | 0.30 |
| 10/01/2014 | 8.10 | 1.95 | 2.75 | 0.07 | 0.0 | 1.20 | 0.0 | 0.36 | 0.55 |
| 24/01/2014 | 4.52 | 1.25 | 2.61 | 0.33 | 0.0 | 2.27 | 0.09 | 0.59 | 0.68 |

## 2.5. Tobacco

### 1. Survey and collection of biocontrol agents (insect and pathogens) on *Orobanche* (CTRI)

Insects/pathogens were not found on *Orobanche* in the collections studied

### 2. Natural enemies of tobacco aphids infesting different types of tobacco

Different types of tobacco were grown in micro plots of ten plants each and from each plot at weekly intervals and observations were taken on number of coccinellid and syrphid larvae and spiders (**Table 51**).

**Table 51: Mean number of natural enemies in different type of tobacco**

| Treatments | Green lynx spiders | *C. sexmaculata* | *C. repanda* | *Ischiodon scutellare* |
|---|---|---|---|---|
| 1. *N. rustica* | 0.06 (1.02) | 1.96 (1.38) | 0.40 (0.62) | 2.06 (1.40) |
| 2.Chewing | 0.16 (1.07) | 2.06 (1.42) | 1.30 (1.13) | 0.63 (0.77) |
| 3.Lanka Spl | 0.26 (1.12) | 5.63 (2.36) | 2.8 (1.68) | 5.86 (2.41) |
| 4.VT 1158 | 0.12 (1.05) | 3.0 (1.71) | 0.73 (0.82) | 1.66 (1.27) |
| 5.Burley | 0.08 (1.03) | 1.53 (1.22) | 0.86 (0.92) | 1.66 (1.05) |
| 6.Cigar filler | 1.14 (0.80) | 2.26 (1.49) | 1.40 (1.18) | 1.40 (1.17) |
| 7.Natu | 1.04 (0.10) | 3.30 (1.80 ) | 1.66 (1.27) | 3.20 (1.78) |
| SEm | 0.04 | 0.13 | 0.10 | 0.23 |
| P=0.05 | 0.04 | 0.41 | 0.33 | 16.55 |
| CV% | 3.42 | 14.30 | 17.36 | 0.41 |

There were significant differences in the number of spiders per plant in different types of tobacco. Highest number of spiders was found in Lanka followed by chewing, burley, rustica and cigar filler. Least number of spiders was recorded in natu tobacco. Highly significant differences in the number of *C. sexmaculata* per plant in different types of tobacco were observed. Highest number of beetles was found in Lanka followed by natu, VT 1158 cigar filler, chewing and *N. rustica*. Least number of beetles was recorded in burley tobacco. There were highly significant differences in the number of *C. repanda* per plant in different types of tobacco. Highest number of beetles was found in Lanka followed by natu, cigar filler, chewing, burley and VT 1158.Significant differences in the number of *Ischiodon scutellare* per plant in different types of tobacco was observed. Highest number of beetles were found in Lanka followed by natu, cigar filler, chewing, burley and VT 1158.

## 2.6. RICE

### 1. Seasonal abundance of predatory spiders in rice ecosystem (ANGRAU, SKUAST)

### ANGRAU - Hyderabad

Population dynamics of the predatory spiders were worked out using quadrate method for the collection made during morning hours in both Kharif *and* summer seasons. Five fields of paddy were randomly selected from the intense paddy growing area. All the spiders were collected from 10 quadrates (1×1m) from each field at weekly interval. Conspicuous spiders through size colour and webs on the top of the plant were collected first. Later, each plant was searched from top to bottom on leaves, tillers and panicles for spiders. Ground area near each plant within the quadrate was searched. Five pitfall traps on each border (20/field) were installed in each field. Collections were made on alternate days. Adult males and females were identified up to species level with the help of available literature and their relative abundance and other diversity indices were worked out (**Tables 52 and 53**).

**Table 52: Relative abundance of Spiders in Rajendranagar area during *Kharif,* 2013**

| Genus of Spiders Collected | Level of Abundance |
|---|---|
| *Tetragnatha* | 302 |
| *Clubiona* | 181 |
| *Pardosa* | 63 |
| *Oxyopes* | 323 |
| *Neoscona* | 28 |
| *Argiope* | 47 |
| *Thomisus* | 142 |
| *Atypena* | 93 |
| Unknown | 62 |
| **Total spiders collected** | 1241 |
| **Species Diversity (Shannon Weiner index)** | 1.62 |
| **Species richness** | 9 |
| **Species evenness** | 0.79 |
| **Spider density** | 1.59-5.6 spiders/sq.m |

**Table 53: Relative abundance of Spiders in Rajendranagar area during *Rabi,* 2013**

| Genus of Spiders Collected | Level of Abundance |
|---|---|
| *Tetragnatha* | 923 |
| *Pardosa* | 497 |
| *Oxyopes* | 694 |
| *Thomisus* | 65 |
| *Atypena* | 76 |
| **Total spiders collected** | 2255 |
| **Species Diversity (Shannon Weiner index)** | 1.32 |
| **Species richness** | 6 |
| **Species evenness** | 0.76 |
| **Spider density** | 11.12 - 18.56 spiders/sq.m. |

## SKUAST - Srinagar

Thirty four species belongs to 25 genera under 11 families were recorded. Out of 16 species belonged to web building spiders, belongs four families (Araneidae, Tetragnathidae, Linyphiidae, Theridiidae); 14 species of visual hunting group belongs to 6 families (Lycosidae, Salticidae, Oxyopidae, Gnaphosidae, Pisauridae) and 4 species of tactile hunter belongs to 2 families (Thomisidae, Clubionidae) (**Table 54**). The total collected web-spinning spiders are again categorized into four group i.e., orb- spinning spider (family-Araneidae), four jawed spider (family-Tetragnathidae), dwarf spider (family-Linyphiidae), and comb foot spider (family- Theridiidae). The visual hunting spiders are divided into 6 groups i.e., wolf spider (family-Lycosidae), Jumping spider (family-Salticidae), lynx spider (family-Oxyopidae) and ground spider (family-Gnaphosidae) and nursery web spiders (family-Pisauridae) and tactile hunting spiders are categorized as crab spider (family-Thomosidae) and sac spider or 2-clawed spider (family-Clubionidae). Among web building spiders, *Theridion* sp., *Neoscona mukerjei* Tikader and *Araneus anantnagensis*Tikader were most abundant while as from visual hunting, *Lycosa altitudus*Tikader and Malhotra, *Pisaura* sp[1] and among tactile hunter, *Xusticus* sp. and *Clubiona japonicola* Boesenberg and St. were recorded most abundant species. Among all groups of spider, the relative abundance of family Lycosidae (26.77%) was higher, followed by Theridiidae (12.47%) (**Table 55**). The relative abundance of visual hunters was higher (51.62 %) than web building (30.81 %) and tactile hunter group of spiders (17.57%) (**Table 56**). The species diversity and evenness of indices of visual hunter were observed greater as compared to web building spiders and tactile hunter group spiders. Species richness of web building spiders was higher as compared to visual hunter and tactile hunter group spiders (**Table 57**). The peak population of spider fauna was recorded in 34$^{th}$ Standard week in Srinagar and 33$^{rd}$ Standard week in Anantnag district which ranged from 11-13 spiders/quadrate and peak population (6-7/quadrate) of grass hopper (*Oxya nitidula*) was recorded a week earlier to spider peak population in both district . In 33$^{rd}$ standard week, the climatic factors were recorded which include maximum temperature 21.74 $^{0}$C, minimum temperature 16.86 $^{0}$C, rainfall 158.6 mm, relative humidity morning 90.14%, relative humidity evening 84.0% and sunshine 0.21 hr while as in 34th standard week, the climatic factors were recorded as maximum temperature 30.36 $^{0}$C, minimum temperature 17.07 $^{0}$C, rainfall 3.4 mm, relative humidity morning 75.28%, relative humidity evening 62.57% and sunshine 9.34hrs (**Table 59**).

**Table 54: Biodiversity of spider fauna in temperate rice ecosystem of Kashmir during 2013**

| Group, Family, Genus, species | Biodiversity of spider fauna of temperate rice ecosystem of Kashmir | | | | | | | | | Spider Captured in sampling method |
|---|---|---|---|---|---|---|---|---|---|---|
| | Srinagar | | | Budgam | | | Anantnag | | | |
| | a | b | c | d | e | f | g | h | i | |
| Web builders | | | | | | | | | | Q |
| Family-Araneidae Dahl (Orb-spider) | | | | | | | | | | Q |
| *Neoscona theisi* (Walckenaer) | + | + | + | - | + | + | + | + | - | Q |
| *Neoscona mukerjei* Tikader | + | + | + | + | + | + | - | - | + | Q |
| *Araneus anantnagensis* | - | - | - | - | - | - | + | + | + | Q |
| *Araneus* sp. | + | - | + | - | + | + | - | + | - | Q |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Nephila* sp. | - | + | + | + | + | + | - | + | + | Q |
| *Cyclosa elongata* (Biswas & Raychaudhuri) | + | + | - | + | + | + | + | - | - | Q |
| *Argiope* sp. | - | - | - | - | + | - | + | + | - | Q |
| Family-Tetragnathidae Menge (Four Jawed Spider) | | | | | | | | | | |
| *Tetragnatha* sp. | + | + | + | + | + | + | + | + | + | Q |
| *Tetraganagha maxillosa* Thorell | + | - | - | - | + | - | + | + | - | Q |
| *Tetraganagha mandibulalta* | + | + | - | - | - | + | - | - | + | Q |
| *Leucauge celebesiana* (Walckenaer) | + | + | + | + | + | + | + | + | + | Q |
| *Eucta* sp. | + | + | + | + | + | + | + | - | + | Q |
| Family- Theridiidae Sundevall (Comb Foot Spider) | | | | | | | | | | |
| *Theridion* sp. | + | + | + | + | + | + | + | + | + | Q |
| Family- Linyphiidae Blackwall (Dwarf Spider) | | | | | | | | | | |
| *Linyphia* sp. | + | + | + | - | + | + | - | + | - | Q |
| *Lepthyphantes* sp. | + | - | - | - | + | + | - | + | + | Q |
| *Eriogona rohtagensis* Tikader. | - | + | - | + | - | - | + | - | + | Q |
| Visual Hunters | | | | | | | | | | Q |
| Family-Lycosidae Sundevall (Wolf spider) | | | | | | | | | | |
| *Pardosa altitudus*Tikader and Malhotra | + | + | + | + | + | + | + | + | + | Q, P |
| *Pardosa* sp. | + | + | + | + | + | + | + | + | + | Q, P |
| *Arctosa* sp. | - | + | + | + | - | + | - | - | + | Q,P |
| Family- Salticidae Blackwall (Jumping spider) | | | | | | | | | | |
| *Bianor albobimaculatus* (Lucas) | + | - | + | - | + | + | - | - | + | Q, P |
| *Marpissa* sp. | - | + | + | + | - | + | + | + | - | Q, P |
| *Myrmarachne* sp. | + | + | - | + | + | + | + | + | + | Q, P |
| *Myrmarachne himalayensis* Narayan | - | + | + | + | - | - | - | + | - | Q, P |
| *Zygoballus* sp. | + | + | + | - | + | + | + | - | + | Q, P |
| Family- OxyopidaeThorell (Lynx spider) | | | | | | | | | | |
| *Oxyopes* sp. | + | + | + | + | + | + | + | + | + | Q |
| *Oxyopes javanus* (Thorell) | + | + | + | + | + | + | + | - | + | Q |
| Family-Ganphosidae Pocock (Ground Spider) | | | | | | | | | | |
| *Setaphis* sp. | + | + | + | + | + | + | - | + | + | Q, P |
| *Zelotes* sp. | - | + | + | + | + | + | - | + | - | Q, P |
| Family- *Pisauridae* Simon (Nursery Web Spiders) | | | | | | | | | | |
| *Pisaura* sp.1 | + | + | + | + | + | + | + | - | + | Q, P |
| *Pisaura* sp.2 | + | - | + | + | + | + | + | + | + | Q, P |
| Tactile hunters | | | | | | | | | | |
| Family-*Thomisidae Sundevell* (Crab spider) | | | | | | | | | | |
| *Thomisus* sp. | + | + | + | + | + | + | + | + | + | Q, P |
| *Xysticus* sp. | + | + | + | + | + | + | + | + | + | Q, P |
| Family-*Clubionidae* Wagner (Sac spider) | | | | | | | | | | |
| *Clubiona* sp. | + | + | + | + | + | + | + | + | + | Q, P |
| *Clubiona japonicola* (Boesen berg and St.) | + | + | + | + | + | + | + | + | + | Q, P |
| Total species Collected in each location | **26** | **27** | **27** | **25** | **28** | **30** | **23** | **24** | **25** | |
| Totalspecies Collected | **34** | | | | | | | | | |

Locations (a= Shalimar, b= Dara, c= Zakoora, d= Najan, e= Arath, f= Soibugh, g=Khag h= Kokarnag, i= Khudwani)

Sampling methods, Q = Quadrate, P = Pitfall Trap

**Table 55: Relative abundance of spider families in rice ecosystem of different districts of Kashmir during 2013**

| Spider families | Srinagar (2550) | | | | | | Budgam (2242) | | | | | | Anantnag (2471) | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Shalimar (837*) | | Dara (881*) | | Zakoora (832*) | | Najan (795*) | | Arth (699*) | | Soibugh (748*) | | Khag (845*) | | Kokarnag (816*) | | Khudwani (810*) | | (7263*) | |
| | % | Cum % | % | Cum % | % | Cum % | % | Cum % | % | Cum % | % | Cum % | % | Cum % | % | Cum % | % | Cum % | % | Cum % |
| Araneidae | 5.85 | 5.85 | 5.79 | 5.79 | 6.25 | 6.25 | 6.53 | 6.52 | 5.29 | 5.29 | 5.75 | 5.75 | 6.63 | 6.63 | 7.47 | 7.47 | 7.78 | 7.78 | 6.39 | 6.39 |
| Tetragnathidae | 8.00 | 13.85 | 7.49 | 13.28 | 9.49 | 15.74 | 8.94 | 15.44 | 6.02 | 11.31 | 7.13 | 12.88 | 8.40 | 14.64 | 10.78 | 18.35 | 10.74 | 18.52 | 8.61 | 15.00 |
| Theridiidae | 12.54 | 26.39 | 12.03 | 25.31 | 11.54 | 27.28 | 13.60 | 29.04 | 14.16 | 25.47 | 10.82 | 23.70 | 13.14 | 27.77 | 12.38 | 30.63 | 12.22 | 30.74 | 12.47 | 27.47 |
| Linyphidae | 2.50 | 28.89 | 7.75 | 33.06 | 2.16 | 29.44 | 4.25 | 33.23 | 5.00 | 30.47 | 2.80 | 26.50 | 3.90 | 31.67 | 2.33 | 32.96 | 3.58 | 34.32 | 3.34 | 30.81 |
| Lycosidae | 27.12 | 56.01 | 27.58 | 60.64 | 24.39 | 53.83 | 26.32 | 59.66 | 30.47 | 60.94 | 26.47 | 52.97 | 25.21 | 56.88 | 29.29 | 62.25 | 24.57 | 58.89 | 26.77 | 57.58 |
| Salticidae | 9.55 | 65.56 | 10.56 | 71.21 | 11.78 | 65.61 | 10.20 | 69.86 | 11.30 | 72.24 | 10.69 | 63.66 | 9.35 | 66.23 | 8.59 | 70.84 | 10.74 | 69.63 | 10.32 | 67.90 |
| Oxyopidae | 6.81 | 72.37 | 5.45 | 76.65 | 5.89 | 71.5 | 4.91 | 74.77 | 5.29 | 77.53 | 6.55 | 70.21 | 6.03 | 72.26 | 7.35 | 78.19 | 5.31 | 74.94 | 5.97 | 73.87 |
| Gnaphosidae | 2.86 | 75.23 | 3.29 | 79.94 | 3.73 | 75.23 | 2.65 | 77.42 | 4.58 | 82.11 | 3.74 | 73.95 | 2.84 | 75.10 | 5.51 | 83.70 | 4.07 | 79.01 | 3.77 | 77.64 |
| Pisauridae | 4.56 | 79.79 | 4.99 | 84.93 | 4.33 | 79.56 | 6.81 | 84.23 | 5.29 | 87.40 | 6.42 | 80.37 | 5.21 | 80.31 | 2.08 | 85.78 | 4.57 | 83.58 | 4.89 | 82.53 |
| Thomisidae | 11.59 | 91.40 | 10.78 | 95.71 | 10.95 | 90.51 | 10.70 | 94.93 | 7.45 | 94.85 | 10.57 | 90.94 | 11.95 | 92.26 | 8.33 | 94.11 | 10.00 | 93.58 | 10.31 | 92.84 |
| Clubionidae | 8.62 | 100 | 8.29 | 100 | 9.49 | 100 | 5.07 | 100 | 5.15 | 100 | 8.56 | 100 | 7.34 | 100 | 5.89 | 100 | 6.42 | 100 | 7.26 | 100 |

*Numbers in parentheses are total spider numbers on which percentage are based; %= Cumulative per cent of collected spiders

**Table 56: Relative abundance of spiders of various foraging behaviour in rice ecosystem of Kashmir during 2013**

| Foraging behavior | Srinagar (2550) | | | Budgam (2242) | | | Anantnag (2471) | | | Total (7263*) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Shalimar (837*) | Dara (881*) | Zakoora (832*) | Najan (795*) | Arath (699*) | Soibugh (748*) | Khag (845*) | Kokarnag (816*) | Khudwani (810*) | |
| Web builders[a] | 28.91 | 29.06 | 29.44 | 33.24 | 30.47 | 26.60 | 32.07 | 32.96 | 34.32 | 30.81 |
| Visual hunters[b] | 50.89 | 51.88 | 50.12 | 50.89 | 56.93 | 54.27 | 48.64 | 52.82 | 49.26 | 51.62 |
| Tactile hunters[c] | 20.20 | 19.06 | 20.44 | 15.87 | 12.59 | 19.12 | 19.29 | 14.22 | 16.42 | 17.57 |

*Numbers in parentheses are total spider numbers on which percentage are based
[a]Araneidae, Tetragnathidae, Theridiidae and Linyphiidae
[b]Lycosidae, Salticidae, Oxyopidae, Gnaphosidae and Pisauridae
[c]Thomisidae and Clubionidae

**Table 57: Parameter of abundance of spider fauna in rice ecosystem of Kashmir during 2013**

| Spider group/family | Parameter of abundance of spider fauna in rice ecosystem of Kashmir | | | | |
|---|---|---|---|---|---|
| | n | S | E | H’ | ma |
| Web-building | | | | | |
| Araneidae | 464 | 7 | 1.071 | 1.015 | 4.215 |
| Tetragnathidae | 625 | 5 | 1.354 | 1.016 | 1.955 |
| Theridiidae | 906 | 1 | 3.266 | 0.993 | 0.960 |
| Linyphiidae | 243 | 3 | 2.689 | 1.131 | 1.274 |
| Sub-total | 2238 | 16 | 0.483 | 0.890 | 6.758 |
| Visual Hunter | | | | | |
| Lycosidae | 1944 | 3 | 1.690 | 0.859 | 0.968 |
| Salticidae | 750 | 5 | 1.601 | 1.074 | 2.102 |
| Oxyopidae | 433 | 2 | 3.797 | 1.273 | 0.523 |
| Gnaphosidae | 267 | 2 | 3.470 | 1.076 | 0.501 |
| Pisauridae | 355 | 2 | 3.806 | 1.036 | 0.545 |
| Sub-total | 3749 | 14 | 0.350 | 0.994 | 6.286 |
| Tactile hunter | | | | | |
| Thomisidae | 749 | 2 | 3.553 | 1.091 | 0.519 |
| Clubionidae | 527 | 2 | 4.195 | 1.049 | 0.542 |
| Sub-total | 1276 | 4 | 1.128 | 0.918 | 1.626 |
| Total | 7263 | 34 | | | |

N = Total number of individual in all species, S = number of species, E = indices of evenness, H’ = species diversity, ma = species richness

**Table 58: Population fluctuation of spider fauna in relation to environmental factors as well as insect pests (Grasshopper) in Kashmir during 2013**

| Standard weeks | Population of spiders and grass hopper (GH)/quadrate | | | | | | | | | | | | | | | | Environmental factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Srinagar | | | | | | | | Anantnag | | | | | | | | | | | | |
| | Shalimar | | Dara | | Zakoora | | Mean | | Kokarnag | | Khudwani | | Khanbal | | Mean | | | | | | |
| | Spider | GH | Spider | GH | | GH | Spider | GH | Spider | GH | Spider | GH | Spider | GH | Spider | GH | Min. Temp. ($^0$C) | Max. Temp. ($^0$C) | Morning Humidity | Evening Humidity | Rainfall (mm) |
| 27 | 1.5 | 0.5 | 0.5 | 1.2 | 1.4 | 1.5 | 1.4 | 1.0 | 1.1 | 2.0 | 1.0 | 2.6 | 1.2 | 2.8 | 1.1 | 2.4 | 31.2 | 15.7 | 78.5 | 45.8 | 15.8 |
| 28 | 3.0 | 1.2 | 2.5 | 1.3 | 2.0 | 2.0 | 2.5 | 1.5 | 2.5 | 2.5 | 1.8 | 3.5 | 4.6 | 3.2 | 2.9 | 3.0 | 29.0 | 16.4 | 81.5 | 51.4 | 35.2 |
| 2 | 3.4 | 1.9 | 3.0 | 2.5 | 4.4 | 3.4 | 3.6 | 2.6 | 3.6 | 3.5 | 2.2 | 4.6 | 5.8 | 4.4 | 3.2 | 4.1 | 31.1 | 18.3 | 74.3 | 48.6 | 8.0 |
| 30 | 4.7 | 3.2 | 4.0 | 3.5 | 5.6 | 3.9 | 4.1 | 3.5 | 4.3 | 4.6 | 4.7 | 5.3 | 6.2 | 5.6 | 4.7 | 5.1 | 32.7 | 18.4 | 71.8 | 44.1 | 3.2 |
| 31 | 4.8 | 4.5 | 5.5 | 4.9 | 6.2 | 4.3 | 5.5 | 4.5 | 7.2 | 5.8 | 5.8 | 5.7 | 6.8 | 5.7 | 5.9 | 5.7 | 30.5 | 19.3 | 79.7 | 56.3 | 18.4 |
| 32 | 6.7 | 5.7 | 6.0 | 6.4 | 7.2 | 5.7 | 7.3 | 5.9 | 9.3 | 6.3 | 8.8 | 6.8 | 7.6 | 6.6 | 8.5 | 6.5 | 32.1 | 19.1 | 77.1 | 47.0 | 6.2 |
| 33 | 8.2 | 6.3 | 10.5 | 7.0 | 9.2 | 6.7 | 9.6 | 6.6 | 11.5 | 6.2 | 11.6 | 6.0 | 11.9 | 6.0 | 11.8 | 6.0 | 21.7 | 16.8 | 90.1 | 84.0 | 158.6 |
| 34 | 11.0 | 5.8 | 13.0 | 6.5 | 12.5 | 5.6 | 12.1 | 5.9 | 9.2 | 6.0 | 9.5 | 5.7 | 9.8 | 5.7 | 9.6 | 5.8 | 30.4 | 17.1 | 75.3 | 62.5 | 3.4 |
| 35 | 10.3 | 5.6 | 9.2 | 5.7 | 9.0 | 4.9 | 8.1 | 5.4 | 8.3 | 5.8 | 8.0 | 5.3 | 7.5 | 5.2 | 7.9 | 5.4 | 28.6 | 15.7 | 83.8 | 60.5 | 0.6 |
| 36 | 9.4 | 4.2 | 8.8 | 4.3 | 7.4 | 4.6 | 7.2 | 4.3 | 7.0 | 5.6 | 7.6 | 4.9 | 5.3 | 4.5 | 5.9 | 5 | 29.5 | 13.4 | 79.5 | 51.7 | 7.8 |
| 37 | 6.2 | 4.1 | 7.4 | 3.9 | 5.8 | 4.0 | 5.4 | 4.0 | 6.3 | 5.4 | 6.3 | 4.5 | 4.0 | 4.2 | 4.8 | 4.7 | 23.7 | 13.5 | 86.8 | 67.3 | 21.0 |
| 38 | 5.9 | 3.8 | 6.5 | 3.4 | 4.0 | 3.8 | 5.1 | 3.6 | 4.8 | 5.2 | 4.9 | 3.8 | 3.2 | 3.7 | 3.9 | 4.2 | 28.9 | 9.0 | 81.0 | 48.0 | 0.0 |
| 39 | 3.6 | 3.4 | 4.4 | 3.3 | 3.5 | 3.5 | 3.1 | 3.4 | 4.2 | 4.8 | 4.7 | 3.2 | 3.1 | 3.3 | 3.6 | 3.7 | 28.2 | 11.6 | 85.3 | 63.4 | 2.4 |
| 40 | 2.8 | 2.8 | 3.6 | 3.0 | 3.0 | 3.1 | 2.9 | 2.9 | 3.1 | 4.5 | 3.2 | 2.6 | 2.3 | 2.6 | 2.5 | 3.2 | 29.0 | 11.7 | 85.4 | 45.5 | 0.0 |
| 41 | 2.2 | 2.3 | 2.4 | 2.8 | 2.0 | 2.2 | 1.5 | 2.4 | 2.1 | 3.5 | 1.5 | 2.2 | 1.5 | 2.1 | 1.3 | 2.6 | 24.7 | 12.8 | 88.5 | 65.0 | 11.6 |

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

Cage studies were conducted for evaluating the effectiveness of entomopathogens against rice bug *Leptocorisa* sp.adults and nymphs with the following treatments.

T1: *Beauveriabassiana* @ $2x10^8$ spores/ ml
T2: *Beauveria bassiana*@ $2x10^9$ spores/ml
T3: *Metarhizium anisopliae* @ $2x10^8$ spores/ ml
T4: *Metarhizium anisopliae*@$2x10^9$ spores/ml
T5: *Lecanicillium lecanii* @$2x10^8$ spores/ ml
T6: *Lecanicillium lecanii*@$2x10^9$ spores/ml
T7: *Paecilomyces fumosoroseus* @ $2x10^8$ spores/ ml
T8: *Paecilomyces fumosoroseus*@ $2x10^9$ spores/ml

Ten bugs were released in each cage and treated with entomopathogens. Observations were taken from 3rd day onwards.Only *M. Anisopliae* was found causing mortality and mycosis on rice bugs (**Table 59**).

**Table 59: Effect of entomopathogens on *Leptocorisa* sp.**

| **Treatments** | **Infected gundhi bugs (percentage)** | | |
|---|---|---|---|
| | **3rd DAS** | **5th DAS** | **Total** |
| *B. bassiana* @ $2x10^8$ spores/ ml | 0 | 0 | 0 |
| *B. bassiana* @ $2x10^9$ spores/ml | 0 | 0 | 0 |
| *M. anisopliae* @ $2x10^8$ spores/ ml | 6.66 | 60.0 | 66.66 |
| *M. anisopliae* @$2x10^9$ spores/ml | 20 | 73 | 93 |
| *L. lecanii* @$2x10^8$ spores/ ml | 0 | 0 | 0 |
| *L. lecanii* @$2x10^9$ spores/ml | 0 | 0 | 0 |
| *P. fumosoroseus* @ $2x10^8$ spores/ ml | 0 | 0 | 0 |
| *P. fumosoroseus* @ $2x10^9$ spores/ml | 0 | 0 | 0 |

## 2.7. Maize

### 1. Demonstration of *Trichogramma chilonis* against maize stem borer, *Chilo partellus* (MPUAT)

The treatment consisting of two releases of *Trichogramma chilonis* @ 1,00,000 parasitoids/ha at 6 and 25 days after germination and four releases of *Trichogramma chilonis* @ 1,50,000 parasitoids/ha at 10 days intervals initiating first release of 25 days after germination. The experiment on maize variety PHEM-2 was carried out during kharif, 2013 in three locations (Malvi, Bhinder and Girwa). Each location was of one ha and divided into 10 segments of equal size to serve as 10 replications. *Trichogramma chilonis* were released for the management of *Chilo partellus* and all the packages of practices were followed by farmers at their field in Mavli, Bhinder and Girwa. Mean egg parasitism was worked out by recording observation 10 egg masses from field at random, to confirm the (per cent) parasitism. Mean dead hearts (%) was worked out in from 50 randomly selected plants. Grain yield was analyzed by ‘t’ test.

The study revealed that four releases of *T. chilonis* @ 150000 parasitoids /ha at 10 days intervals initiating first release at 25 days after germination was found most effective against maize stem borer which reduced dead heart by 2.58, 2.88 and 2.94% in Mavli, Bhinder and Girwa respectively. The treatment was also resulted in 48.5% egg parasitism with yield of 32.1 q/ ha in Mavli which was higher than other two locations (**Table 60**). The cost benefit ratio indicated that both the treatments increased the net return over control (**Table 61**).

**Table 60: Effect of *Trichogramma chilonis* release against maize stem borer, *Chilo partellus***

| Sr. No. | Treatments | Mavli | | | Bhinder | | | Girwa | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean egg parasitism (%) | Dead hearts (%) | Grain yield (q/ha) | Mean egg parasitism (%) | Dead hearts (%) | Grain yield (q/ha) | Mean egg parasitism (%) | Dead hearts (%) | Grain yield (q/ha) |
| 1 | **Treatment 1** | 28.15 (31.93) | 7.18 (15.54) | 25.55 | 24.23 (29.27) | 7.54 (15.93) | 19.54 | 29.55 (32.92) | 7.28 (15.48) | 20.35 |
| 2 | **Treatment 2** | 48.55 (44.16) | 2.58 (9.2) | 32.12 | 42.29 (50.56) | 2.88 (9.77) | 27.15 | 49.46 (44.69) | 2.94 (9.87) | 26.5 |
| 3 | **Control** | 5.17 (13.14) | 15.16 (22.91) | 18.11 | 6.17 (14.38) | 18.29 (25.31) | 17.95 | 4.87 (12.74) | 18.91 (25.77) | 18.85 |
| | SEM | 3.38 | 1.98 | 1.22 | 4.12 | 2.29 | 1.98 | 5.66 | 2.51 | 1.25 |
| | CD | 9.75 | 5.59 | 3.54 | 13.54 | 7.12 | 5.78 | 16.74 | 7.19 | 4.05 |

Note:- Heavy rainfall in October first week reduced the yield.

**Table 61: Cost benefit analysis of *Trichogramma chilonis* release against maize stem borer, *Chilo partellus* at Mavli**

| Treatments | Yield (kg/ha) | Additional yield over control | Value of yield /ha (Rs) | Cost of treatments (Rs/ha) | Net return over control (Rs/ha) |
|---|---|---|---|---|---|
| **Treatment 1** | 2555 | 744 | 9672 | 350 | 9322 |
| **Treatment 2** | 3212 | 1401 | 18213 | 1190 | 17023 |
| **Control** | 1811 | - | - | - | - |

- *Rs 13/kg of grain.

## 2.8. Sorghum

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

An experiment was conducted at the Directorate of Sorghum Research (DSR) farm, Hyderabad, Andhra Pradesh, during post-rainy 2013 - 2014. The experimental material consisted of sorghum variety C43 sown on 23-10-2013 for evaluation of entomofungal formulations against stem borer. All the recommended agronomic practices were followed. The trial was laid in randomized block design with following eight treatments.

1. *Beauveria bassiana* strain Bb 23 @5ml/ lt*
2. *Beauveria bassiana* strain Bb 45 @5ml/ lt
3. *Beauveria bassiana* strain Bb 14 @5ml/ lt
4. *Metarhizium anisopliae* strain Ma 35 @5ml/ lt
5. *Metarhizium anisopliae* strain Ma 36 @5ml/ lt
6. *Metarhizium anisopliae* strain Ma 52 @5ml/ lt
7. Recommended practice (Carbofuran 3 G whorl application @ 8 kg/ha at 20 DAE)
8. Control (Untreated)

No insecticide was applied in the experimental plots. Entomofungal formulations received from NBAII, Bangalore were sprayed at 20, 30 DAE at the recommended dose. The carbofuran 3G was also applied as one of the treatments. The observations were recorded on plants with dead hearts at 45 DAE, number of exit holes/plant, stem tunneling and seed yield / plot.

**Deadhearts (%):** The deadhearts caused by *C partellus* at 45 DAE following application of entomofungal formulation indicated that the strain Ma 36, Ma 35, Bb 14 and Bb 45 caused significant reduction in deadhearts (9.6, 9.7, 9.9 and 10.2 %) respectively as compared to control which recorded 14.8 % deadhearts. Whorl application of carbofuran @ 8 kg/ha was significantly better (3.6 %) over the entomofungal formulations (**Table 62**).

**Exit holes (no/stalk)**: The data on exit holes/ stalk revealed that formulation Ma 36, Ma 35 recorded significantly less damage (0.4, 0.7 exit holes/ stalk) respectively over the control (4.9 exit holes/ stalk) and the damage was on par with carbofuran application (0.3 exit holes/ stalk) indicating their effectiveness (**Table 62**).

**Stem tunneling (%):** The data on stem tunneling caused by *C partellus* indicated that the strain Ma 36 and Ma 35 resulted significant reduction in stem tunneling (1.0 and 1.7 %), respectively as compared to control which recorded 4.5 % deadhearts. Carbofuran whorl application @ 8 kg/ha was significantly best (0.7 %) and was on par with the strain Ma 36 and Ma 35.

**Grain yield (kg/plot):** The grains harvested from the experimental plot (19.2 $m^2$) indicated that the strain Ma 36 and Ma 35 caused significant increase in grain yield (5.27 and 5.32 kg/ plot), respectively as compared to control which recorded 3.12 kg/plot. Carbofuran whorl application @ 8 kg/ha was significantly superior (5.33 kg/plot) and was on par with the strain Ma 36 and Ma 35 (**Table 62**).

**Table 62: Evaluation of entomofungal formulations of *B. bassiana* and *M. anisopliaea* against stem borer in sorghum**

| Treat-ment | Isolate | DH % 45 DAE | EHS (no.) | ST % | Grain yield Kg/ 19.2 $m^2$ |
|---|---|---|---|---|---|
| T1 | Bb 23 @5ml/ lt* | 12.2 $^{c}$ | 4.7 $^{c}$ | 4.1 $^{d}$ | 3.65 $^{b}$ |
| T2 | Bb 45 @5ml/ lt | 10.2 $^{b}$ | 3.1 $^{b}$ | 2.4 $^{b}$ | 3.62 $^{b}$ |
| T3 | Bb 14 @5ml/ lt | 9.9 $^{b}$ | 2.9 $^{b}$ | 2.6 $^{bc}$ | 3.68 $^{b}$ |
| T4 | Ma 35 @5ml/ lt | 9.7 $^{b}$ | 0.7 $^{a}$ | 1.7 $^{ab}$ | 5.32 $^{a}$ |
| T5 | Ma 36 @5ml/ lt | 9.6 $^{b}$ | 0.4 $^{a}$ | 1.0 $^{a}$ | 5.27 $^{a}$ |
| T6 | Ma 52 @5ml/ lt | 13.2 $^{c}$ | 4.8 $^{c}$ | 3.9 $^{cd}$ | 3.54 $^{b}$ |
| T7 | Carbofuran 3 G whorl application @ 8 kg/ha at 20 DAE | 3.6 $^{a}$ | 0.3 $^{a}$ | 0.7 $^{a}$ | 5.33 $^{a}$ |
| T8 | Control (Untreated) | 14.8$^{c}$ | 4.9 $^{c}$ | 4.5 $^{d}$ | 3.12 $^{c}$ |
| | **CD (0.05)** | **1.8** | **1.5** | **1.4** | **0.46** |
| | **CV %** | **14.3** | **21.3** | **19.7** | **10.2** |

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

## 2.9. Pulses

**1. Evaluation of *Bt* liquid formulations of NBAII (PDBC-BT1 and NBAII-BTG4) and IARI *Bt* against pigeon pea pod borer (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*). (AAU-A, MPKV, ANGRAU, UAS-Raichur).**

**AAU-A**

**Season and year** : *Kharif* –2013
**Treatments** : 11

1. PDBC-BT1 @ 1% spray
2. PDBC-BT1 @ 2% spray
3. NBAII-BTG4 @ 1% spray
4. NBAII-BTG4 @ 2% spray
5. IARI *Bt* isolates @ 1% spray
6. IARI *Bt* isolates @ 2% spray
7. *Beauveria bassiana* @ 1.5kg/ha
8. *Beauveria bassiana* @ 2.0kg/ha
9. NSKE 5% spray
10. Chlorpyriphos @ 0.04 % spray
11. Control

Replications **:** 3
Design **:** RBD
Crop and variety **:** Pigeonpea, BDN-2
Spacing **:** 90 x 20 cm
Plot size **:** Gross : 5.4 x 4.0 m
Net : 3.6 x 3.6 m

**Spray schedule:** Three sprays (pre flowering, post flowering and pod formation).

**Results:**

Larval population and pod damage recorded before impose of insecticidal treatments showed no significant differences.

**(1) Larval population of *H. armigera***

Data (**Table 63**) on larval population of *H. armigera* recorded during 7 or 14 days after treatment (DAT) of individual years as well as pooled indicated that the incidence of the pest reduced significantly in all the treated plots over untreated check. Pooled data computed for three years revealed that All the *Bt* formulation insecticides treatments found equally effective in suppressing the incidence of the pest. In which PDBC-BT-1 @ 2% or 1%, NBAII-BT G4 @ 2%, IARI *Bt* isolate @ 2% exhibited 0.52 to 0.56 larva which were at par with chemical insecticides (0.42). Both the treatments of *B. bassiana* and NSKE proved inferior whereas the treatments of IARI *Bt* isolate @ 1% and PDBC-BT-1 @ 1% found mediocre in suppressing the larva of pod borer.

**(2) Pod damage:**

Pooled data computed for three years revealed significantly least (4.90 %) per cent of damage pods in plots treated with chlorpyriphos over other treatments. All the microbial insecticides found to be at par, however the plots treated with PDBC-BT1 @ 2% showed minimum (6.79%) damage pods followed by PDBC-BT1 @ 1% (7.06%). The treatment of NBAII-BT G4 @ 2%, IARI *Bt* isolate @ 2%, NBAII-BT G4 @ 1% and IARI *Bt* isolate @ 1% proved equally effective against the pest. These four treatments exhibited pod damage ranging from 6.79 to 7.60% and differed significantly from rest of the treatments. Both the treatments of *B. bassiana* and NSKE proved higher pod damage ranging from (8.26 to 8.59%) as compared to other treatments. With respect to pod damage, these microbial insecticides found at par with chemical treatment. Pooled results also showed the superiority of the above treatments **(Table 64)**.

**(3) Grain damage:**

Pooled data computed for three years grain damage **(Table 65)** recorded at harvest revealed that the plots treated with chemical insecticide registered significantly low (5.28%) incidence of *H. armigera* in comparison to microbial insecticides. All the *Bt* based microbial insecticides exhibited grain damage ranging from 8.77 to 10.71% and found at par. *B. bassiana* applied @ 1.5 and 2.0 kg/ha proved inferior in suppressing the pest incidence.

**(4) Yield:**

Pooled data computed for three years grain yield data (**Table 66**) indicated that maximum (1841 kg/ha) yield was registered in plots treated with chemical insecticide followed by NBAII-BT G4 2% (1761 kg/ha) and 1% (1680 kg/ha). With respect to grain yield all the *Bt* formulations found to be equally effective and found at par, except PDBC-BT 1 applied @ 1%. Both the doses of NBAII-BT G4 produced significantly higher yields than *Beauveria bassiana* and NSKE @ 5%.

**Status:** Concluded

**Table 63 : Impact of different *Bt* formulations on population of pigeon pea pod borer, *H. armigera* infesting pigeon pea**

| S. No. | Treatments | 2011-12 | 2012-13 | 2013-14 | Pooled |
|---|---|---|---|---|---|
| 1 | PDBC-BT1 @ 1 % spary | 1.02 (0.54) | 1.13 (0.78) | 1.06 (0.62) | 1.07 (0.64) |
| 2 | PDBC-BT1 @ 2 % spary | 0.96 (0.42) | 1.07 (0.64) | 1.00 (0.50) | 1.01 (0.52) |
| 3 | NBAII-BTG4 @ 1 % spary | 0.98 (0.46) | 1.07 (0.64) | 1.03 (0.56) | 1.03 (0.56) |
| 4 | NBAII-BTG4 @ 2 % spary | 0.97 (0.44) | 1.10 (0.71) | 1.02 (0.54) | 1.03 (0.56) |
| 5 | IARI *Bt* isolates @ 1% spray | 0.97 (0.44) | 1.11 (0.73) | 1.02 (0.54) | 1.04 (0.58) |
| 6 | IARI *Bt* isolates @ 2% spray | 0.96 (0.42) | 1.10 (0.71) | 1.02 (0.54) | 1.03 (0.56) |
| 7 | *Beauveria bassiana* @ 1.5 kg/ha | 1.07 (0.64) | 1.21 (0.96) | 1.13 (0.78) | 1.14 (0.80) |
| 8 | *Beauveria bassiana* @ 2.0 kg/ha | 1.06 (0.62) | 1.19 (0.92) | 1.12 (0.75) | 1.12 (0.75) |
| 9 | NSKE 5% | 1.05 (0.60) | 1.18 (0.89) | 1.11 (0.73) | 1.11 (0.73) |

| | | | | | |
|---|---|---|---|---|---|
| 10 | Chlorpyriphos @ 0.04% spray | 0.90 (0.31) | 1.02 (0.54) | 0.94 (0.38) | 0.96 (0.42) |
| 11 | Control | 1.26 (1.09) | 1.48 (1.69) | 1.41 (1.49) | 1.38 (1.40) |
| | S.Em.± Treatment (T) | 0.04 | 0.04 | 0.03 | 0.03 |
| | Period (P) | 0.04 | 0.02 | 0.02 | 0.01 |
| | Spray (S) | 0.01 | 0.02 | 0.02 | 0.01 |
| | T x P | 0.05 | 0.07 | 0.06 | 0.02 |
| | S x T | 0.04 | - | 0.03 | 0.03 |
| | S x P | 0.02 | - | 0.05 | 0.01 |
| | S x T x P | 0.06 | - | 0.09 | 0.04 |
| | C. D. at 5% T | 0.11 | 0.10 | 0.09 | 0.08 |
| | P | 0.22 | - | 0.04 | 0.02 |
| | S | 0.04 | - | 0.05 | 0.02 |
| | T x P | NS | 0.20 | NS | 0.06 |
| | S x T | NS | - | NS | 0.07 |
| | S x P | 0.05 | - | NS | 0.03 |
| | S x T x P | NS | - | NS | 0.10 |
| | C. V. % | 10.83 | 10.87 | 14.08 | 9.87 |

**Table 64: Impact of different *Bt* formulations on pod damage due to *H. armigera* in pigeon pea**

| Sr. No. | Treatments | 2011-12 | 2012-13 | 2013-14 | Pooled |
|---|---|---|---|---|---|
| 1 | PDBC-BT1 @ 1 % spary | 14.05 (5.89) | 16.76 (8.32) | 15.43 (7.08) | 15.41 (7.06) |
| 2 | PDBC-BT1 @ 2 % spary | 13.16 (5.18) | 16.65 (8.21) | 15.47 (7.12) | 15.10 (6.79) |
| 3 | NBAII-BTG4 @ 1 % spary | 14.08 (5.92) | 17.04 (8.59) | 16.14 (7.73) | 15.75 (7.37) |
| 4 | NBAII-BTG4 @ 2 % spary | 13.47 (5.43) | 16.92 (8.47) | 15.97 (7.57) | 15.45 (7.10) |
| 5 | IARI *Bt* isolates @ 1% spray | 13.93 (5.80) | 17.32 (8.86) | 16.75 (8.31) | 16.00 (7.60) |
| 6 | IARI *Bt* isolates @ 2% spray | 13.62 (5.55) | 17.08 (8.63) | 16.33 (7.91) | 15.68 (7.30) |
| 7 | *Beauveria bassiana* @ 1.5 kg/ha | 15.65 (7.28) | 18.25 (9.81) | 17.23 (8.77) | 17.04 (8.59) |
| 8 | *Beauveria bassiana* @ 2.0 kg/ha | 15.29 (6.95) | 18.39 (9.95) | 17.28 (8.82) | 16.99 (8.54) |
| 9 | NSKE 5% | 14.89 (6.60) | 18.10 (9.65) | 17.10 (8.65) | 16.70 (8.26) |
| 10 | Chlorpyriphos @ 0.04% spray | 10.77 (3.49) | 14.79 (6.52) | 12.82 (4.92) | 12.79 (4.90) |
| 11 | Control | 19.30 (10.92) | 22.30 (14.40) | 20.32 (12.06) | 20.64 (12.43) |
| | S.Em.± Treatment (T) | 0.59 | 0.59 | 0.55 | 0.58 |
| | Period (P) | - | - | - | 0.15 |
| | Spray (S) | - | - | - | - |
| | T x P | 1.00 | 1.00 | 0.95 | 0.50 |
| | S x T | - | - | - | - |
| | S x P | - | - | - | - |

| | | | | | |
|---|---|---|---|---|---|
| | S x T x P | - | - | - | - |
| | C. D. at 5% T | 1.66 | 1.67 | 1.67 | 1.72 |
| | P | - | - | - | 0.42 |
| | S | - | - | - | - |
| | T x P | NS | NS | NS | 1.40 |
| | S x T | - | - | - | - |
| | S x P | - | - | - | - |
| | S x T x P | - | - | - | - |
| | C. V. % | 11.98 | 10.59 | 9.98 | 9.36 |

**Table 65: Impact of different *Bt* formulations on grain damage due to *H. armigera* in pigeon pea**

| Sr. No. | Treatments | 2011-12 | 2012-13 | 2013-14 | Pooled |
|---|---|---|---|---|---|
| 1 | PDBC-BT1 @ 1 % spary | 18.57 (10.14) | 19.25 (10.87) | 19.49 (11.13) | 19.10 (10.71) |
| 2 | PDBC-BT1 @ 2 % spary | 15.98 (7.58) | 17.57 (9.11) | 18.23 (9.79) | 17.26 (8.80) |
| 3 | NBAII-BTG4 @ 1 % spary | 17.25 (8.79) | 18.83 (10.42) | 19.27 (10.89) | 18.45 (10.02) |
| 4 | NBAII-BTG4 @ 2 % spary | 16.24 (7.82) | 17.39 (8.93) | 18.05 (9.60) | 17.23 (8.77) |
| 5 | IARI *Bt* isolates @ 1% spray | 17.65 (9.19) | 19.11 (10.72) | 19.46 (11.10) | 18.74 (10.32) |
| 6 | IARI *Bt* isolates @ 2% spray | 17.37 (8.91) | 19.34 (10.97) | 19.14 (10.75) | 18.62 (10.19) |
| 7 | *Beauveria bassiana* @ 1.5 kg/ha | 20.08 (11.79) | 22.55 (14.71) | 22.00 (14.03) | 21.54 (13.48) |
| 8 | *Beauveria bassiana* @ 2.0 kg/ha | 19.19 (10.80) | 19.96 (11.65) | 20.34 (12.08) | 19.83 (11.51) |
| 9 | NSKE 5% | 17.99 (9.54) | 18.60 (10.17) | 18.90 (10.49) | 18.48 (10.05) |
| 10 | Chlorpyriphos @ 0.04% spray | 12.10 (4.39) | 14.42 (6.20) | 13.39 (5.36) | 13.28 (5.28) |
| 11 | Control | 23.06 (15.34) | 25.73 (18.85) | 26.29 (19.62) | 25.03 (17.90) |
| | S.Em.± Treatment (T) | 0.68 | 0.73 | 0.46 | 0.94 |
| | Period (P) | - | - | - | 0.16 |
| | Spray (S) | - | - | - | - |
| | T x P | 1.25 | 1.37 | 0.77 | 0.54 |
| | S x T | - | - | - | - |
| | S x P | - | - | - | - |
| | S x T x P | - | - | - | - |
| | C. D. at 5% T | 1.91 | 2.05 | 2.19 | 2.78 |
| | P | - | - | - | 0.45 |
| | S | - | - | - | - |
| | T x P | NS | NS | NS | 1.48 |
| | S x T | - | - | - | - |
| | S x P | - | - | - | - |
| | S x T x P | - | - | - | - |
| | C. V. % | 12.16 | 12.29 | 13.56 | 8.51 |

**Table 66 : Impact of different *Bt* formulation on yield of pigeon pea**

| Sr. No. | Treatments | Yield (kg/ha) | | | |
|---|---|---|---|---|---|
| | | **2011-12** | **2012-13** | **2013-14** | **Pooled** |
| 1 | PDBC-BT1 @ 1 % spary | 1259.66 | 1249.67 | 1250.00 | 1253.11 |
| 2 | PDBC-BT1 @ 2 % spary | 1574.33 | 1564.33 | 1569.33 | 1569.33 |
| 3 | NBAII-BTG4 @ 1 % spary | 1666.66 | 1695.00 | 1678.66 | 1680.11 |
| 4 | NBAII-BTG4 @ 2 % spary | 1774.66 | 1750.00 | 1759.33 | 1761.33 |
| 5 | IARI *Bt* isolates @ 1% spray | 1481.66 | 1463.33 | 1469.66 | 1471.55 |
| 6 | IARI *Bt* isolates @ 2% spray | 1389.00 | 1375.33 | 1372.33 | 1378.88 |
| 7 | *Beauveria bassiana* @ 1.5 kg/ha | 1083.33 | 1068.33 | 1076.00 | 1075.88 |
| 8 | *Beauveria bassiana* @ 2.0 kg/ha | 1157.66 | 1137.67 | 1145.33 | 1146.88 |
| 9 | NSKE 5% | 1111.33 | 1092.00 | 1101.66 | 1101.66 |
| 10 | Chlorpyriphos @ 0.04% spray | 1851.66 | 1832.66 | 1839.00 | 1841.11 |
| 11 | Control | 990.33 | 965.00 | 984.33 | 979.88 |
| | S.Em.± T | 167.11 | 166 | 119.84 | 46.06 |
| | TXP | - | - | - | 76.42 |
| | C.D. at 5% T | 492.96 | 491.3 | 353.54 | 215.44 |
| | T X P | - | - | - | NS |
| | C.V. % | 20.75 | 20.88 | 14.97 | 19.07 |

**ANGRAU - Hyderabad**

The trials were laid out in ARS, Tandur. Formulations were supplied by NBAII and treatments were administered. Treatmental differences were, however, inconclusive due to less population load of *Helicoverpa armigera* during the experimental period.

**MPKV - Pune**

A field experiment was conducted on the research farm of Botany Section, College of Agriculture, Pune. The pigeon pea seeds var. ICPL-87 was sown at 30 x 10 cm spacing in 8 x 5 m plots on 06/8/2013. The trial was laid out in RBD with nine treatments and three replications. The treatments comprised spraying of liquid formulations of *Bt* strains PDBC-BT1 @ 1 and 2%, NBAII-BTG4 @ 1 and 2%, *Beauveria bassiana* @ 1.5 and 2.0 kg/ha, NSKE 5%, chlorpyriphos 0.04% as standard chemical check and untreated control. The four sprays were given on 3/10/2013, 18/10/2013, 03/11/2013 and 29/11/2013. The larval population of *H. armigera* and *M. testulalis* were recorded a day before treatment application as pre-count and post counts at 3 and 7 days after each spray. The data on larval population were transformed into $\sqrt{x+0.5}$ values, per cent pod and seed damage transformed to arc sin values and yield data converted into quintal per ha. The data were then subjected to analysis of variance.

The results in **Tables 67, 68** and **69** indicated that three sprays of chlorpyriphos 0.04% at fortnightly interval was significantly superior over other treatments in suppressing the larval population of *H. armigera* (av. 1.2 larva/plant) and *M. testulalis* (av. 2.2 larvae/plant) on pigeon pea and recorded minimum pod (11.2%) and seed (8.6%) damage with maximum 16.4 q/ha yield. It was however, at par with the *Bt* strain NBAII-BTG4 @ 2% in respect of pod damage (11.8%) and yield (14.8 q/ha). Moreover, the treatment PDBC-BT1 @ 2% was also found to be equally effective to superior ones. The *Bt* strain NBAII-BTG4 @ 2% ranked next best to the insecticidal spray in recording surviving larval population of *H. armigera* (av. 1.7 larvae/plant) and *M. testulalis* (av. 3.7 larvae/plant).

**Table 67: Effect of *Bt* formulations against *Helicoverpa armigera* in pigeon pea**

| Treatment | Larval population/plant after | | | | | |
|---|---|---|---|---|---|---|
| | Pre-count | II spray | | III spray | | Average |
| | | 3 DAS | 7 DAS | 3 DAS | 7 DAS | |
| T1: PDBC-BT1 @ 1% | 4.8$^{a}$ | 5.1$^{b}$ | 2.6$^{b}$ | 1.7$^{c}$ | 1.6$^{d}$ | 2.7$^{c}$ |
| T2: PDBC-BT1 @ 2% | 4.9$^{a}$ | 4.6$^{b}$ | 1.9$^{a}$ | 1.2$^{b}$ | 0.7$^{b}$ | 2.1$^{b}$ |
| T3: NBAII- BTG4 @ 1% | 4.9$^{a}$ | 3.5$^{a}$ | 2.0$^{a}$ | 1.4$^{b}$ | 0.8$^{b}$ | 1.9$^{b}$ |
| T4: NBAII- BTG4 @ 2% | 5.0$^{a}$ | 3.6$^{a}$ | 1.8$^{a}$ | 0.9$^{b}$ | 0.5$^{a}$ | 1.7$^{b}$ |
| T5: *B. bassiana* @ 1.5 kg/ha | 4.9$^{a}$ | 5.0$^{b}$ | 3.4$^{b}$ | 2.2$^{d}$ | 1.7$^{d}$ | 3.1$^{d}$ |
| T6: *B. bassiana* @ 2.0 kg/ha | 4.9$^{a}$ | 3.8$^{a}$ | 2.6$^{b}$ | 1.7$^{c}$ | 1.2$^{c}$ | 2.3$^{c}$ |
| T7: NSKE 5% suspension | 4.9$^{a}$ | 5.7$^{b}$ | 4.5$^{c}$ | 2.4$^{d}$ | 2.0$^{c}$ | 3.7$^{e}$ |
| T8: Chlorpyriphos 0.04% | 5.0$^{a}$ | 2.8$^{a}$ | 1.4$^{a}$ | 0.4$^{a}$ | 0.1$^{a}$ | 1.2$^{a}$ |
| T9: Untreated control | 5.0$^{a}$ | 5.9$^{c}$ | 7.6$^{d}$ | 8.9$^{e}$ | 11.1$^{e}$ | 8.4$^{f}$ |
| CD (p = 0.05) | NS | 0.38 | 0.34 | 0.22 | 0.25 | 0.17 |

**Table 68: Effect of *Bt* formulations against *Maruca testulalis* in pigeon pea**

| Treatment | Larval population/plant after | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | I spray | | | II spray | | III spray | | Aver-age |
| | Pre-count | 3 DAS | 7 DAS | 3 DAS | 7 DAS | 3 DAS | 7 DAS | |
| T1: PDBC-BT1 @ 1% | 4.1$^{a}$ | 4.6$^{b}$ | 6.6$^{d}$ | 12.0$^{c}$ | 8.2$^{b}$ | 4.2$^{d}$ | 2.9$^{c}$ | 6.4$^{e}$ |
| T2: PDBC-BT1 @ 2% | 4.0$^{a}$ | 3.1$^{a}$ | 3.9$^{b}$ | 9.8$^{b}$ | 6.2$^{b}$ | 3.2$^{b}$ | 1.5$^{b}$ | 4.6$^{c}$ |
| T3:NBAII-BTG4 @ 1% | 4.1$^{a}$ | 4.1$^{b}$ | 5.3$^{c}$ | 9.9$^{b}$ | 7.4$^{b}$ | 3.9$^{c}$ | 3.4$^{c}$ | 5.7$^{d}$ |
| T4:NBAII- BTG4 @ 2% | 4.1$^{a}$ | 3.2$^{a}$ | 2.3$^{a}$ | 8.7$^{b}$ | 4.2$^{a}$ | 2.2$^{b}$ | 1.4$^{b}$ | 3.7$^{b}$ |
| T5: *B. bassiana* 1.5 kg/ha | 4.0$^{a}$ | 4.2$^{b}$ | 5.4$^{c}$ | 13.7$^{c}$ | 9.8$^{c}$ | 5.9$^{d}$ | 5.4$^{d}$ | 7.4$^{e}$ |
| T6: *B. bassiana* 2.0 kg/ha | 4.1$^{a}$ | 3.5$^{b}$ | 3.7$^{b}$ | 11.7$^{c}$ | 8.9$^{c}$ | 4.6$^{b}$ | 4.4$^{c}$ | 6.1$^{e}$ |
| T7: NSKE 5% suspension | 4.1$^{a}$ | 4.3$^{b}$ | 4.5$^{b}$ | 11.8$^{c}$ | 9.4$^{c}$ | 6.4$^{d}$ | 5.3$^{d}$ | 6.9$^{e}$ |
| T8: Chlorpyriphos 0.04% | 4.1$^{a}$ | 2.4$^{a}$ | 1.9$^{a}$ | 4.4$^{a}$ | 3.1$^{a}$ | 1.1$^{a}$ | 0.3$^{a}$ | 2.2$^{a}$ |
| T9: Untreated control | 4.1$^{a}$ | 6.7$^{c}$ | 11.3$^{e}$ | 25.8$^{d}$ | 30.3$^{d}$ | 23.0$^{e}$ | 21.2$^{e}$ | 19.7$^{f}$ |
| **CD (p = 0.05)** | **NS** | **0.29** | **0.36** | **0.55** | **0.48** | **0.44** | **0.47** | **0.14** |

**Table 69: Effect of *Bt* formulations on pod damage and yield of pigeon pea**

| Treatment | Pod damage (%) | Seed damage (%) | Yield (q/ha) |
|---|---|---|---|
| T1: PDBC-BT1 @ 1% | 19.2$^{c}$ | 17.5$^{b}$ | 13.5$^{b}$ |
| T2: PDBC-BT1 @ 2% | 14.1$^{b}$ | 12.1$^{b}$ | 14.7$^{a}$ |
| T3: NBAII-BTG4 @ 1% | 18.5$^{c}$ | 16.2$^{c}$ | 13.7$^{b}$ |
| T4: NBAII-BTG4 @ 2% | 11.8$^{a}$ | 10.3$^{a}$ | 14.8$^{a}$ |
| T5: *B. bassiana* @ 1.5 kg/ha | 24.8$^{d}$ | 22.1$^{e}$ | 10.8$^{c}$ |
| T6: *B. bassiana* @ 2.0 kg/ha | 21.8$^{d}$ | 20.1$^{d}$ | 10.5$^{c}$ |
| T7: NSKE 5% suspension | 20.0$^{c}$ | 18.1$^{d}$ | 11.4$^{c}$ |
| T8: Chlorpyriphos 0.04% | 11.2$^{a}$ | 8.6$^{a}$ | 16.4$^{a}$ |
| T9: Untreated control | 28.8$^{e}$ | 25.0$^{f}$ | 8.5$^{d}$ |
| **CD (p = 0.05)** | **1.15** | **1.92** | **1.90** |

**UAS-Raichur**

Among all the bioagents tested against pod borer the bioagent NBAII BTG 4 *Bt* @ 2g/lit was found effective which recorded 10.84 per cent pod damage and it was statistically superior over rest of the bioagents. NBAII BTG 4 *Bt* @ 1g/lit recorded 15.49 per cent pod damage ant it was on par with PDBC *Bt* 1 @ 2g/lit which recorded 11.31 per cent pod damage. Both the dosages of fungal pathogen, *Beauveria bassiana* were found statistically inferior. Untreated control recorded maximum pod damage of 27.35 per cent pod damage. NBAII BTG 4 *Bt* recorded minimum seed damage of 1.14 per cent seed damage which was followed by NBAII BTG 4 *Bt* @ 1g/lit. NBAII BTG 4 *Bt* recordeed higher grain yield of 14.88 q/ha and differed statistically with other bioagents. Untreated control recorded minimum grain yield of 7.57 q/ha (**Table 70**).

**Table 70: Evaluation of NBAII liquid formulations (PDBC *Bt 1* and PDBC *Bt 2*) and IARI *Bt* against pigeon pea pod borer (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*) during 2013-14**

| Sl. No. | Treatment | Dosage (g/ml/lit) | % Pod damage | % Seed damage | Grain Yield (q/ha) |
|---|---|---|---|---|---|
| 1 | PDBC Bt 1 | 10 | 17.64 (25.58) | 1.78 (7.67) | 9.57 |
| 2 | PDBC Bt 1 | 20 | 11.31 (19.65) | 1.29 (6.52) | 14.31 |
| 3 | NBAII BTG 4 | 10 | 15.49 (23.96) | 1.49 (7.01) | 9.61 |
| 4 | NBAII BTG 4 | 20 | 10.84 (19.22) | 1.14 (6.12) | 14.88 |
| 5 | *Beauveria bassiana* | 1.5 | 20.94 (27.23) | 2.28 (8.68) | 9.15 |
| 6 | *Beauveria bassiana* | 2.0 | 20.66 (27.03) | 2.11 (8.35) | 9.42 |
| 7 | NSKE | 5 | 12.87 (21.02) | 1.08 (5.97) | 10.74 |
| 8 | Chlorpyriphos | 2.0 | 10.13 (18.56) | 0.78 (5.07) | 15.89 |
| 9 | Untreated control | -- | 27.35 (31.53) | 8.92 (17.38) | 7.57 |
| SEm ± | | | 0.21 | 0.15 | 0.32 |
| CD at 5 % | | | 0.63 | 0.47 | 0.95 |

Figures in parenthesis are arcsine transformed values

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

The pest incidence was very low crop and results were non-significant. Therefore, the experiment will be repeated again during the cropping season of the current year.

### 3. BIPM against *H. armigera* in chick pea (MPUAT):

**MPUAT**

Title : **BIPM against *H. armigera* in chick pea (MPUAT)**
Location : Agronomy farm RCA, MPUAT, Udaipur.
Year : 2013-14

Experimental Detail
Treatments : 4
Replication : 3
Design : RBD
Crop and variety : Dahod Yellow
Date of sowing : 25.10.2013

**<u>Treatments:-</u>**

1. Installation of pheromone trap 5/ha.
2. Two sprays of Bt @ 1kg/ha first at flowering stage and second after 15 days of first spray
3. Two sprays of HaNPV first at flowering stage and second after 15 days of first spray

**Result:**

The experiment result showed that the per cent pod damage in chick pea was significantly lower in two sprays of HaNPV @ 250 LE/ha. and it was statically at par with Bt @ 1kg/ha. Yield qt/ha in chick pea also followed same trends that is maximum with 14.35 qt/ha and13.56 qt/ha, respectively. Whereas, pheromone trap found less effective in *H. armigera* for control as compared to HaNPV @ 250 LE/ha. and it was statically at par with Bt @ 1kg/ha **(Table 71)**.

**Table 71: BIPM against *H. armigera* in chick pea (MPUAT)**

| Sr. No. | Treatments | Dose | Per cent pod damage | Yield kg/ha |
|---|---|---|---|---|
| 1 | Pheromone trap | 5/ha | 7.15 (15.50) | 10.72 |
| 2 | Bt @ 1kg/ha | Two sprays | 4.76 (12.60) | 13.56 |
| 3 | HaNPV | Two sprays | 2.93 (9.85) | 14.35 |
| 5 | Control | - | 8.82 (17.27) | 8.52 |
| | Sem. ± | | .86 | .52 |
| | CD 5% | | 2.45 | 1.54 |

Figures in the per cent are angular transformed values.

## 2.10. Oil Seeds

### 1. Biological suppression of safflower aphid, *Uroleucon compositae* on safflower (ANGRAU, MPKV)

**ANGRAU - Hyderabad**

**Treatments:**
**T1** *Beauveria bassiana*
**T2** *Metarrhizium anisopliae*
**T3** *Lecanicillium lecanii* @ 1.5 x $10^{13}$ conidia/ha
**T4** Neem oil
**T5** Insecticidal check
**T6** Untreated Control

**Net Plot size:** 40 sq.mt (5 x 8m)

**No. of Replications**: 4

**Design:** RBD

**Variety:** Nari 11

**Timing of Treatment Applications**:

The first spray was given on initial occurrence of the pest and rest based on abundance of pest. Cloth screen was used to avoid drift into neighbouring plots.

**Observation Protocol:**

Aphid population in 10 randomly selected plants (terminal shoots) from each plot was recorded before treatment and 10 days after each treatment. Yield per plot was recorded at harvest.

Among the bio control options tested, *Lecanicillium lecanii* @ 5 g/l proved to be effective and was on par with the insecticidal check in suppressing population of aphids. Neem oil was found to be the next promising after *L. lecanii* which has recorded levels of aphid population higher than *L. lecanii* but much lower than other treatments namely *B. bassiana, M. anisopliae, Bt* and untreated control **(Table 72)**.

**Table 72: Demonstration of Biological Suppression of *Uroleucon compositae* in non spiny safflower varieties.**

| S.No. | Treatment | Aphid population (per 10 plants) | | Yield (kg/ha) |
|---|---|---|---|---|
| | | After first application | After second application | |
| 1. | *Beauveria bassiana* | 272 | 135 | 397 |
| 2. | *Metarrhizium anisopliae* | 281 | 122 | 412 |
| 3. | *Lecanicillium lecanii* @ 1.5 x $10^{13}$ conidia/ha | 132 | 87 | 479 |
| 4. | Neem oil | 120 | 92 | 456 |
| 5. | Insecticidal check | 72 | 81 | 531 |
| 6. | Untreated Control | 512 | 435 | 239 |

**MPKV - Pune**

A field experiment was conducted on the research farm of Entomology Section, College of Agriculture, Pune during *rabi* 2013-14. The seeds of safflower var. SSF 658 (non-spiny) were sown at the rate 10 kg/ha at 45 x 20 cm spacing in the plots of 8 x 5 m size on 27/11/2013. The trial was laid out in randomized block design with seven treatments and three replications. The treatments comprised release of *Chrysoperla zastrowi sillemi* @ 5,000 grubs/ha, spraying of *L. lecanii, B. bassiana, M. anisopliae* each @ $10^{13}$ conidia/ha, NSKE 5% suspension, insecticidal check dimethoate 30EC @ 0.05% and untreated control. Three releases of *Chrysoperla* and three sprays of remaining treatments were given at fortnightly interval starting from 14/01/2013. The aphid population was recorded on 5 cm apical shoot per plant from 10 randomly selected plants per plot a day before treatment application and post counts at 7 days after each spray. Data on aphid population transformed into $\sqrt{x+0.5}$ values for statistical analysis. The yield data was recorded on per plot basis and converted into quintal/ha for statistical analysis.

Data in **Table 73** revealed that three sprays of dimethoate @ 0.05% at fortnightly interval were significantly superior over other treatments in suppressing the aphid population (4.9 aphids/5 cm apical twig) on non-spiny variety of safflower and increased the yield (11.3 q/ha). However, similar sprays of *M. anisopliae* @ $10^{13}$ conidia/ha given at fortnightly interval found to be the next best treatment in reducing the aphid population. The treatments with *M. anisopliae* and NSKE 5% were statistically comparable with superior treatment in respect of safflower yield.

**Table 73: Effect of different bioagents on aphid population and yield of safflower**

| Treatment | Aphid population/5 cm shoot/plant, 7 days after | | | | | Yield (q/ha) |
|---|---|---|---|---|---|---|
| | Pre-count | I spray | II spray | III spray | Average | |
| T1: *Chrysoperla* @ 5,000 grubs/ha | 47.2 $^{a}$ | 39.5 $^{c}$ | 28.6 $^{d}$ | 19.5 $^{e}$ | 29.2 $^{e}$ | 7.6 $^{c}$ |
| T2: *V. lecanii* @ $10^{13}$ conidia/ha | 46.9 $^{a}$ | 32.5 $^{c}$ | 19.2 $^{c}$ | 9.8 $^{c}$ | 20.5 $^{d}$ | 8.2 $^{b}$ |
| T3: *B. bassiana* @ $10^{13}$ conidia/ha | 47.7 $^{a}$ | 41.0 $^{d}$ | 23.3 $^{c}$ | 16.4 $^{d}$ | 26.9 $^{d}$ | 7.8 $^{b}$ |
| T4: *M. anisopliae* @ $10^{13}$ conidia/ha | 47.0 $^{a}$ | 16.3 $^{b}$ | 5.9 $^{a}$ | 1.9 $^{a}$ | 8.0 $^{b}$ | 10.9 $^{a}$ |
| T5: NSKE @ 5% | 46.9 $^{a}$ | 19.2 $^{b}$ | 12.5 $^{b}$ | 5.5 $^{b}$ | 12.4 $^{c}$ | 10.5 $^{a}$ |
| T6: Dimethoate .05% | 46.7 $^{a}$ | 10.3 $^{a}$ | 3.9 $^{a}$ | 0.4 $^{a}$ | 4.9 $^{a}$ | 11.3 $^{a}$ |
| T7: Untreated control | 47.5 $^{a}$ | 50.8 $^{d}$ | 57.7 $^{e}$ | 63.2 $^{f}$ | 57.2 $^{f}$ | 5.1 $^{d}$ |
| **CD (p = 0.05)** | **NS** | **0.61** | **0.76** | **0.68** | **0.38** | **1.81** |

**2. Evaluation of entomopathogens against soybean insect pest complex (MPKV)**

The experiment was conducted on the research farm of Botany Section, College of Agriculture, Pune during *Kharif* 2013. The seeds of soybean var. JS- 9305 were sown at 45 x 10 cm distance in 5 x 4 m plots on 7/8/2013. The trial was laid out in randomized block design with six treatments and four replications. The treatments comprised MPKV and NBAII strains of *Nomuraea rileyi* @ $10^{8}$ conidia/ml, *Sl*NPV @ 250 LE/ha (1.5 x $10^{12}$ POBs/ha), EPN *Heterorhabditis indica* @ 1 billion IJs/ha, NSKE 5% suspension and untreated control. Three sprays were given at fortnightly interval starting from 12/9/2013.

The larval population of *Spodoptera litura* was recorded in 1 m row at 5 spots per plot a day before treatment application as pre-count and post counts, a week after each spray. The data on larval population were transformed into $\sqrt{x+0.5}$ values for statistical analysis. About 30 larvae of *S. litura* per plot were collected 24 hr after third spray along with food and brought to the laboratory. The larvae were reared on the food collected from the respective plots till mortality / pupation to compute per cent mortality due to diseased conditions. At harvest, grain yield per plot were recorded and then converted into quintal per ha.

The results in **Table 74** indicated that three sprays of *Sl*NPV @ 250 LE/ha (1.5 x $10^{12}$ POBs/ ha) was significantly superior in suppressing the larval population of *S. litura* (2.2 larvae/m row) with 78.0 per cent mortality due to virus infection and gave maximum of 21.9 q/ha yield of soybean. It was, however, at par with *N. rileyi* strains of MPKV as well as NBAII. The MPKV strain of *N. rileyi* showed av. 2.7 surviving larval population of *S. litura* per m row with 65.0 per cent mortality due to fungal infection and 19.3 q/ha yield followed by NBAII strain. The treatments with NSKE and EPN were found to be the next best ones.

**Table 74: Effect of entomopathogens on larval population of *S. litura* and yield of Soybean**

| **Treatment** | **Larval population/m row, 7 days after** | | | | | **Pathogenesity/ mortality (%)** | **Yield (q/ha)** |
|---|---|---|---|---|---|---|---|
| | **Pre-count** | **I spray** | **II spray** | **III spray** | **Aver-age** | | |
| T1: *N. rileyi* @ $10^{8}$ conidia/ml- MPKV strain | 5.9 $^{a}$ | 4.3 $^{a}$ | 2.4 $^{a}$ | 1.4 $^{b}$ | 2.7 $^{a}$ | 65.0 | 19.3 $^{a}$ |
| T2: *N. rileyi* @ $10^{8}$ conidia/ml - NBAII strain | 5.8 $^{a}$ | 4.3 $^{a}$ | 2.7 $^{a}$ | 1.3 $^{a}$ | 2.8 $^{a}$ | 54.0 | 19.0 $^{a}$ |
| T3: *Sl*NPV @ 250 LE/ha | 6.0 $^{a}$ | 4.1 $^{a}$ | 1.9 $^{a}$ | 0.5 $^{a}$ | 2.2 $^{a}$ | 78.0 | 21.9 $^{a}$ |
| T4: EPN-*H. indica* @ 1 billion IJs/ha | 5.9 $^{a}$ | 5.7 $^{a}$ | 4.1 $^{b}$ | 2.8 $^{c}$ | 4.2 $^{c}$ | 43.0 | 16.2 $^{b}$ |
| T5: NSKE 5% suspension | 6.1 $^{a}$ | 5.9 $^{b}$ | 4.1 $^{b}$ | 2.1 $^{b}$ | 4.0 $^{b}$ | 47.0 | 16.3 $^{b}$ |
| T6: Untreated control | 6.0 $^{a}$ | 8.7 $^{c}$ | 12.3 $^{c}$ | 15.4 $^{d}$ | 12.1 $^{d}$ | 5.7 | 12.3 $^{c}$ |
| **CD (p = 0.05)** | **NS** | **0.36** | **0.35** | **0.33** | **0.14** | | **3.12** |

### 3. Validation of IPM module in soybean (MPUAT)

| | | |
|---|---|---|
| Season | | :Kharif 2013 |
| Crop | | : Soybean |
| Experimental Details: | | |
| Location | | : Agronomy farm RCA, MPUAT, Udaipur & farmers field |
| Design | | : RBD |
| Replication | | : 03 |
| Plot Size | Gross | : 5.0x3.6 m |
| No. of rows/plot | | : 10 |
| Row length | | : 5.0 |
| Spacing | Row to Row | : 0.30m |
| | Plant to plant | : 0.10m |
| Fertilizer doses (Basal) | | : 20:60 |

No. of treatments : 5
Date of sowing : 10 July, 2013
Date of germination : 15 July, 2013

**<u>Treatments:-</u>**

1. Seed treatment with Trichoderma @ 8g/kg. Seed.
2. Soil application of *Metarhizium anisopliae* @ 2.5x10$^{13}$ spore/ha along with FYM for control of white grubs
3. Two releases of *Trichogramma chilonis* @ 1 lakh/ha at 10 days intervals starting at flowering.
4. Two sprays of NSKE 5%
5. Two sprays of *Nomuraea rileyi* @ 1.5 x10$^{11}$ conidia/ha. against *Spodoptera litura*

**Observation Recorded**

1. Observations of larval counts of the green semi looper and tobacco caterpillar were recorded at per meter row length (mrl) after 7 days of spraying.
2. Observations of sucking pests/3 trifoliate leaves were recorded after 7 days of spraying.
3. Grain yield per plots.

The insect population and damage data were subjected to square root and arcsine-transformed values for statistical analysis, respectively. Grain yield per plot were recorded and analyzed statistically.

The experiment was laid out at Agronomy Farm RCA, MPUAT Udaipur and at farmers field at Intali village Mavli in *kharif* 2013. Soybean variety JS-9305 was sown for the experiment. Detailed study of experiment revealed that two sprays of NSKE 5% were significantly effective in controlling of major pests of soybean and produced higher grain yield of 15.5 q/ha, whereas soil application of FYM enriched *Metarhizium anisopliae* also found effective in reduction of plant mortality i.e. 4.24% due to soil pest. The module comprising soil application of *M. anisopliae* and two spray of NSKE has potency to manage the pests of soybean needs to be validated on large scale **(Table 75)**.

**Table 75: Validation of IPM module in soybean (MPUAT)**

| Sr. No. | Treatments | Green Semi lopper larval population mrl* | Per cent Plant mortality per plot due to soil pest. | Sucking pests/3 trifoliate leaves | Tobacco caterpillar larval population mrl* | Yield (qt/ha) |
|---|---|---|---|---|---|---|
| 1 | Trichoderma | 3.7 (11.09) | 8.54 (16.99) | 3.51 (10.71) | 4.52 (14.27) | 9.10 |
| 2 | *Metarhizium anisopliae* | 2.5 (9.09) | 4.24 (11.88) | 2.24 (8.71) | 3.59 (10.92) | 10.72 |
| 3 | *Trichogramma chilonis* | 3.1 (10.14) | 7.25 (15.62) | 2.95 (9.88) | 2.64 (9.77) | 11.05 |
| 4 | NSKE 5% | 2.8 (9.63) | 5.25 (13.24) | 2.18 (8.49) | 2.28 (8.64) | 15.5 |
| 5 | *Nomuraea rileyi* | 3.2 (10.30) | 6.12 (14.32) | 3.51 (10.79) | 2.73 (9.51) | 11.57 |
| 6 | Farmer Practices | 4.8 (12.65) | 8.98 (17.43) | 5.22 (13.20) | 6.24 | 6.89 |
| | Sem± | 0.08 | .06 | 0.07 | 0.11 | 0.15 |
| | CD 5% | 0.23 | 0.18 | 0.21 | 0.32 | 0.42 |

* Per meter row length
Note: - Heavy rainfall in October first week reduced yield

**4. Field Evaluation of entomofungal pathogens against Soybean defoliators (Dir. Soybean Res.)**

**Objective:** To test the efficacy of different isolates of entomopathogenic fungi against important soybean defoliators under field conditions.

Variety : JS 335
Treatments : 7
Replications : 3
Design : R.B.D.
Plot size : 13.5 sq m
Date of sowing : 29.06.2013
Date of germination : 04.07.2013
Treatments :

| Treatment | Particulars | Dose |
|---|---|---|
| $T_1$ | DSRBB1 of *B. bassiana* | $10^8$ spores/ml |
| $T_2$ | DSRBB2 of *B. bassiana* | $10^8$ spores/ml |
| $T_3$ | DSRBB3 of *B. bassiana* | $10^8$ spores/ml |
| $T_4$ | DSRBB5 of *B. bassiana* | $10^8$ spores/ml |
| $T_5$ | NBAIIBB1 of *B. bassiana* | $10^8$ spores/ml |
| $T_6$ | commercial strain *B. bassiana* | $10^8$ spores/ml |
| $T_7$ | Control | - |

**Target Pests:** Soybean lepidopteron defoliators [*Chrysodeixis acuta* (Walker), *Diachrysia orichalcea* (Fabricius), *Gesonia gemma* Swinhoe, and *Spodoptera litura* (Fabricius)]

**Observations:** 1. Per cent infection of larvae per meter crop row length
2. Grain Yield

**Results:** A field trial was conducted at the Research Farm of Directorate of Soybean Research (ICAR), Indore during *kharif* 2013 to evaluate the efficacy of native strains of *Beauveria bassiana* against major soybean lepidopteron defoliators; *Chrysodeixis acuta* (Walker), *Diachrysia orichalcea* (Fabricius), *Gesonia gemma* Swinhoe, and *Spodoptera litura* (Fabricius). There were seven treatments consisting of six *B. bassiana* strains; four of DSR, Indore, one of NBAII, Bengaluru, one commercial strain and untreated control. One aqueous spray of $10^8$ spores/ml strength was applied at pod initiation stage. Observations were recorded seven days after spraying for number of larvae for meter crop row and yield at harvest.

Treatment effects on all the parameters were not significant (**Table 76**) and *B. bassiana* infection was not observed in the field. However, in treatment DSRBB5 lower semiloopers population was (0.33 per mrl) recorded as compared to the control (0.67 per mrl). Population of *G. gemma* larvae was lower in all the treatments as compared to control (2.22 per mrl) and in the treatment DSRBB1 lowest population (0.22 per mrl) was recorded. The same treatment was found to be free from *S. litura* infestation as compared to the control treatment (0.33). Though treatment effects for grain yield were not significant, all the treatments yielded higher as compared to the control (291 Kg $ha^{-1}$), highest being recorded in DSRBB3 (423 Kg $ha^{-1}$) followed by the commercial strain (402 Kg $ha^{-1}$).

**Table 76: Efficacy of native *Beauveria bassiana* isolates against semiloopers and tobacco caterpillar in soybean in year 2013**

| Treatment | Number of larvae per meter 7DAT | | | Yield Kg $ha^{-1}$ |
|---|---|---|---|---|
| | **Semiloopers*** | ***Gesonia gemma*** | ***S. litura*** | |
| DSRBB1 | 0.67[a] (1.07) | 0.22[a] (0.84) | 0.00[a] (0.71) | 373[a] |
| DSRBB2 | 1.67[a] (1.46) | 0.44[a] (0.95) | 0.33[a] (0.90) | 391[a] |
| DSRBB3 | 0.67[a] (1.05) | 1.11[a] (1.21) | 0.55[a] (1.02) | 423[a] |
| DSRBB5 | 0.33[a] (0.90) | 1.33[a] (1.35) | 1.00[a] (1.17) | 266[a] |
| NBAIIBB | 0.67[a] (1.07) | 0.88[a] (1.17) | 0.33[a] (0.90) | 316[a] |
| Commercial | 0.78[a] (1.09) | 1.11[a] (1.24) | 1.67[a] (1.25) | 402[a] |
| Control | 0.67[a] (1.08) | 2.22[a] (1.60) | 0.33[a] (0.90) | 291[a] |
| F (*df* = 6, 12) | 1.71 | 1.92 | 0.54 | 1.87 |
| P>F (ANOVA) | 0.20 | 0.15 | 0.78 | 0.15 |

Figures in the parentheses are square root transformed values. Means within a column followed by the same alphabet are significantly not different (Tukey's test, P>0.05).
**Chrysodeixis acuta +Diachrysia orichalcea* DAT: days after treatment

**5. Biological control of pests of gingelly (OUAT)**

**Crop got completely damaged due to severe cyclone in Orissa. The trial will be conducted in the next season.**

## 2.11. Coconut

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

An outbreak of *Opisina arenosella* was noticed in Paruthikuzhi area of Trivandrum Dist. during April 2013 in West Coast Tall variety coconut palms aged above 30 years with a spread of about 2ha of area. An average leaf damage of 79.34 ± 2.56% and pest population of 203/100 leaflet was recorded. An awareness campaign on biological control of the pest was conducted in the area during April 2013 with active participation of Parasite Breeding Station, Trivandrum, Department of Agriculture and peoples representatives of the locality.

Regular monitoring and release of larval parasitoids *viz*, *Goniozus nephantidis* and *Bracon brevicornis* were undertaken @ 20 parasitoid / palm at monthly intervals. Leaf damage due to pest attack showed significant reduction during March 2014 (16.75±1.49% leaf damage) and pest population also showed reduction (76.35%) after release of parasitoids (**Table 77 and 78**). The palms and pest incidence are being monitored.

**Table 77: Coconut leaf damage (%) and population of the *Opisina arenoeslla* at Paruthikuzhi (Trivandrum Dist., Kerala)**

| **Leaf damage in coconut by *O. arenosella*** | | **t value** |
|---|---|---|
| **Period** | **Mean percent leaf infestation ± SE** | |
| April 2013 | 74.39 ±2.56 | |
| October 2013 | 35.16±1.21 | 14.12* |
| March 2014 | 16.76±1.49 | 22.58* |
| Reduction in leaf damage (%) | 77.47 | |

**Table 78: Population of *O. arenosella* at Paruthikuzhi (Trivandrum Dist., Kerala)**

| **Period** | **Population of *O. arenosella* (Number/100 leaflet)** | **Natural enemies recorded (number of cocoons /100 leaflet)** |
|---|---|---|
| April 2013 | 203 | *Apanteles taragamae (10)*<br>*Goniozus nephantidis (2)*<br>*Brachymeria nosatoi(6)* |
| October 2013 | 112 | *Apanteles taragamae (7)*<br>*Goniozus nephantidis (24)*<br>*Brachymeria nosatoi (8)*<br>*Bracon brevicornis (16)* |
| March 2014 | 48 | *Apanteles taragamae (3)*<br>*Goniozus nephantidis (10)*<br>*Bracon brevicornis (8)* |
| Reduction in pest population (%) | 76.35 | |

**Demonstration on Integrated management of *Opisina arenosella* in Karnataka:**

A demonstration trial was laid out by CPCRI Scientists in the coconut garden of Sri P. Rudrappa, Jajur village, Jajuru post, Arasikere (Tq.), Hassan (Dist.) during December 11-13, 2013. All pest and palm health management strategies were showcased in the demonstration trial comprising of 50 palms of Tiptur Tall variety. Pest management included removal of 3-4 older pest-infested leaves and application of chlorantriniprole @ 0.1 ml /l of water. Stage specific parasitoids *viz.*, *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoid/palm were released subsequently. Opening trenches around the basin of the palm, incorporation of 25 kg FYM and 50% recommended dose of fertilizers coupled with drip irrigation were included in health improvement strategies. Disease-suppressive compost technology using *Trichoderma* sp. is also displayed as part of demonstration. Plot was monitored at monthly intervals. Leaf damage due to pest attack showed a reduction of 33.54% over a period of 4 months.

**2. Scaling up utilization of *M. anisopliae* through technology transfer (CPCRI)**

Training on production of *M.anisopliae* for biological suppression of coconut rhinoceros beetle was imparted to farmers with emphasis on women groups (3 groups from 2 districts of Kerala). Awareness programmes through field level farmers interactive meetings (9 programmes) and mass media utilization were done for technology transfer.

**Training on farm level mass production of *M. anisopliae***

1) Training programme by master trainees of Edava Womens Association (capacity building by CPCRI) to Women group of Kollam Dist, during November 2013.
2) One day training for a group of 50 farmers from Cherthala particularly farm women on February 2014.
3) Women self help group of Bharanikkavu Krihsibhavan during March 2014.

Mass multiplied *Metarhizium anisopliae* in the laboratory in rice media at CPCRI, Kayamkulam. Well sporulated fungal colures were packed as 100g packets which were used for field application of the breeding sites of rhinoceros beetle. 150kg of *Metarhizium* anisopliae culture were supplied to farmers. Treatment of breeding sites (1186 sites) of rhinoceros beetle in 4 panchayaths were undertaken in collaboration with farmers club NABARD (Krishnapuram), FFS members (Kandalloor), Milk society members (Devikulangara) and farmers direct contact with CPCRI, Kayamkulam.

**3. Entomopathogenic nematodes for management of Red palm weevil (*Rhynchophorus ferrugineus*) (CPCRI)**

In general, 5-7% palms are infested by red palm weevil in the country and being a concealed borer it becomes fatal enemy of coconut on most occasions.

Higher virulence of local entomopathogenic nematode (EPN) strain of *Heterorhabditis indica* (LC 50 =355.5 IJ) in the suppression of *Rhynchophorus ferrugineus grubs* as well as greater susceptibility (82.5%) of pre-pupal stage than that of grubs was indicated. Synergistic interaction of *H. indica* (1500 IJ) with imidacloprid (0.002%) against red palm weevil grubs was reported for the first time. Imidacloprid dose used in the interaction study was one-tenth of recommended dose employed for curative management of the pest. Combined application of *H. indica* and imidacloprid (0.002%) would be an effective curative treatment in the field level management of red palm weevil in coconut.

Field evaluation of EPN alone on talc based preparation was not very encouraging for curative treatment of red palm weevil infestation on coconut palm. Delivery of EPN in water suspension was found ineffective as it enhanced the moisture content of damaged tissues further and failed to infect the host under higher moisture regime. A unique delivery mechanism of cadaver form impregnated in filter paper sachets was found effective when placed on leaf axils of infested palms. Placement of three filter paper sachets containing 12-15 *H. indica*-infected *Galleria mellonella* cadavers on the leaf axils after application of 0.002% imidacloprid is being field evaluated.

## 2.12. Tropical Fruits

### 1. Field evaluation of *Metarhizium anisopliae* against mango hoppers (KAU, MPKV, IIHR)

### KAU - THRISSUR

1. Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers *Idioscopus niveosparsus* (Leth.)

   Location: Instructional Farm, Vellanikkara, Thrissur
   Season: January 2014 – March 2014
   Design: CRD
   Treatments: 6
   Replication: 5
   Variety: Prior
   T1: *Metarhizium anisopliae* oil formulation @ 1ml/2l
   T2: *M. anisopliae* liquid formulation @ 1ml/2l
   T3: *M. anisopliae* talc formulation 10g/l
   T4: Chemical- Imidacloprid @0.3ml/l
   T5: Botanical- Nimbicidine @0.3 %
   T6: Control

Different formulations of *Metarhizium* along with chemical and botanical insecticides were evaluated against mango hoppers. Three sprayings were done from January onwards at weekly intervals. Observations on the number of hoppers per inflorescence were recorded before and after treatment application. Recorded the fruit set per inflorescence also. Observations were made from five panicles per tree. The results are given in **Table 79.**

**Table 79: Effect of *M. anisopliae* formulations against *Idioscopus niveosparsus***

| Treatments | Number of hoppers per panicle | | | Fruit set (number/panicle) |
|---|---|---|---|---|
| | Pre count | Post count | | |
| | | 1st spray | 2nd spray | |
| *M. anisopliae* oil formulation @ 1ml/2l | 5.13 | 2.87 $^{bc}$ | 1.49 $^{c}$ | 1.26 |
| *M. anisopliae* liquid formulation @ 1ml/2l | 5.41 | 3.31 $^{b}$ | 2.28 $^{b}$ | 1.34 |
| *M. anisopliae* talc formulation 10g/l | 5.36 | 3.00 $^{bc}$ | 2.27 $^{b}$ | 1.33 |
| Imidacloprid @0.3ml/l | 5.53 | 0.71 $^{d}$ | 0.71 $^{d}$ | 1.55 |
| Nimbicidine @0.3 % | 4.95 | 2.51 $^{c}$ | 1.30 $^{cd}$ | 1.30 |
| Control | 5.07 | 4.55 $^{a}$ | 3.37 $^{a}$ | 1.09 |
| Significance | NS | S** | S** | NS |
| CV % | 13.33 | 18.73 | 28.2 | 19.44 |

Data was analysed after $\sqrt{X+0.5}$ transformation
S**- Significant at 1% level NS-Non Significant

Significant reduction in hopper population was found in chemical sprayed trees followed by Nimbicidin sprayed trees. Liquid and talc formulations of *M. anisopliae* were on par in reducing the hopper population and these treatments were significantly superior than control. Oil formulation of *M. anisopliae* was found superior than the other two *M. anisopliae* formulations, and it was on par with Nimbicidin. There was no significant difference between treatments in fruit set.

**MPKV - Pune**

***Idioscopus niveosparsus* (L.)**

The trial was laid out in the mango orchards at Regional Fruit Research Station, Ganeshkhind, Pune in December 2013. Each treatment block had 50 trees which further divided into five sub-plots as replicates. The planting distance was 10 x 10 m. The treatments comprised application of *Metarhizium anisopliae* @ 1 x $10^9$ spores/ml with adjuvant (sunflower oil 1 ml/l + Triton-X 100 @ 0.1 ml/l) during off-season followed by four sprays of the fungal preparation during flowering at weekly interval, four sprays of *M. anisopliae* @ 1 x $10^9$ spores/ml with adjuvant during flowering, four sprays *M. anisopliae* @ 1 x $10^7$ spores/ml with adjuvant during flowering, one spray of imidacloprid @ 0.3 ml/l during flowering and untreated control. The hopper population was recorded before treatment applications and post counts a week after each spray from four inflorescence per tree and as such 10 trees per plot as well as number of fruits set per inflorescence. The off-season spray of *M. anisopliae* was given on 16/12/2013 and subsequent four sprays were given during flowering starting from 24/01/2014. Data on surviving hopper population were transformed into √x+0.5 values before subjecting to analysis of variance.

The results in **Table 80** show that spraying of *M. anisopliae* @ 1 x $10^9$ spores/ml during offseason in the month of December followed by four sprays of the pathogen mixed with adjuvant (sunflower oil 1 ml/lit + Triton- X 100 @ 0.1 ml/lit) at weekly interval during flowering found significantly superior over other treatments in suppressing the hopper population and increased fruit setting. The mean surviving population was recorded as 10.6 hoppers and 11.8 fruit sets per inflorescence in this treatment as against 53.2 hoppers and 5.7 fruits set of mango per inflorescence in untreated control block.

**Table 80: Effect of *Metarhizium anisopliae* on hopper population and fruit set of mango**

| Treatment | Hopper population/ inflorescence, 7 days after spray | | | | | | Fruit set / inflore scence |
|---|---|---|---|---|---|---|---|
| | Pre-count | I | II | III | IV | Aver-age | |
| T1: *M. anisopliae* @ 1 x $10^9$ spores/ml with adjuvant - 1 spray in off-season + 4 sprays in flowering | 37.2 [a] | 21.3 [b] | 10.8 [a] | 7.2 [a] | 2.9 [a] | 10.6 [a] | 11.8 [a] |
| T2: *M. anisopliae* @ 1 x $10^9$ spores/ml with adjuvant - 4 sprays in flowering | 35.7 [a] | 26.2 [b] | 18.7 [b] | 16.3 [b] | 6.9 [b] | 17.0 [b] | 10.4 [a] |
| T3: *M. anisopliae* @ 1 x $10^7$ spores/ml with adjuvant - 4 sprays in flowering | 35.4 [a] | 26.9 [b] | 20.4 [b] | 17.2 [b] | 11.7 [c] | 19.0 [c] | 8.9 [b] |
| T4: Imidacloprid @ 0.3 ml/l -1 spray at pre-flowering | 37.0 [a] | 13.9 [a] | 17.7 [b] | 21.9 [c] | 24.7 [d] | 19.6 [c] | 8.2 [b] |
| T5: Untreated control | 37.0 [a] | 43.9 [c] | 52.2 [c] | 63.2 [d] | 53.4 [e] | 53.2 [d] | 5.7 [c] |
| **CD (p = 0.05)** | **NS** | **0.80** | **0.78** | **0.80** | **0.73** | **0.44** | **1.90** |

**IIHR**

The experiment was carried out in a farmer's field situated at Hessarghatta, Bangalore. Spraying was initiated under field condition with the appearance of 4 -5 adult hoppers / panicle. Four treatments were included in addition to control and check. The oil and liquid formulation were sprayed at 1ml/2L, while talc @ 10g/1L covering the tree uniformly. Each treatment consisted of 10 trees where each tree represented a replication. A total of three sprays of the formulations at five days interval were done, while a single spray of chemical pesticide confidor @ 0.3ml /L was given. Sprays were given in the evening hours. Hoppers remain hidden during sunlight and move to the panicles in the early morning and late evening period. Observations were made on the number dead at 24 hours interval till 72 hours after each spray. Second and third spray of the formulation was given at 5 days interval.

At 72 hrs of first spray, oil and liquid formulations recorded 54 and 69 per cent mortality while talc recorded 75 per cent mortality while by 8th day 85 and 93 per cent mortality was recorded. Talc formulation recorded 75 and 100 per cent mortality by 72 and 144 hrs respectively. However, 100 percent mortality was recorded by third application of oil, liquid and talc formulations. In all treatments including formulations, no recurrence of hoppers could be recorded **(Table 81)**.

**Table 81: Effect of biological control on hopper population**

| Treatments | Post count and percent inhibition after spray | | | | | |
|---|---|---|---|---|---|---|
| | 1st spray | | 2nd spray | | 3rd spray | |
| | 48 hrs (2nd day) | 72 hrs (3rd day) | 144 hrs (7th day) | 170 hrs ( 8th day) | 288hrs ( 12th day) | 312hrs ( 13th day) |
| Oil formulation of *M. anisopliae* | 46.15 | 53.84 | 75.00 | 84.61 | 92.20 | 100 |
| Water formulation | 53.84 | 69.23 | 84.61 | 92.85 | 100 | 100 |
| Talc formulation | 66.66 | 75.00 | 100 | 100 | 100 | 100 |
| Chemical | 83.24 | 100 | - | - | - | - |
| Control | 0 | 0 | 0 | 0 | 0 | 0 |

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

**CISH**

**1. Parasitoids and Predators:**

A roving survey was conducted in mango growing belts of Uttar Pradesh. During survey four districts were covered viz., Lucknow, Faizabad, Sitapur and Unnao. About 25 different natural enemies have been collected from the mango ecosystem, comprising of Coccinellids, Syrphids and spiders, whereas parasitoids belonging to three major families' *viz*., Ichnuemoniid, Braconid and Chalcidid. Detailed identification of the collected natural enemies is yet to be ascertained.

## 2. Entomopathogenic nematodes:

A random survey was conducted in Sitapur district of Uttar Pradesh for the isolation of entomopathogenic nematodes (EPN). 25 samples of 500 g each were collected from surface soils of mango orchards. They were baited with last instar larvae of *Galleria mellonella* and observed for mortality for a week. Based on the characteristic colour change of cadaver they were placed on modified white traps for the extraction of EPNs. Out of the 25 samples, only one sample tested positive for the presence of EPN and it has been identified as *Steinernema* sp. belonging to the '*Steinernema carpocapsae*' and is designated as *Steinernema* sp. strain CISH-3.

## 3. Biological suppression of mealy bugs, *Maconellicoccus hirsutus* and *Ferrisia virgata* with *Scymnus coccivora* on custard apple (MPKV)

### MPKV - Pune

A field evaluation of predators against mealy bugs on custard apple was carried out in farmers' orchards at village Waghapur Tal. Haveli, Dist. Pune. The custard apple (cv. Balanagar) orchards were 5 years old and planted at 5 x 5 m distance. A separate orchard (0.15-0.20 R) was selected for release of each predators, *Scymnus coccivora* @ 5 and 10 grubs/infested tree, *Cryptolaemus montrouzieri* @ 5 grubs/tree and spraying of *Lecanicillium lecanii* @ $10^{13}$ conidia/ha. The applications of bioagents carried out twice during July-August 2013 at monthly interval. Untreated control plot was maintained separately. The incidence of mealy bug species, *Maconellicoccus hirsutus* and *Ferrisia virgata* were recorded before release of the predators and post-counts at fortnightly interval from 10 fruits per tree and as such from 10 randomly selected trees per plot. Cumulative means were worked out from the surviving mealy bugs population recorded at fortnightly interval. The data were transformed into $\sqrt{x+0.5}$ values for statistical analysis. The intensity rating of mealy bugs on fruits was recorded in 1-5 scale from the same trees of each plot. The yield of marketable fruits per tree was recorded on weight basis at harvest. Data in **Tables 82, 83** and **84** revealed that two releases of *Scymnus coccivora* @ 10 grubs per infested tree at monthly interval during July-August 2013 found to be significantly superior in suppressing the population of mealy bug species *viz.*, *M. hirsutus* (10.6 mealy bugs/fruit) and *F. virgata* (3.6 mealy bugs/fruit) in custard apple orchards and increased yield of marketable fruits (34.9 kg/tree). It was, however, at par with similar releases of *Cryptolaemus montrouzieri* @ 5 grubs per infested tree. The pest intensity rating was recorded low (1.0-1.2) in these treatment orchards.

**Table 82. Effect of release of predators for the control of *M. hirsutus* in custard apple**

| Treatment | Mealy bugs population /infested fruit | | | | | |
|---|---|---|---|---|---|---|
| | Pre-count | I release | | II release | | Average |
| | | 15 DAR | 30 DAR | 15 DAR | 30 DAR | |
| T1: *S. coccivora* @ 5 grubs/tree | 24.6 [a] | 21.8 [b] | 18.6 [b] | 13.7 [b] | 7.8 [b] | 15.5 [b] |
| T2: *S. coccivora* @ 10 grubs/tree | 24.9 [a] | 19.2 [a] | 14.5 [a] | 7.2 [a] | 1.4 [a] | 10.6 [a] |
| T3: *V. lecanii* @ $10^{13}$ conidia/ha | 24.6 [a] | 21.9 [b] | 20.6 [b] | 14.7 [c] | 6.5 [b] | 15.9 [b] |
| T4: *C. montrouzieri* @ 5 grubs/tree | 24.8 [a] | 17.2 [a] | 14.3 [a] | 8.4 [a] | 1.8 [a] | 10.4 [a] |
| T5: Untreated control | 24.7 [a] | 30.2 [c] | 33.1 [c] | 37.9 [d] | 51.9 [c] | 38.3 [c] |
| **CD (p = 0.05)** | **NS** | **0.42** | **0.51** | **0.50** | **0.60** | **0.29** |

**Table 83: Effect of release of predators for the control of *F. virgata* in custard apple**

| Treatment | Mealy bugs population /infested fruit | | | | | |
|---|---|---|---|---|---|---|
| | Pre-count | I release | | II release | | Average |
| | | 15 DAR | 30 DAR | 15 DAR | 30 DAR | |
| T1: *S. coccivora* @ 5 grubs/tree | 10.2 [a] | 9.1 [a] | 4.3 [a] | 3.6 [b] | 1.9 [b] | 4.7 [b] |
| T2: *S. coccivora* @ 10 grubs/tree | 9.9 [a] | 9.0 [a] | 3.9 [a] | 1.2 [a] | 0.3 [a] | 3.6 [a] |
| T3: *V. lecanii* @ $10^{13}$ conidia/ha | 9.9 [a] | 8.9 [a] | 5.8 [b] | 4.5 [c] | 2.7 [c] | 5.5 [b] |
| T4: *C. montrouzieri* @ 5 grubs/tree | 10.1 [a] | 8.3 [a] | 4.9 [a] | 1.9 [a] | 1.0 [a] | 4.0 [a] |
| T5: Untreated control | 10.0 [a] | 11.9 [b] | 17.0[c] | 19.9 [d] | 22.9 [d] | 17.9 [c] |
| CD (p = 0.05) | NS | 0.49 | 0.34 | 0.37 | 0.36 | 0.22 |

**Table 84: Effect of release of predators on intensity of mealy bugs and yield of Custard apple**

| Treatment | Pest intensity rating | Yield (kg / plant) |
|---|---|---|
| T1: *S. coccivora* @ 5 grubs/tree | 1.5 | 29.3 [b] |
| T2: *S. coccivora* @ 10 grubs/tree | 1.0 | 34.9 [a] |
| T3: *V. lecanii* @ $10^{13}$ conidia/ha | 1.3 | 30.4 [b] |
| T4: *C. montrouzieri* @ 5 grubs/tree | 1.2 | 33.1 [a] |
| T5:Untreated control | 2.6 | 23.6 [c] |
| **CD (p = 0.05)** | | **4.32** |

**4. Monitor and record of incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts (MPKV, KAU, OUAT, TNAU, IIHR, NBAII)**

**MPKV - Pune**

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

The incidence of papaya mealy bug (PMB) was noticed to the extent of 12.8 to 21.0 per cent in Pune, Jalgaon, Dhule, Nandurbar and Ahmednagar districts in western Maharashtra. The average pest population density was relatively low during this year (23.5 mealy bugs/ leaf) in Pune district followed by Nandurbar and Dhule. The population of parasitoid, *A. papayae* recorded more (10.6 adults/leaf) in Pune region than other parts of the state **(Table 85)**. Severe population of PMB was also observed in pigeon pea and weed velvet leaf locally called as *Pethari* (*Abution indicum* L.) heavily parasitized by *Acerophagus papayae*.

**Table 85: Survey and record of papaya mealy bug in western Maharashtra**

| District surveyed | PMB incidence (%) | Pest intensity rating | *A. papayae* adults/leaf |
|---|---|---|---|
| Pune | 21.0 | 2.8 | 10.6 |
| Ahmednagar | 13.6 | 2.1 | 4.2 |
| Jalgaon | 12.8 | 2.4 | 3.7 |
| Dhule | 16.6 | 2.2 | 4.6 |
| Nandurbar | 20.8 | 2.8 | 5.8 |
| Nashik | 0.0 | 0.0 | 0.0 |
| Solapur | 3.8 | 1.6 | 2.7 |
| Kolhapur | 2.4 | 1.8 | 2.4 |
| Satara | 2.6 | 1.3 | 2.1 |
| Sangli | 1.2 | 1.0 | 1.6 |
| **Range** | **1.2-21.0** | **1.0-2.8** | **1.6-10.6** |

In addition, three papaya orchards from Pune region were regularly visited twice in a month during the period from March to December 2013 and recorded PMB incidence and pest intensity rating. Data in **Table 86** The incidence of PMB was recorded high during the period from April to July 2013 with peak during June 2013 (14.6 to 25.1%). Natural enemies particularly the parasitoid *Acerophagus papayae* population was increased enormously during May to July and again in October 2013 (10 to 20 adults/ leaf) which resulted in drastic decline in mealy bug population at Baner and Loni Kand orchards in October 2013. Thereafter, the PMB incidence was gradually declined till December 2013 (0.8 to 2.4%) with existence of the parasitoids (av. 3.6 adults/leaf). In Baner orchard, the parasitoids *Acerophagus papayae* N. and S. as well as *Pseudleptomastix mexicana* N. and S. and predator *Spalgis epius* were recorded.

**Table 86: Monitoring the incidence of papaya mealy bug in Pune region of Maharashtra.**

| Month | PMB incidence (%) and Pest intensity rating | | |
|---|---|---|---|
| | G1 (Baner) | G2 (Ganeshkhind) | G3 (Loni Kand) |
| April 2013 | 13.2 (1.2) | 9.8 (1.3) | 8.6 (1.1) |
| May 2013 | 15.2 (2.1) | 16.9 (2.2) | 12.0 (2.2) |
| June 2013 | 25.1 (2.7) | 15.0 (2.3) | 14.6 (2.4) |
| July 2013 | 18.4 (1.6) | 11.0 (1.9) | 10.7 (1.9) |
| August 2013 | 13.4 (1.2) | 7.0 (1.4) | 8.3 (1.1) |
| September 2013 | 4.3 (1.0) | 3.0 (1.3) | 4.3 (1.0) |
| October 2013 | 5.6 (1.4) | 2.5 (1.0) | 1.5 (1.0) |
| November 2013 | 4.8 (1.3) | 1.1 (1.2) | 1.3 (1.1) |
| December 2013 | 2.4 (1.0) | 0.8 (1.0) | 1.1 (1.2) |

Figures in bracket are pest intensity rating (1-5)

**Natural enemies recorded in the papaya mealy bug colonies:**

i. Encyrtid parasitoid, *Acerophagus papayae* N. & S.
ii. *Pseudleptomastix mexicana* N. & S.
iii. *Spalgis epius* (Westwood)
iv. *Coccinella septempunctata* Linn.
v. *Scymnus* sp.
vi. Anthocorids
vii. *Mallada* sp.
viii. *Brumoides* sp.
ix. Syrphids
x. Spiders

**Alternate hosts of papaya mealy bug in Maharashtra**

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

1. Pigeon pea (*Cajanus cajan* L.)
2. Weed Velvet leaf locally called Pethari (*Abution indicum* L. )
3. Parthenium (*Parthenium hysterophorus* L.)
4. Safed chafa (*Plumeria alba*) and
5. Mulberry (*Morus* sp.) and
6. Teak (*Tectona grandis* L.)

**KAU - Thrissur**

Random survey was carried out in different districts of Kerala. The pest incidence was low in all areas. Survey showed that the parasitoid established very well in all areas **(Table 87)**. Other hosts in which papaya mealy bug infestation was noticed were tapioca and change rose (*Hibiscus mutabilis*). Parasitisation level of *Acerophagus papayae* on tapioca was studied and it was found that there was up to 27.8 per cent parasitism.

**Table 87: Details of incidence of papaya mealybug and its parasitoid**

| No. of Villages surveyed in different districts | Plants infested (%) | Infestation grading | Incidence of *A. papayae* |
|---|---|---|---|
| Thrissur - 11 | 1.6 | Medium | Present |
| Ernakulam - 4 | 1.14 | Medium | Present |
| Palakkad - 5 | Not observed | | |
| Malappuram - 5 | Not observed | | |
| Wayanad - 6 | 5.48 | Medium | Present |
| Kozhikode - 4 | 1.5 | Very low to medium | Present |
| Kasaragod - 5 | Not observed | | |
| Trivandum -5 | Not observed | | |

Impact on savings by the suppression of papaya mealybug.

In Kerala, papaya has not been grown on plantation scale. It is cultivated only in homesteads for vegetable and fruit purposes. There are approximately 78 lakhs homesteads in Kerala, out of 78 lakhs homesteads, 25% per cent is having at least one papaya plant per homestead and so papaya plants in Kerals is considered as 20 lakhs. Average yield of a papaya plant is five kg. and cost of one kg papaya is Rs. 5. Thus the monitory benefit is approximately five crores per annum.

Mulberry**:** Mulberry is cultivated in about 300 acres in Kerala, mainly in Idukki, Wayanad and Palakkad districts. During 2009-10 periods mulbbery cultivation was severely infested by papaya mealybug. Suppression of papaya mealybug by the parasitoid saved the silk industry in Kerala. Average cocoon production per year is 350 kg/ acre and from 300 acres, the production is 105000 kg per year and average cost of cocoon is Rs. 200/ kg. The income from 300 acres comes about 2.1 crores. The estimated cost of production of cocoon is as Rs. 32000/ year/ acre and for 300 acres Rs. 96 lakhs per year. The net income is 1.1 crores/ year.

Tapioca**:** In Kerala total area for tapioca cultivation is 75000 ha and production 30t/ha. The mealybug infestation affected the tapioca production also. Approximate cost of cultivation is Rs. 50,000/ ha and the income Rs. 3 lakh/ha/year (@ Rs. 10000/ t). Thus the net savings is 2.5 lakhs/ha and 1.8 crores/ year in Kerala.

Infestation of papaya mealybug was observed on rubber trees and in teak nurseries. Timely release of the parasitoid saved these plantation crops without much crop loss. Maintained the culture of *Acerophagus papaya*e in the laboratory

**TNAU - Coimbatore**

**Results:**

Survey conducted in four districts of Tamil Nadu *viz*., Coimbatore, Erode, Tiruppur, and Salem indicated that a very low incidence of *Paracoccus marginatus* ranging from 0.0 to 11.5 per cent during July 2013 to February 2014 on papaya. In general, the incidence was more during October to February (**Table 88**). *Paracoccus marginatus* was also observed on other crops viz., cotton, tapioca, mulberry, jatropa and tomato from 0 to 11 per cent (**Table 88**). *Acerophagus papayae*, *Cryptolaemus montrouzieri*, *Spalgis epius* and *Stethorus* were observed on papaya mealybug in all the four districts (**Table 88**).

**Table 88: Incidence of papaya mealybug on papaya and its natural enemies**

| **Places surveyed** | **Period** | ***P.marginatus* incidence (%)** | **Natural enemy/5 leaves** | | | |
|---|---|---|---|---|---|---|
| | | | ***A.papayae*** | ***Cryptolaemus*** | ***Stethorus*** | ***Spalgis epius*** |
| Coimbatore | July 13 | 3.5 | 0 | 1 | 0 | 0 |
| | Aug 13 | 1.0 | 0 | 0 | 0 | 1 |
| | Sep 13 | 2.5 | 1 | 0 | 0 | 0 |
| | Oct 13 | 5.5 | 0 | 2 | 0 | 0 |
| | Nov13 | 3.0 | 2 | 0 | 0 | 1 |
| | Dec 13 | 7.0 | 2 | 1 | 1 | 2 |
| | Jan 14 | 8.5 | 5 | 3 | 2 | 0 |
| | Feb14 | 9.0 | 5 | 1 | 2 | 1 |
| Tiruppur | July 13 | 0.0 | 0 | 0 | 0 | 1 |
| | Aug 13 | 4.5 | 1 | 2 | 0 | 0 |
| | Sep 13 | 3.0 | 2 | 1 | 0 | 0 |
| | Oct 13 | 6.5 | 2 | 2 | 1 | 0 |
| | Nov13 | 5.0 | 2 | 0 | 1 | 2 |
| | Dec 13 | 7.5 | 5 | 1 | 0 | 1 |
| | Jan 14 | 8.0 | 3 | 1 | 2 | 0 |
| | Feb14 | 10.5 | 7 | 2 | 1 | 0 |
| Erode | July 13 | 3.0 | 0 | 0 | 0 | 1 |
| | Aug 13 | 7.0 | 2 | 1 | 1 | 1 |
| | Sep 13 | 8.5 | 3 | 0 | 0 | 0 |
| | Oct 13 | 4.0 | 1 | 0 | 0 | 0 |
| | Nov13 | 6.0 | 3 | 2 | 1 | 0 |
| | Dec 13 | 8.0 | 3 | 1 | 0 | 2 |
| | Jan 14 | 11.5 | 4 | 2 | 2 | 1 |
| | Feb14 | 8.5 | 2 | 0 | 0 | 1 |
| Salem | July 13 | 2.5 | 0 | 0 | 0 | 0 |
| | Aug 13 | 5.5 | 1 | 2 | 1 | 1 |
| | Sep 13 | 5.0 | 0 | 0 | 0 | 2 |
| | Oct 13 | 10.5 | 5 | 1 | 0 | 1 |
| | Nov13 | 8.5 | 2 | 0 | 2 | 0 |
| | Dec 13 | 6.0 | 2 | 0 | 1 | 2 |
| | Jan 14 | 11.5 | 4 | 2 | 1 | 1 |
| | Feb14 | 7.5 | 3 | 0 | 0 | 1 |

**IIHR**

Regular field visits have been carried out to monitor the permanent establishment of *Acerophagus papaya* in the field. As far as papaya mealybug *Paracoccus marginatus* is concerned, no fresh damage could be seen in orchards or areas anywhere in and around Bangalore where earlier releases of *A. papaya* were made. Only in one occasion a small level infestation of mealybug was observed in papaya nursery plants. However, the infestation was got controlled by naturally occurring *A. papaya*. This observation revealed that the parasitoid got permanently established in the field. No introduction of parasitoid is required in any orchards. The presence of mealybug was not observed either on alternate hosts such as parthenium weeds or other flora (Okra, brinjal, tomato, mulberry etc) near the papaya orchards and other places. This means that in general there is a great reduction in papaya mealybug population in nature by the action of introduced parasitoid.

**NBAII**

Based on the samples received from various sources and also the survey conducted for the incidence of papaya mealybug in Karnataka it was observed that the infestation was very low and scanty.

**Papaya mealybug on Mulberry:** Infestation in mulberry was surveyed in the districts of Tumkur, Mandya, Chamarajnagar, Ramanagar, Kollegal, Kolar and Hassan the results are presented below.

Incidence of papaya mealybug was very low in almost all the locations surveyed in Karnataka. Damages in the score of 3 (1-5 Scale) and below only were observed sporadically in homesteads. Survey in about 25 orchards of papaya in Mandya, Bangalore, Kanakapura, Mysore, Chamarajanagar, Nelamangala, Devanahalli, Kolar, Tumkur road, Kollegal, Maddur and Hassan. *Acerophagus papaya* was found in all the places where ever papaya mealybug was observed. *Spalgius apius* was also recorded **(Table 89)**.

**Table 89: Occurrence of papaya mealybug on Papaya, weeds and other host plants in Karnataka**.

| Area Surveyed | Level of incidence | Percent parasitization by *A. papayae* | Other predators/ parasitoids |
|---|---|---|---|
| Tumkur<br>Nelamangala, Kunigal, Hirehalli, Kyatahsandra, Chiknayakanahalli, KB Cross and surrounding areas | Very low incidence<br>Below 1% level | Parasitoids observed where ever mealybugs collected. | Nil |
| Mandya<br>Mandya, Madla, V.C. Farm, Melkote Road, KRS Road, Maddur, K.M. doddi. Kollegal road | Very low incidence below 1% level | Parasitoids present | *Spalgius* present<br>*P. mexicana* |
| Ramnagar, Kollegal road, Nagamangala road, Magadi road, Maddur road | Very low incidence below 1% level | Scanty | nil |
| Kollegal<br>Muttathi Road | Very low incidence few Parthenium plants had mixed mealybug infestation | Scanty | |
| Chamarajnagar,<br>Hadi, BR hills road, | 2 percent of mulberry near the road side damaged | Parasitoids present 20-28% | *P. mexicana* |
| Kolar | Very low incidence (<1%) | | |
| Hassan | Very low incidence (<1%) | | |

Hibiscus was found to harbor papaya mealybug in low populations in most of the localities surveyed. On Hibiscus papaya mealybug was found invariably associated with Meconellicoccus hirsutus, Phenacoccus solenopsis, Ferrisia virgata, on tapioca it was found associated with *P. madeirrensis*. *Acerophagus papaya* parasitized upto 72 percent on hibiscus (mean of 8 observations).

Several weeds were found to harbor papaya mealybug, predominant ones are the *Parthenium, Sida acuta, Acalypha*, and crotons. A high level of 84-86 per cent parasitization was observed in PMB infesting Parthenium and 72-79 per cent in case of *Sida acuta* and *Acalypa.* On Croton Parasitization was low with 29-42 percent. In the previous study in laboratory it was confirmed that there was no significant variation in parasitization by *A. papaya* on PMB grown on different weed species.

**Supply of cultures:** *Acerophagus papaya* cultures were sent to Nashik, Rajamundry, OUAT Bhuvaneshwar, Guwahati, Madhurai, Pondicherry, Kyangulam, Rayakottai, Ananthpur, Chittoor in addition to local supplies in Karnataka

**5. Biocontrol of papaya mealy bug in Gujarat (AAU-A)**

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

Methodology (in detail):

A regular survey was be made in 5 randomly selected villages in each district of middle Gujarat region to determine the infestation of papaya mealy bug, *P. marginatus*. Farmers' fields were visited at fortnightly interval. 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) was determined.

| Grade | Population |
|---|---|
| 1 | very low |
| 2 | low |
| 3 | medium |
| 4 | high |
| 5 | very high |

Observations recorded:

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

Results in detail:

Very low and scanty incidence of papaya mealybug was recorded in all the surveyed areas, except for one garden at Sandeshar village in Petlad taluk of Anand district where severe incidence was noticed and the farmer burnt all the infested plants. It was found that sixteen fields in seven villages were found infested with mealy bug in Anand district.

## 6. Bio-efficacy of EPNs against citrus trunk borer, *Pseudonemorphus versteegi* (Ritsema)

### CAU - Pasighat

Field evaluation for bio-efficacy of EPNs against citrus trunk borer, *P. versteegi* were carried out at two locations *viz.* Pasighat and Ringging of Arunachal Pradesh. Fourteen treatments i. e. treatments with EPN strains CAU-1, CAU-2, CAU-3, CAUH-1, CAUH-2 and NBAII-1 as stem injection @ 50 ijs/ml of water and as cadaver application (wrapping two cadaver by muslin cloth and binding at one meter height from the ground level) separately, a check (stem injection with dichlorvos 0.05%) and an untreated control were maintained. In each location, three orchards were selected to serve as three replications of the treatments. For each treatment, ten infested plants were selected (140 infested plants/ orchard) and the numbers of holes with fresh frass materials were counted before applications of the treatments. Two rounds of application of the treatments were made once during last week of April and the second application at second week of May. Observations on the efficacy of the treatments were recorded at monthly interval starting from 2$^{nd}$ fortnight of May upto 2$^{nd}$ 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 89.53 and 89.71 per cent at Pasighat and rengging, respectively. Among the EPN treatments, CAU-1 stem injection (37.22 % reduction) was observed as the best treatment and it was closely followed by CAUH-1 stem injection (33.90% reduction), NBAII-01 stem injection (33.27% reduction) and CAUH-2 stem injection (32.54% reduction) at Pasighat. However, at Rengging, CAUH-1 stem injection gave the highest reduction in trunk borer infestation among the EPNs with 36.75% reduction and it was closely followed by CAU-1 stem injection (36.43% reduction), NBAII-01 stem injection (35.37% reduction) and CAUH-2 stem injection (33.33% reduction). The stem injections of the EPNs were found more effective than their respective cadaver treatments (**Table 90**).

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

| Treatments | Pasighat ( average of three orchard) | | | Ringging (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 | 14.33 | 9.00 | 37.22 (37.60) | 14.67 | 9.33 | 36.43 (37.12) |
| CAU-2 Stem injection | 12.33 | 8.67 | 29.44 (32.82) | 14.67 | 10.00 | 31.55 (34.14) |
| CAU-3 Stem injection | 13.00 | 9.33 | 27.63 (31.36) | 12.33 | 8.33 | 32.48 (34.73) |
| CAUH-1 Stem injection | 11.67 | 7.67 | 33.90 (35.59) | 14.67 | 9.33 | 36.75 (37.31) |
| CAUH-2 Stem injection | 13.33 | 9.00 | 32.54 (34.75) | 13.00 | 8.67 | 33.33 (35.24) |
| CAU-1 Cadaver application | 12.00 | 9.00 | 25.12 (30.08) | 12.33 | 10.00 | 21.58 (27.62) |
| CAU-2 Cadaver application | 13.33 | 10.00 | 24.98 (29.96) | 14.00 | 10.67 | 21.15 (27.28) |
| CAU-3 Cadaver application | 11.67 | 9.00 | 22.69 (28.43) | 14.00 | 11.33 | 18.89 (25.75) |
| CAUH-1 Cadaver application | 13.67 | 10.00 | 27.00 (31.21) | 14.33 | 10.67 | 25.56 (30.33) |
| CAUH-2 Cadaver application | 15.00 | 11.00 | 26.74 (31.15) | 13.00 | 9.67 | 25.55 (30.35) |
| NBAII-01 Stem injection | 13.00 | 8.67 | 33.27 (35.21) | 15.00 | 9.67 | 35.37 (36.48) |
| NBAII-01 Cadaver application | 12.67 | 9.33 | 26.50 (30.90) | 13.67 | 11.00 | 19.37 (26.08) |
| Dichlorvos Stem injection | 12.67 | 1.33 | 89.53 (71.01) | 14.00 | 1.00 | 89.71 (71.57) |
| Untreated control | 12.67 | 12.00 | 5.16 (16.10) | 13.33 | 12.33 | 7.51 (15.89) |
| SEd | 1.24 | 0.97 | 3.01 | 1.27 | 0.85 | 1.88 |
| $CD_{0.05}$ | NS | 1.99 | 6.19 | NS | 1.75 | 3.86 |
| CV% | | 13.39 | 10.96 | | 11.03 | 6.85 |

**Figures in the parentheses are angular transformed values.**

**7. Laboratory & field evaluation of entomopathogens against banana pseudostem weevil (KAU)**

**KAU - THRISSUR**

Laboratory and field evaluation of entomopathogens against *Odoiporus longicollis*

Design: CRD
Treatments: 4
Replication: 6

Treatments
T1: *Metarhizium anisopliae* ($10^7$ spores/ml)
T2: *Metarhizium anisopliae* ($10^8$ spores/ml)
T3: *Beauveria bassiana* ($10^7$ spores/ml)
T4: *Beauveria bassiana* ($10^8$ spores/ml)

First and second instar grubs & adults of banana pseudostem borer were treated with two different concentrations of the entomopathogens. The observations were taken from 5th day onwards. The cadavers were transferred to humid chamber daily. The infection of fungus was confirmed by observing the growth of fungus. The result is given in the **Table 91.**

**Table 91: Effect of entomopathogens on banana pseudostem borer**

| Treatments | Infected grubs (Per cent) |
|---|---|
| *M. anisopliae* ($10^7$ spores/ml) | 16.5 |
| *M. anisopliae* ($10^8$ spores/ml) | 74.9 |
| *B. bassiana* ($10^7$ spores/ml) | 24.9 |
| *B. bassiana* ($10^8$ spores/ml) | 83.3 |

*B. bassiana* ($10^8$ spores /ml) and *M. anisopliae* ($10^8$ spores /ml) were found causing good mycosis on grubs of banana pseudostem weevil.

There was no infection to the adults by spraying $10^7$ and $10^8$ spores/ml of *B. bassiana* and *M. anisopliae*. But it was found infected by *B. bassiana* at a concentration of $10^9$ spores /ml.

a. Field evaluation of entomopathogens against banana pseudostem weevil

Design: RBD
Treatments : 6
Replication: 5
Season : October 2013 - continuing

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

The treatments were applied from 4th month onwards at monthly interval. The experiment is in progress

**8. Laboratory and field evaluation of entomopathogens against pineapple mealybug *Dysmicoccus brevipes* (Cockerell) (Hemiptera: Pseudococcidae) (KAU)**

Laboratory and field evaluation of entomopathogens against pineapple mealybug *Dysmicoccus brevipes* (Cockerell)

a. Laboratory evaluation of entomopathogens against pineapple mealybug Design: CRD
   Treatments: 11
   Replication: 3

   TI: *Metarhizium anisopliae* ($10^7$ spores/ ml)
   T2: *M. anisopliae* ($10^8$ spores/ ml)
   T3: *M. anisopliae* ($10^9$ spores/ ml)
   T4: *Beauveria bassiana* ($10^7$ spores/ ml)
   T5: *B.bassiana* ($10^8$ spores/ ml)
   T6: *B. bassiana* ($10^9$ spores/ ml)
   T7: *Lecanicillium lecanii* ($10^7$ spores/ ml)
   T8: *L. lecanii* ($10^8$ spores/ ml)
   T9: *L. lecanii* ($10^9$ spores/ ml)
   T10: Imidacloprid 0.3 ml/l
   T11: Control (Distilled water)

The infested pineapple fruits collected from the field and were treated with the different concentrations of entomopathogens in the lab. The observations were taken from 3rd day onwards upto 7th day. The infection was noticed only in treatments with *L. leacanii* @ $10^8$ spores/ml & $10^9$ spores/ml. The cadavers were transferred to humid chamber. The infection of fungus is confirmed by observing mycosis. In chemical control all the mealybugs were found dead.

b. Field evaluation of entomopathogens against pineapple mealybug *Dysmicoccus brevipes*

Treatments : 5
Replication: 6
Season: October 2013 -continuing

T1: *Lecanicillium lecanii* @ $10^8$ spores/ml
T2: *Lecanicillium lecanii* @ $10^9$ spores/ml
T3: Imidacloprid 0.3ml/l
T4: Botanical
T5:Control
The crop is in the field. The experiment is in progress.

## 2.13. Temperate Fruits

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

Entomopathogenic fungi, *Metarhizium anisopliae* and *Beauveria bassiana* ($10^6$ conidia/ cm² each), and entomopathogenic nematodes, *Steinernema carpocapsae* and *Heterorhabditis indica* (80IJ/ cm² each) were evaluated against the apple root borer, *Dorysthenes hugelii* and compared with chlorpyriphos (0.06%) and untreated control in the farmer's field at Nerwa of district Shimla, Himachal Pradesh. The experiment was conducted on bearing trees of apple (cv. Royal Delicious) in randomized block design with each treatment replicated four times. The treatments were applied during the month of September, 2013 and the observations were recorded during December, 2013 at the time of basins preparation. At the time of observations, number of live and dead grubs of *D. hugelii* were counted and pooled to get total number of larvae present in the tree basin for calculation of per cent mortality. Data presented in **Table 92** reveal that among different biopesticides evaluated *Metarhizium anisopliae* ($10^6$ conidia /cm²) was the most effective resulting in 82.6 per cent mortality of the larvae and was on par with chlorpyriphos (0.06%) which killed 87.5 per cent of the grubs. Biopesticides like *Beauveria bassiana* ($10^6$ conidia/cm²), *Heterorhabditis indica* and *Steinernema carpocapsae*(80 IJ/cm² each) were, however, only moderately effective against apple root borer resulting in 47.4, 36.3 and 30.8 per cent mortality of the grubs, respectively, as against 6.4 per cent in untreated control.

**Table 92: Evaluation of entomopathogenic fungi and EPNs against *Dorysthenes hugelii***

| SN | Treatment | Larval mortality (%) |
|---|---|---|
| 1 | *Steinernema carpocapsae* (80 IJ/cm²) | 30.8 (33.6)$^{b}$ |
| 2 | *Heterorhabditis indica* (80 IJ/cm²) | 36.3 (37.0)$^{b}$ |
| 3 | *Beauveria bassiana* ($10^6$ conidia/cm$^2$) | 47.4 (43.5)$^{b}$ |
| 4 | *Metarahizium anisopliae* ($10^6$ conidia/cm$^2$) | 82.6 (65.6)$^{a}$ |
| 5 | Chlorpyriphos (0.06%) | 87.5(69.5)$^{a}$ |
| 6 | Control( Untreated) | 6.4 (10.4)$^{c}$ |
| | CD (p=0.05) | (8.99) |
| | CV (%) | 48.04 |

Figures in parentheses are arc sine transformed values

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

Some spiders, endoparasitic ichneumonid and ectoparasitic braconid were associated with overwintered larvae of codling moth, in the apple orchards of Kargil. The predators and parasitoids were found both under the bark of apple and apricot. The parasitoids overwintered with the host larvae and emerged in July. Some dead cadavers of codling moth were also collected but confirmation of causative agent could not be done as the pathogens failed to multiply on artificial media. Exploration of indigenous Trichogramma sp. through sentinel cards failed.

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

Average apple fruit damage in treated orchards ranged from 48.7 to 66.5 per cent as compared to 76.3 per cent in untreated control during 2013 in different location of Kargil (**Table 93**). Per cent reduction in fruit damage over control as a result of treatment ranged from 9.80 to 27.66 per cent. Maximum mean fruit damage was recorded in the *T. cacoeciae* treated plants (66.5 %) and lowest fruit damage (48.7%) was recorded in combination of *T. embryophagum*+*T. cacoeciae* + Pheromone. Maximum mean per cent fruit damage reduction over control was recorded in combination of *T. embryophagum*+*T. cacoeciae* + Pheromone trap (27.66%) which was significantly higher than other treatments while as lowest reduction was recorded in *T. cacoeciae* treated plants (9.80 %).

The maximum mean catch of codling moth (48.5/ trap) recorded in Mangmore in the month of July was not significantly higher than other locations (**Table 94**). But the average number of codling moth catches in 1$^{st}$ fortnight of July was significantly higher than 2$^{nd}$ fortnight in all locations.

The highest field persistence 14.3 % was recorded in *T. embryophagum*+*T. cacoeciae* + Pheromone trap treated plot followed by *T. embryophagum*+ *T. cacoeciae* (13.8%) which was observed significant over control and other treatments.

Highest yield data from observed orchards was recorded from *T. embryophagum*+*T. cacoeciae* + Pheromone trap treated plot, (5.1boxes/plant) followed by *T. embryophagum*+ *T. cacoeciae* (4.9 boxes/ plant) and *T. embryophagum*+ Insect pheromone (4.4 boxes /plant). Other treatment showed lower yield and the yield were recorded lowest in untreated field (2.9 boxes /plant).

**Table: 93. Impact of field release of *T.embryophagum* and *T.*cacoeciae against codling moth, *Cydia pomonella* in apple orchards, at Kargil, during 2013.**

| Treatment | % damage of fruits on tree | | | | | | Mean | % damage in dropped fruits | | | | | | Mean | Average fruit damage (%) | | | | | | Mean | % Reduction in fruit damage over control | | | | | | Mean | Field* persistenceof parasitoids (%) | Yield/ plant (no.of boxes) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | | A | B | C | D | E | F | | A | B | C | D | E | F | | A | B | C | D | E | F | | | |
| *T.embryophagum* (Te) | 31.6 (5.6) | 29.8 (5.5) | 32.0 (5.7) | 36.6 (6.0) | 27.9 (5.3) | 32.3 (5.7) | 31.7 (5.6) | 88.6 (9.4) | 91.2 (9.5) | 90.1 (9.5) | 87.6 (9.3) | 92.2 (9.6) | 95.8 (9.8) | 90.9 (9.5) | 60.1 (7.7) | 60.5 (7.8) | 61.0 (7.8) | 62.1 (7.9) | 60.0 (7.7) | 64.0 (8.0) | 61.2 (7.8) | 15.5 (4.0) | 19.8 (4.5) | 13.9 (3.7) | 17.5 (4.2) | 14.3 (3.8) | 9.60 (3.1) | 15.10 (3.9) | 9.2 (3.1) | 3.9 |
| *T.cacoeciae* (Tc) | 40.2 (6.3) | 38.6 (6.2) | 34.1 (5.8) | 41.3 (6.4) | 44.4 (6.7) | 32.4 (5.7) | 38.5 (6.2) | 92.3 (9.6) | 95.4 (9.7) | 94.6 (9.7) | 91.8 (9.6) | 97.6 (9.9) | 92.0 (9.6) | 93.9 (9.7) | 66.2 (8.1) | 69.0 (8.3) | 64.3 (8.0) | 66.5 (8.1) | 71.0 (8.4) | 62.2 (7.9) | 66.5 (8.1) | 9.4 (3.1) | 11.3 (3.4) | 10.6 (3.3) | 13.1 (3.6) | 3.3 (1.9) | 11.4 (3.4) | 9.80 (3.2) | 8.7 (3.0) | 3.6 |
| Insect pheromone (Ip) | 34.4 (5.9) | 32.4 (5.7) | 31.9 (5.6) | 36.5 (6.0) | 40.0 (6.3) | 39.8 (6.3) | 35.8 (6.0) | 90.5 (9.5) | 88.6 (9.4) | 93.4 (9.4) | 91.1 (9.5) | 92.6 (9.6) | 94.2 (9.7) | 91.7 (9.6) | 62.4 7.9) | 60.5 (7.8) | 62.6 (7.9) | 63.8 (8.0) | 66.3 (8.1) | 67.0 (8.2) | 63.7 (8.0) | 13.2 (3.7) | 19.8 (4.5) | 12.3 (3.5) | 15.8 (4.0) | 8.0 (2.9) | 7.30 (2.7) | 12.73 (3.6) | 4.6 (2.2) | 3.8 |
| Te + Ip | 28.6 (5.3) | 29.4 (5.4) | 26.5 (5.1) | 25.3 (5.0) | 26.2 (5.1) | 28.0 (5.3) | 27.3 (5.2) | 80.5 (9.0) | 88.3 (9.4) | 80.1 (8.9) | 77.5 (8.8) | 87.2 (9.3) | 86.5 (9.3) | 83.3 (9.1) | 54.5 (7.4) | 58.8 (7.7) | 53.3 (7.3) | 51.4 (7.2) | 56.7 (7.5) | 57.2 (7.5) | 55.3 (7.4) | 21.1 (4.6) | 21.5 (4.6) | 21.6 (4.7) | 28.2 (5.3) | 17.6 (4.2) | 17.1 (4.1) | 21.18 (4.7) | 9.3 (3.1) | 4.4 |
| Tc +Ip | 30.9 (5.6) | 32.4 (5.7) | 36.0 (6.0) | 33.4 (5.8) | 29.6 (5.4) | 30.7 (5.5) | 32.1 (5.7) | 83.2 (9.1) | 90.1 (9.5) | 83.5 (9.1) | 80.3 (8.9) | 92.6 (9.6) | 88.4 (9.4) | 86.3 (9.3) | 57.0 (7.5) | 61.2 (7.8) | 59.7 (7.7) | 56.8 (7.7) | 61.1 (7.8) | 59.5 (7.7) | 59.2 (7.7) | 18.6 (4.3) | 19.1 (4.4) | 15.2 (3.9) | 22.8 (4.8) | 13.2 (3.7) | 14.8 (3.9) | 17.28 (4.2) | 8.8 (3.0) | 3.9 |
| Te + Tc | 26.8 (5.2) | 29.6 (5.4) | 30.1 (5.50 | 27.5 (5.2) | 24.8 (5.0) | 23.9 (4.9) | 27.1 (5.2) | 74.5 (8.6) | 83.6 (9.1) | 79.0 (8.9) | 73.1 (8.5) | 81.6 (9.0) | 80.3 (8.9) | 78.6 (8.8) | 50.6 (7.1) | 56.6 (7.5) | 54.5 (7.4) | 50.3 (7.1) | 53.1 (7.3) | 52.1 (7.2) | 52.8 (7.3) | 24.9 (5.0) | 23.7 (4.9) | 20.4 (4.5) | 29.3 (5.4) | 21.15 (4.6) | 21.5 (4.6) | 23.50 (4.8) | 13.8 (3.7) | 4.9 |
| Te+ Tc + Ip | 25.4 (5.0) | 27.2 (5.2) | 29.1 (5.4) | 24.6 (5.0) | 21.6 (4.7) | 22.6 (4.8) | 25.0 (5.0) | 65.4 (8.1) | 80.1 (8.9) | 70.0 (8.3) | 70.2 (8.4) | 77.6 (8.8) | 70.8 (8.4) | 72.35 (8.5) | 45.4 (6.7) | 53.6 (7.3) | 49.5 (7.0) | 47.4 (6.9) | 49.6 (7.0) | 46.7 (6.8) | 48.7 (7.0) | 30.2 (5.5) | 26.6 (5.2) | 25.4 (5.0) | 32.20 (5.7) | 24.7 (5.0) | 26.9 (5.2) | 27.66 (5.3) | 14.3 (3.8) | 5.1 |
| Untreated check | 59.8 (7.7) | 62.4 (7.9) | 55.3 (7.4) | 61.7 (7.8) | 58.4 (7.6) | 57.6 (7.6) | 59.2 (7.7) | 1.5 .5) | 98.2 (9.9) | 94.6 (8.7) | 97.5 (9.8) | 90.2 (9.5) | 89.7 (9.4) | 93.6 (9.7) | 75.6 (8.7) | 80.3 (8.9) | 74.9 (8.6) | 79.6 (8.9) | 74.3 (8.6) | 73.6 (8.6) | 76.3 (8.7) | - | - | - | - | - | - | - | 3.9 (2.0) | 2.9 |
| C.D. (0.05) | 3.7 | 5.1 | 4.8 | 5.3 | 6. | 5.7 | - | 7.3 | 9.2 | 8.6 | 7.9 | 6.7 | 5.9 | - | 3.2 | 4.5 | 4.2 | 5.4 | 4.1 | 6.7 | | 4.8 | 3.3 | 4.6 | 3.5 | 3.1 | 4.3 | - | 4.6 | 0.87 |

Locations of Kargil: A = Khomeini, B = Hardas, C = Mangmore, D= Shanigund, E = Mingy, F = Slikchey
*T.embryophagum* and *T.cacoeciae* released @ 1, 00,000/ha
Figure in each column represent mean of 10 observations
*Field persistence of parasitoids by placing sentinel Corcyra egg cards
Figure in parentheses are square root transformations ( $\sqrt{x+0.5}$)

**Table 94: Mass trapping of codling moth, *Cydia pomonella* through pheromone traps in apple orchards at Kargil during 2013.**

| Location | Average no. of codling moth trapped / trap | | Mean | Student's t-Test |
|---|---|---|---|---|
| | Ist fortnight of July | $2^{nd}$ fortnight of July | | |
| Bagh-e-Khomeini | 65.33 | 25.42 | 45.37 | -4.34**,d.f=32 |
| | (8.54) | (4.83) | (6.68) | |
| Hardas | 62.25 | 22.52 | 42.25 | |
| | (7.92) | (4.77) | (6.53) | |
| Shanigund plain | 48.50 | 28.50 | 38.50 | |
| | (7.00) | (4.36) | (6.24) | |
| Mingy | 42.00 | 23.25 | 32.62 | |
| | (6.52) | (4.87) | (5.75) | |
| Slikchey | 53.50 | 26.50 | 40.00 | |
| | (7.35) | (5.20) | (6.26) | |
| Mangmore | 68.50 | 29.50 | 48.50 | |
| | (8.51) | (5.48) | (7.00) | |
| C.D(0.05) | 3.1 | 1.9 | | |
| C.V(0.05) | 41.90 | 36.49 | | |

Figures in each column represents mean of 4 observations
Figure in parentheses are square root transformations ($\sqrt{x+0.5}$)

## 2.14. Vegetables

### Tomato

### 1. Field demonstration of BIPM package for the management of key pests of Tomato (TNAU)

The experiment was conducted Madampatty on tomato variety 5005 Laxmi with African marigold as Trap crop in an acre. The BIPM package ($T_1$) comprised of the following treatments:

- Seedling root dip with *Pseudomonas* 2% solution
- Planting African marigold as trap crop
- Installation of yellow sticky trap @ 50 No's /ha.
- Installation of bird perches @ 10/ha.
- Need based application of *B.t* and NPV based on pheromone monitoring
- Management of sucking pests with Azadirachtin spray
- Release of *Trichogramma pretiosum* @ 50,000 No's /ha (3 releases at weekly intervals) and
- Release of *Chrysopa* grubs @ 50,000 No's /ha.

The BIPM package was compared with the Framers practice ($T_2$) consisting of Dimethoate 0.06% spray at 30 days after planting and two sprays of quinalphos 0.05% at 60 and 75 days after planting. The population of sucking pests (aphids, thrips, leafhoppers and whiteflies) and fruit borer were recorded at 15 days interval along with natural enemy activity.

The population of sucking pest and fruit borer *Helicoverpa armigera* incidence were significantly lower in the BIPM plots compared to farmers practice **(Table 95 & 96).** The incidence of fruit borer was 6.4 to 8.6% in BIPM as compared to 14.2 to 15.8% in farmers practice at 75 to 105 DAT. The fruit yield (36.80t/ha) was significantly higher in BIPM plot as compared to farmers practice (32.45t/ha) with a cost benefit ratio of 1:3.2. **(Table 96).** Higher natural enemy *viz.*, *Chrysopa* and coccinellid activity was noticed in BIPM demonstration plot.

**Table 95: Field demonstration of BIPM package for the management of key pests of Tomato (sucking pests)**

| Treatments | Population of Sucking pests- DAS ( 5 plants) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leafhoppers | | | Aphids | | | Thrips | | | whiteflies | | |
| | 30 | 45 | 60 | 45 | 60 | 75 | 60 | 75 | 90 | 75 | 90 | 105 |
| BIPM | 12.1 a | 19.5 a | 10.1 a | 7.2 a | 3.6 a | 1.1 a | 4.7 a | 2.0 a | 3.1 a | 1.8 a | 2.7 a | 3.1 a |
| Farmers practice | 13.2 a | 26.4 b | 20.1 b | 7.8 a | 11.4 b | 8.6 b | 7.8 | 9.5 b | 11.1 b | 4.1 b | 4.6 b | 6.3 b |

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

**Table. 96. Field demonstration of BIPM package for the management of key pests of Tomato (*Helicoverpa armigera*)**

| Treatments | % damage by *Helicoverpa armigera* | | | Population of natural enemies/ 5 plants | | | | | | Fruit yield (t/ha) | Cost Benefit Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 75 DAT | | 90 DAT | | 105 DAT | | | |
| | 75 DAT | 90 DAT | 105 DAT | *Chrysopa* | *Coccinellid* | *Chrysopa* | *Coccinellid* | *Chrysopa* | *Coccinellid* | | |
| BIPM | 6.4[a] | 8.2[a] | 8.6[a] | 3.0[a] | 5.0[a] | 2.0[a] | 4.0[a] | 6.0[a] | 5.0[a] | 36.8[a] | 1:3.2 |
| Farmers practice | 14.6[b] | 15.8[b] | 14.2[a] | 0.0[b] | 2.0[a] | 0.0[b] | 1.0[a] | 2.0[b] | 2.0[a] | 32.45[b] | - |

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

**2. BIPM against *H. armigera* in tomato (MPUAT)**

The experiment was conducted during 2013-14 on variety "Pusa Ruby" at Horticulture Farm RCA, MPUAT, Udaipur. The treatments comprised of i. Installation of pheromone trap 5/ha., ii. Six releases of *Trichogramma* starting at flowering stage in tomato, iii. Two sprays of Bt @ 1kg/ ha first at flowering stage and second after 15 days of first spray, and iv. Two sprays of HaNPV @ 250 L.E./ ha, first at flowering stage and second after 15 days of first spray.

The larval population of *H. armigera* and its damage to tomato fruits (recorded at 7 days after treatment) revealed significant reduction in all the treated plots over control. Two sprays of Bt K @ 1kg/ha and two sprays of HaNPV @ 250 LE/ha (microbial insecticides) evaluated found to be equally effective against the pest and produced fruit yield 164.5 and 155.9 q/ha., respectively. While, the percent infested fruits was 3.18 and 4.17, respectively. The per cent infested fruits was 11.53and the yield was 62.0 q/ha in the control plots. The trial needs to be validated on large scale at farmer's field.

**Brinjal**

**3. Biological control of Brinjal mealy bug *Coccidohystrix insolitus* (TNAU)**

The experiment was carried out at Thondamuthur on variety "Ravaiya (Purple) Hybrid" with the following treatments, replicated thrice.

$T_1$ Release of *cryptolaemus* @ 1500/ha
$T_2$ Release of *Scymnus*@ 1500/ha
$T_3$ Release of *Brumus suturoides* @ 1500/ha
$T_4$ *Verticillium lecanii* $10^8$ cfu /ml
$T_5$ *Chrysopa* 50,000 first instar grubs/ha
$T_6$ Profenphos 50 EC 2ml /litre
$T_7$ Control. T

There were two **releases of** predator/ insecticide treatment. Mealy bug incidence was recorded on 3 leaves/plant and predators as number of adults/ plant.

The releases of *Brumus suturoides* @ 1500/ha, *Scymnus* @ 1500/ha and *Cryptolaemus* @ 1500/ha significantly recorded lesser population of mealybugs over control. The insecticide profenphos (@ 2ml/l) recorded the minimum population of mealy bugs with higher yield of 57.1 t/ha. Among the different treatments, the entomopathogen *Verticillium lecanii* sprayed plot was on a par with control **(Table 97)**

**Table.97. Biological control of brinjal mealy bug *Coccidohystrix insolitus***

| Treatments | Pre Treatment | One week after I release/spray | | One week after II release/spray | | Yield Kg/ha |
|---|---|---|---|---|---|---|
| | Mealybug/ Plant (3 leaves) | Mealybug/ Plant | Predator/ 10 Plants | Mealybug/ Plant | Predator/ 10 Plants | |
| Release of *cryptolaemus* @ 1500/ha | 17.8[a] | 13.6[b] | 1.3 | 11.6[bc] | 1.7 | 65.5[b] |
| Release of *Scymnus*@ 1500/ha | 15.4[a] | 10.6[b] | 3.3 | 9.8[b] | 4.0 | 66.9[b] |
| Release of *Brumus suturoides* @ 1500/ha | 18.2[a] | 9.4[b] | 2.0 | 7.6[b] | 2.7 | 68.1[b] |
| *Verticillium lecanii* $10^8$ cfu /ml | 16.4[a] | 15.8[c] | 0.8 | 16.8[a] | 1.4 | 60.6[c] |
| *Chrysopa* 50,000 first instar grubs/ha | 15.6[a] | 13.6[b] | 1.0 | 14.2[c] | 1.8 | 61.7[c] |
| Profenophos 2 ml/l | 17.0[a] | 4.2[a] | 0.0 | 1.8[a] | 0.0 | 76.3[a] |
| Control | 17.4[a] | 17.2[c] | 0.8 | 18.6[d] | 1.2 | 57.1[c] |

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

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

The experiment was laid out on the research farm of Entomology Section, College of Agriculture, Pune, on variety Panchaganga during December 2013. Five modules with the following treatments were evaluated.

T1: *Trichogramma chilonis* (*Tc*) @ 50,000 parasitoids/ha. (Six releases)
T2: *T. chilonis* + NSKE 5% suspension (*Tc* + *Tc* + NSKE + *Tc* + *Tc* + NSKE)
T3: *T. chilonis* + *B. thuringiensis* @ 1 lit./ha (*Tc* + *Tc* + *Bt* + *Tc* + *Tc* + *Bt*)
T4: NSKE + *B. thuringiensis* (NSKE + NSKE + *Bt* + NSKE + NSKE + *Bt*)

(T1 - T4 were given at weekly intervals)

T5: *T. chilonis* + NSKE + *B. thuringiensis* (*Tc* + NSKE + *Bt* + *Tc* + NSKE +*Bt*)

T6: Farmer's practice- three sprays of profenophos 0.05% at 15 days interval

T7: Untreated control

Each treatment block surrounded with paired row of maize.

The observations on per cent shoot infestation before initiation of treatments and shoot and fruit infestation were recorded at weekly intervals from 5 randomly selected plants per treatment plot. Egg parasitism by *T. chilonis* was recorded through retrieval by placing sentinel egg-cards of *Corcyra* at 3 spots in each treatment blocks.

The results indicated that three sprays of profenophos 0.05% at fortnightly interval found significantly superior in reducing the shoot (9.1%) and fruit (9.4%) infestation and gave maximum yield of marketable brinjal (228.6 q/ha). The yield in untreated control was 171.5q/ha with 16-21% shoot and 20-21% fruit damage, respectively.

The BIPM module with releases of *T. chilonis* @ 50,000 parasitoids/ha followed by spraying of NSKE 5% and *B. thuringiensis* @ 1 lit./ha twice at weekly interval was the next best treatment with 10.6% shoot and 15.3% fruit infestation, and 42.5% parasitism by *T. chilonis*. An yield of 217.8 q/ha was obtained in this module which was on par with modules consisting *T. chilonis* + *Bt* (T3) and NSKE +*Bt* (T4).

**5. Management of major pests of brinjal (MPUAT):**

The experiment was laid at Horticulture farm RCA, MPUAT, Udaipur, during 2013-14

The variety "Pusa Samrat" was raised and the programme included the treatments viz.,

1. Raising of disease and insect free seedling applying *Trichoderma* and neem based insecticide.
2. Placement yellow sticky traps @ 5/ha and six releases of *Trichogramma* sp. @ 1 lakh/ha starting from flowering stage.
3. Two sprays of *Verticillium lecanii* against sucking pests followed by six releases of *Trichogramma species* @ 1 lakh/ha starting from flowering stage.
4. Two sprays of NSKE and six releases of *Trichogramma species* @ 1 lakh/ha starting from flowering stage.

*Trichoderma* and neem based insecticides significantly reduced plant mortality in nursery. Whereas, NSKE and six release of *Trichogramma* sp. significantly reduced the fruit and shoot damage and also sucking pests population and recorded an yield of 192 qt/ ha. Yellow sticky traps @ 5/ha and six release of *Trichogramma* sp. @ 1 lakh/ha was effective against sucking pests and yielded 156 qt/ha which was statically at par with NSKE six release of *Trichogramma* sp**. (Table 98).**

**Table 98: Management of major pest of brinjal (MPUAT)**

| Sr. No. | Treatments | Mortality in nursery (%) | Infestation in fruit and shoot damage (%) | Sucking pests/3 leaves | Yield (qt/ha) |
|---|---|---|---|---|---|
| 1 | Trichoderma & neem based insecticide | 2.11 (8.35) | 8.75 (17.20) | 15.6 (23.26) | 156 |
| 2 | Yellow sticky traps @ 5/ha and six release of *Trichogramma species* @ 1 lakh/ha | 5.18 (13.15) | 5.68 (13.78) | 2.6 (9.27) | 152 |
| 3 | *Verticillium lecani* followed with six releases of *Trichogramma species* @ 1 lakh/ha | 5.72 (13.83) | 6.72 (15.02) | 3.2 (10.30) | 169 |
| 4 | Two sprays of NSKE and six release of *Trichogramma* sp. | 4.17 (11.78) | 4.17 (11.78) | 2.8 (9.63) | 192 |
| 6 | Control | 8.56 (17.02) | 10.73 (10.12) | 17.7 (24.87) | 104 |
| | Sem. ± | 0.62 | 0.35 | 0.75 | 7.51 |
| | CD 5% | 1.82 | 1.63 | 2.19 | 21.72 |

**Cauliflower**

**6. Efficacy of B.t strains against Diamond backmoth in Cauliflower (TNAU)**

The trial was conducted at Devarayapuram during October 2013 on variety "Early Synthetic". The treatments comprised of -- $T_1$ PDBC-BT1 @ 1% spray, $T_2$ PDBC-BT1 @ 2% spray, $T_3$ NBAII-BTG4 @ 1% spray, $T_4$ NBAII-BTG4 @ 2% spray, $T_5$ *Beauveria bassiana* @ 2.0kg/ha, $T_6$ NSKE 5%, $T_7$ Chlorpyriphos @ 0.04 % spray and $T_8$ control.

Three sprays were given at 15 days interval

The Bt formulations at 1 and 2% were significantly reduced the population of DBM by 85.48 to 90.88 per cent on over control at 3 days after third spray. Two formulations *viz.*, PDBC BT 1 and NBAII BTG 4 at 1% and 2% were on a par with the insecticide chlorpyriphos in causing mortality of DBM. A highest yield of 17.8 t/ha was recorded in NBAII BTG 4 @2% spray which was on a par with other Bt formulations and chlorpyriphos treatment **(Table 99).**

**Table 99: Efficacy of B.t strains against Diamondback moth in Cauliflower**

| Treatments | Pre Treat. | DBM 3 days after I spray | | DBM 3 days after II spray | | DBM 3 days after III spray | | Yield Kg/ha |
|---|---|---|---|---|---|---|---|---|
| | DBM/ Plant | DBM/ Plant | % Reduction over control | DBM/ Plant | % Reduction over control | DBM/ Plant | % Reduction over control | |
| PDBC-BT1 @ 1% spray | 28.7$^{a}$ | 7.8$^{ab}$ | 72.16 | 4.5$^{ab}$ | 84.58 | 3.9$^{a}$ | 85.48 | 16.9$^{ab}$ |
| PDBC-BT1 @ 2% spray | 29.5$^{a}$ | 6.6$^{a}$ | 77.09 | 3.8$^{ab}$ | 87.33 | 3.4$^{a}$ | 87.68 | 17.3$^{ab}$ |
| NBAII-BTG4 @ 1% spray | 25.9$^{a}$ | 6.4$^{a}$ | 74.69 | 3.2$^{a}$ | 87.85 | 3.0$^{a}$ | 87.62 | 17.2$^{ab}$ |
| NBAII-BTG4 @ 2% spray | 29.3$^{a}$ | 4.6$^{a}$ | 83.92 | 2.1$^{a}$ | 92.95 | 2.5$^{a}$ | 90.88 | 17.8$^{a}$ |
| *B. bassiana* @ 2 kg/ha | 26.7$^{a}$ | 25.8$^{d}$ | 1.03 | 20.3$^{d}$ | 25.23 | 18.9$^{b}$ | 24.36 | 14.4$^{cd}$ |
| NSKE 5% | 25.8$^{a}$ | 20.2$^{c}$ | 19.81 | 16.5$^{c}$ | 37.11 | 15.6$^{b}$ | 35.39 | 15.1$^{bcd}$ |
| Chlorpyriphos @ 0.04 % spray | 27.8$^{a}$ | 8.8$^{ab}$ | 67.58 | 5.1$^{ab}$ | 81.96 | 4.8$^{a}$ | 81.55 | 16.2$^{abc}$ |
| Control | 29.6$^{a}$ | 28.9$^{e}$ | - | 30.1$^{e}$ | - | 27.7$^{c}$ | - | 13.3$^{d}$ |

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

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

The experiment conducted on cauliflower (S-41 hybrid) at Entomological Research Farm PAU, Ludhiana.. The following are the treatments were imposed in RBD with three replications.

1. Release of *Chrysoperla zastrowi sillemi* @ 5 larvae/ plant against at weekly interval.
2. Planting of mustard crop to collect and destroy eggs of *Pieris brassicae*.
3. Spray of Neemazal (1%) @ 600 ml/acre.
4. Release of *Trichogramma pieridis* @ 1, 00, 000/ ha against *P. brassicae*.
5. Mechanical collection and destruction of *P. brassicae* eggs
6. Spray of Dipel 8L @ 300 g/ acre
7. Farmers' practice: Quinalphos 25 EC @ 400 ml/ acre
8. Control (no treatment)

**Very low incidence of aphids and cabbage butterfly, *Pieris brassicae* was noticed in the first week of March. The treatments will be evaluated when there is population build up of these pests. The experiment is in progress.**

**8. Evaluation of commercial formulations of *Bacillus thuringiensis* and potential microbial isolates against cabbage butterfly, *Pieris brassicae* (PAU)**

The experiment was conducted at Entomological Research farm PAU Ludhiana in randomized block design of 50 $m^2$. There were seven treatments with three replications each. The treatments comprised of - liquid formulations of *Bacillus thuringiensis* (formulations supplied by NBAII, Bangalore) PDBC Bt 1 @ 1%, PDBC Bt 1 @ 2%, NBAII Bt 1 @ 1%, NBAII Bt 1 @ 2%, Commercial formulation Delfin @ 300g/ acre, Chemical control Spinosad 2.5 SC @ 240ml/ acre and untreated control. Three sprays of *Bacillus thuringiensis* formulation at seven days intervals and two sprays of chemical at fifteen days interval were to be sprayed.

The pest appeared in the first week of March. The pre-treatment pest incidence was recorded and the various treatments were evaluated. The experiment is in progress and results will be available in April end.

**9. Collection, evaluation of *Trichogramma chilonis* strains on cole crop insect pests (viz., cauliflower and cabbage) (IARI)**

Experiments were carried out under field conditions on cauliflower and cabbage crops. The incidence of *Plutella xylostella* and *Pieris brassicae* was recorded at weekly intervals.

**Observations indicated that both the insects were absent in the field** in the initial stages of the crop growth. However, few moths and butterflies of *P. xylostella* and *P. brassicae* in the field were noted which did not warrant any application of chemical/biological control agents. Laboratory reared *P. xylostella* were released in the fields, followed by releases of the improved strains of *T. chilonis*. Due to rough weather conditions and frequent spell of showers the insect pest failed to establish in the crop. **The experiment failed.**

**Chilli**

**10. Evaluation of fungal pathogens against sucking pests of hot chilli (*Capsicum sinensis*) (AAU-J)**

The experiment was conducted at Instructional cum Research farm, AAU, Jorhat, against aphids, jassids and mite pests on a local variety, during December 2013.

The treatments included application of i. *Metarhizium anisopliae* (AAU strain) @ $10^9$ cfu /ml, ii. *Beauveria bassiana* (AAU strain) @ $10^9$ cfu /ml, iii. *Metarhizium anisopliae* (Ma-4) NBAII strain@ $10^9$ cfu /ml, iv. *Metarhizium anisopliae* (Ma-35) NBAII strain@ $10^9$ cfu/ml, v. *Beauveria bassiana* (Bb-5a) NBAII strain @ $10^9$ cfu/ml, vi. *Beauveria bassiana* (Bb-23) NBAII strain @ $10^9$ cfu /ml, vii. Imidacloprid @ 15 g ai/ha and Untreated control.

Presently the crop is at vegetative growth stage. The appearance of sucking pest, particularly the alate aphids was observed during March 2014. The pre-treatment counts of aphids per leaf were 5.2. The treatment schedule will be imposed upon build of the population. The experiment is in progress.

**Onion**

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

The experiment was conducted on the research farm of Entomology Section, College of Agriculture, Pune during *rabi* 2013-14, on variety "Phursungi". The treatments comprised of six releases of anthocorid, *Blaptostethus pallescens* @ 10 and 20 nymphs/m row at weekly interval, three sprays of *Metarhizium anisopliae*, *Beauveria bassiana*, *Verticillium lecanii* each @ $10^8$ cfu/ml and profenophos 0.05% at 15 days interval and untreated control. Sandovit 0.1% added as surfactant in spray fluid.

Thrips population was recorded on 10 randomly selected plants per plot a day before initiation of treatments and post counts at 7 days after each release of anthocorids/spray of microbial agents. The intensity of white patches on leaves was recorded on 10 plants from each plot and graded in 1-5 scale.

Three sprays of profenophos 0.05% at fortnightly interval significantly superior over suppressed thrips population (av. 3.2 thrips/plant) with rating of intensity of white patches as '1". This was followed by three sprays of *M. anisopliae* @ $10^8$ cfu /ml which showed av. 7.8 thrips /plant and 1.4 rating of white patches on leaves **(Table 100).**

**Table 100: Effect of anthocorid and microbial agents on suppression of thrips on onion**

| Treatment | Thrip population/plant, 7 days after spray | | | | | Intensity of white patches |
|---|---|---|---|---|---|---|
| | Pre-count | I | II | III | Average | |
| T1: *B. pallescens* @ 10 nymphs/m | 19.9 [a] | 17.1 [b] | 12.5 [c] | 8.3 [c] | 12.6 [d] | 2.5 |
| T2: *B. pallescens* @ 20 nymphs/m | 19.9 [a] | 13.2 [b] | 9.5 [b] | 7.3 [c] | 10.0 [c] | 2.1 |
| T3: *M. anisopliae* @ $10^8$ cfu/ml | 20.0 [a] | 11.9 [a] | 7.5 [b] | 4.2 [b] | 7.9 [b] | 1.4 |
| T4: *B. bassiana* @ $10^8$ cfu/ml | 19.9 [a] | 18.0 [c] | 14.2 [c] | 11.9 [d] | 14.7 [e] | 2.4 |
| T5: *V. lecanii* @ $10^8$ cfu/ml | 19.3 [a] | 15.1 [b] | 12.6 [c] | 7.6 [c] | 11.8 [d] | 2.1 |
| T6: Profenophos 0.05% | 19.6 [a] | 7.9 [a] | 1.3 [a] | 0.4 [a] | 3.2 [a] | 1.0 |
| T7: Untreated control | 20.0 [a] | 25.2 [d] | 30.5 [d] | 37.5 [e] | 31.1 [f] | 3.6 |
| **CD (p = 0.05)** | **NS** | **0.69** | **0.67** | **0.57** | **0.36** | |

**12. Validation of BIPM of thrips on onion (IIHR)**

The validation of BIPM against *Thrips tabaci* was conducted on var. Arka Niketan in exploded block design with 400 sq.m for each treatment (*M. anisopliae* @1x$10^7$ spores/ml, *B. bassiana* @1x $10^7$ spores/ml ( liquid formulations ) Acephate @0.7 g/L and control. Border row of maize was raised in biological control and chemical treatment. Spraying was initiated at 40 DAP and continued at weekly intervals till 85 DAP. The population per plant at ten days interval was recorded and in each treatment about 10 per plants were randomly selected and thrips/plant was recorded in situ. Yield data was also noted.

Significant reduction in thrips/ plant was recorded in all treatments as to control **(Table 101).** A mean population of 16-17 thrips/ plant was recorded in the biological control treatments that were at par and significant over control. Results indicated that border crop of maize and weekly spraying of liquid formulation of M. *anisopliae*@ 1ml/ 2L or *B. bassiana* @ 10ml/L (IIHR) resulted in 64 - 66 percent reduction in thrips /plant population, respectively with a corresponding yield increase.

**Table 101: Field efficacy of entomopathogens formulations on *T.tabaci* on onion.**

| S. No | Treatments | No. of thrips /plant Mean of six observations | % reduction over control | Yield t/ha |
|---|---|---|---|---|
| 1 | *M. anisopliae* @1x$10^7$ spores/ml (liquid formulation) | 16 (varied from. 14 -19) | 66 | 13.03 |
| 2 | *B. bassiana* @1x $10^7$ spores/ml ( liquid formulation ) | 17 ( varied from 13-21) | 64 | 11.1 |
| 4 | Acephate @0.7 g/L | 17 (varied from 13-23) | 63 | 11.2 |
| 5 | Control | 47 ( varied from 13-87) | ------------- | 9.9 |

## Potato

### 13. Evaluation of local and NBAII entomopathogenic strains against soil insects in potato (AAU-J)

The experiment was carried out at Maran Gaon, Jorhat on variety Kufri Megha. *Agrotis ipsilon* (Cut worm) and *Dorylus orientalis* (Red ant) were the target pests. The treatments comprised of i. *Metarhizium anisopliae* (AAU strain, Biometa) 15 q/ha, ii. *Beauveria bassiana* (AAU strain, Biosona) 15 q /ha, iii. Imidacloprid 20 g a.i. /ha as soil drenching. iv. Malathion 5 % dust 40kg/ha as soil application, v. *Metarhizium anisopliae* (NBAII strain) 15 q/ha, vi. *Metarhizium anisopliae* (NBAII strain) 15 q/ha, vii. *Beauveria bassiana* (NBAII strain) 15 q/ha, viii. *Beauveria bassiana* (NBAII strain) 15 q/ha and ix. Untreated control

AAU strain and NBAII strains of *M. Anisopliae, B. Bassiana* were evaluated and malathion dust *was* applied as soil application at the time of sowing, and 35 and 55 days after sowing. Similarly three sprays of Imidacloprid were given as soil drenching. Imidacloprid @ 20 g ai/ha significantly reduced the infestation of soil insects of potato. The per cent infested tubers due to attack of *Dorylus orientalis* and *Agrotis ipsilon* of potato was 10.25 and 11.25, respectively. Among the bio insecticides of NBAII, *Ma*-4, *Bb*-23 and *Bb*-5a of NBAII strains reduced the infestation of *D.orientalis* with 19.0, 19.25, 19.75 % infested tubers compared to the local strains of AAU (*M.a,* Biometa and *Bb*-Biosona) and *Ma*-35 NBAII strain, where the per cent infested tubers was 21.5 and 23.5 and 23.75, respectively. Maximum number of infested tubers (31.75 %) was obtained in untreated control **(Table 102).**

Imidacloprid @ 20g ai/ha (11.25%) and malathion @40kg/ha dust (13.50%) were at par in their efficacies against *A.ipsilon*. No significant difference was with AAU strains of *Ma, Ba* and the strains of NBAII(*Ma*-4,*Ma*-35, *Bb*-5a) in reducing the infestation of *A. Ipsilon* **(Table 102).** The highest yield (83.90 q/ha) was obtained in the plots with imidacloprid @20 g ai/ha followed by *Ma*-4 NBAII strain (83.12 q/ha) compared to 66.00 q/ha in control.

**Table 102: Effect of Local and NBAII strains against soil insects in potato**

| **Treatments** | **Dose** | **% infested tubers by *D. orientalis*** | **% infested tubers by *A. ipsilon*** | **Yield (Q/ha)** | **Increased yield over control (%)** |
|---|---|---|---|---|---|
| *M.anisopliae* (AAU strain) | 15 q/ha | 23.5 (28.93)[c] | 23.0 (28.62)[cd] | 76.97 [c] | 14.52 |
| *B. bassiana* (AAU strain) | 15 q/ha | 21.50(27.60) [bc] | 20.75(27.06)[cd] | 78.30[bc] | 15.70 |
| Imidacloprid | 20g a.i./ha | 10.25(18.61) [a] | 11.25(19.55)[a] | 83.90[a] | 21.33 |
| Malathion 5% dust | 40kg/ha | 21.0(27.24) [bc] | 13.50(21.33)[a] | 79.37[abc] | 16.84 |
| *M.anisopliae* (Ma-4) NBAII strain | 15 q/ha | 19.0(25.81)[b] | 19.5(26.18) [bc] | 83.12[ab] | 20.60 |
| *M.anisopliae* (Ma-35)NBAII strain | 15 q/ha | 23.75(29.15)[c] | 22.75(28.45) [cd] | 76.87 [c] | 14.14 |
| *B.bassiana* (Bb-5a)NBAII strain | 15 q/ha | 19.75(26.54) [b] | 23.75(29.13)[d] | 78.02 [c] | 15.40 |
| *B.bassiana* (Bb-23)NBAII strain | 15 q/ha | 19.25(26.00) [b] | 16.75(23.95)[b] | 78.75 [bc] | 16.19 |
| Untreated control | | 31.75(34.24)[d] | 34.25(35.80)[e] | 66.0[d] | |
| CV % | | 7.21 | 8.90 | 6.15 | |
| CD =0.05 | | 2.01 | 2.44 | 4.94 | |

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

**Okra**

**14. BIPM in Okra (OUAT)**

Crop got completely damaged due to severe cyclone in Orissa. The trial will be conducted in the next season.

**Cassava**

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

The field experiment was carried out against *A. dispersus* on cassava (var. Mulluvadi-1) at Pollachi. BIPM module, farmer's practice and control were divided into eight equal segments and each one was considered as a replication. Population of *A. dispersus* was recorded on 3 leaves in 5 plants and the population of parasitoids and predators was recorded from 10 randomly selected plants, at fortnightly intervals. The treatments included.

Farmer's practice:

Acephate 75 SP @ 1.5 g per litre or monocrotophos 36 WSC @ 2.0 ml per litre or triazophos 40% EC @ 2.5 ml per litre on 3 months, 5 months and 8 months for cassava and weekly interval on brinjal.

Bio-intensive IPM- Yellow sticky traps @ 12 per ha for monitoring, release of *E. guadeloupae* @ 4 parasitized pupae per plant, release of *M. astur* @ 1.0 lakh first instar grub / ha, application of entomopathogens *viz*., *L. lecanii* and *P. fumosoroseus* @ 2 x $10^9$ conidia per ml, application of NSKE 5%, application of triazophos 40% EC @ 2.5 ml per litre, acephate 75 SP @ 1.5 g per litre and control (Untreated).

BIPM module against *A. dispersus* recorded lesser population of *A. dispersus* (76.93 per 5 plants) as compared to farmer's practice (226.11 per 5 plants) and untreated check (320.96 per 5 plants) (Table 104). The per cent reduction of *A. dispersus* population over control was maximum in BIPM module (74.81) than the farmer's practice (29.43). Maximum yield was recorded from BIPM module (36.79 t/ha) as compared to untreated check (21.60 t/ha). Benefit cost ratio (BCR) ranked in the order of superiority as BIPM module (1:3.34) > farmer practice (1: 2.41) on cassava **(Table 103)**.

**Table 103: Effect of BIPM module on *A. dispersus* population, yield and benefit cost ratio (BCR) on cassava**

| Treatment | *A. dispersus*/ 5 plants* | Per cent reduction over control# | Yield (t/ ha) | Yield increase over control (t /ha) | Per cent yield increase over control | Net income (Rs. lakhs) | BCR |
|---|---|---|---|---|---|---|---|
| BIPM | 76.93[c] (8.77) | 74.81[a] (59.87) | 36.79 | 15.19 | 41.28 | 2.14 | 1 : 3.34 |
| Farmer's practice | 226.11[b] (15.04) | 29.43[b] (32.86) | 27.90 | 6.30 | 22.57 | 1.61 | 1 : 2.41 |
| Control | 320.96[a] (17.92) | 0.00[c] (0.00) | 21.60 | 0.00 | 0.00 | 1.30 l | - |
| SEd | 18.2979 | 5.2695 | | | | | |
| CD (P = 0.05) | 37.0426 | 10.6677 | | | | | |

*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); # figures in parentheses are arc sine transformed values

**Detailed studies on biological control of spiralling whitefly**

**Survey for intensity by damage of *A. dispersus* and occurrence of its natural enemies**

Intensive survey was undertaken in seven different states covering Southern and North Eastern states of India *viz*., Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Meghalaya, Mizoram and Tamil Nadu to study host plants and intensity of damage by *A. dispersus*. Sampling units were selected randomly in 5 locations from each state and survey was carried out on the most preferred host plants. The predators and parasitoids were also collected during the survey and identified at National Bureau of Agriculturally Important Insects (NBAII), Bengaluru, Karnataka.

A standard evaluation system was formulated based on the per cent intensity of damage as follows:

$$\text{Intensity of damage (\%)} = \left[\frac{\text{No. of leaves infested}}{\text{Total no. of leaves observed}}\right] \times 100$$

The overall distribution map of *A. dispersus* in India and Tamil Nadu was prepared and the damage was categorized into seven grades as follows:

| Grade | Intensity of damage (%) | Damage category |
|---|---|---|
| 1 | 0 | Nil |
| 2 | 1-10 | Very low |
| 3 | 11-20 | Low |
| 4 | 21-40 | Moderate |
| 5 | 41-60 | High |
| 6 | 61-80 | Very high |
| 7 | 81-100 | Extreme |

**Survey on intensity of damage by *A. disperses***

The results on the distribution and intensity of damage of *A. dispersus* in Southern and Northeastern states of India showed an extreme intensity of damage in Tamil Nadu (99.17 per cent), Kerala (97.74 per cent) and Karnataka (95.31 per cent) **(Table 104).** In Mizoram, the intensity was very high (76.57 per cent), as in Maharashtra (53.25 per cent), but in Andhra Pradesh (29.98 per cent) and Meghalaya (13.97 per cent) the intensity of damage was found to be low.

**Table 104: Intensity of damage of *A. dispersus* in Southern and North Eastern states of India**

| States | Places surveyed | Crops | Mean intensity of damage (%)* | Grade*# | Category |
|---|---|---|---|---|---|
| Andhra Pradesh | Nandyal | *Psidium guajava* L. | 29.98$^{e}$ (33.20) | 4.00 (2.00) | Moderate |
| Karnataka | NBAII, Bangalore, UAS, Dharwad | *Acalypha hispida* Burm. f. *P. guajava* | 95.31$^{b}$ (77.49) | 7.00 (2.65) | Extreme |
| Kerala | Trissur and Palakad | *Manihot esculenta* Crantz. *P. guajava* | 97.74$^{ab}$ (81.36) | 7.00 (2.65) | Extreme |
| Maharashtra | Pune and Solapur | *P. guajava* | 53.25$^{d}$ (46.86) | 5.00 (2.24) | High |
| Meghalaya | Umiam, Shillong | *Rosa* spp. | 13.97$^{f}$ (21.95) | 3.00 (1.73) | Low |
| Mizoram | Kolasib and Aizawl | *P. guajava* and *Euphorbia pulcherrima* Willd. ex Klotzsch | 76.57$^{c}$ (61.05) | 6.00 (2.45) | Very high |
| Tamil Nadu | Coimbatore, Salem and Erode | *M. esculenta* and *P. guajava* | 99.17$^{a}$ (84.78) | 7.00 (2.65) | Extreme |
| | SEd | | 1.8113 | - | |
| | CD (P = 0.01) | | 5.0942 | - | |

NBAII = National Bureau of Agriculturally Important Insects; UAS = University of Agricultural Science.
*Mean of five locations; significant at 1%; figures in parentheses are arc sine transformed values; in a column, means followed by a common letter(s) are not significantly different by DMRT (P = 0.05); # figures in parentheses are square root transformed values

In Tamil Nadu, *A. dispersus* was found in all districts of Tamil Nadu. The intensity of damage was extreme in Coimbatore (99.16 per cent), Dharmapuri (97.44 per cent), Dindigul (95.53 per cent), Erode (98.69 per cent), Namakkal (91.74 per cent), Salem (97.43 per cent), Tiruchirappalli (94.22 per cent), Perambalur (94.43 per cent), Villupuram (93.07 per cent), Thiruvarur (94.74 per cent), Thanjavur (86.36 per cent), Madurai (96.24 per cent), Theni (95.39 per cent), Tirunelveli (93.74 per cent), Kanniyakumari (97.21 per cent), Krishnagiri (95.26 per cent) and Tiruppur (96.95 per cent). The remaining districts recorded very high to low intensity of damage.

**Survey for host range of *A. disperses***

Survey carried out in India showed the occurrence of *A. dispersus* on 153 host species belonging to 54 families. Totally 78 host plants were recorded for the first time, 49 hosts were not recorded earlier in any country, 7 hosts were recorded for the first time in India and 22 hosts were recorded in Tamil Nadu for the first time **(Table 105).** The host plants highly preferred by *A. dispersus* in India are pulses *viz*., *Cajanus cajan* (L.) Millsp., *Vigna unguiculata* (L.) Walp.; oil seeds *viz*., *Arachis hypogaea*; fibre crop *viz*., *Gossypium* spp.; vegetables *viz*., *Solanum melongena* L., *Solanum lycopersicum* L., *Capsicum annuum* L., *Abelmoschus esculentus* (L.) Moench, *Solanum torvum* Sw., *Lablab purpureus* (L.) Sweet, *Moringa oleifera* Lam., *Solanum nigrum* L., *Amaranthus tricolor* L.; fruit crops *viz*., *Psidium guajava* L, *Carica papaya*, *Musa* × *paradisiaca* L., *Annona squamosa* L., *Punica granatum* L., *Carica papaya* L., *Persea americana* Mill., *Manilkara zapota* (L.) P.Royen, *Anacardium occidentale* L. and *Terminalia catappa* L.; tuber crop *viz*., *Manihot esculenta* Crantz, *Amorphophallus paeoniifolius* (Dennst.) Nicolson.; medicinal and aromatic crops *viz*., *Ocimum sanctum* L., *Solanum trilobatum* L., *Murraya koenigii* (L.) Sprengel; ornamentals *viz*., *Rosa* spp., *Zinnia peruviana* (L.) L., *Hibiscus rosa-sinensis* L., *Acalypha hispida* Burm. f., *Euphorbia pulcherrima* Willd. ex Klotzsch, *Crossandra infundibuliformis* (L.) Nees, *Tecoma stans* (L.) Juss. ex Kunth, *Plumeria acuminata* Air.; plantation and forest crops *viz*., *Cocos nucifera* L., *Tectona grandis* L.f., *Millettia pinnata* (L.) Panigrahi, *Jacaranda mimosifolia* D.Don, *Thespesia populnea* (L.) Sol. ex Corrêa, *Bauhinia purpurea* L., *Jatropha* spp., *Simarouba glauca* DC., *Butea monosperma* (Lam.) Taub. and alternate weed hosts *viz*., *Parthenium hysterophorus* L., *Erigeron* sp., *Cassia* spp., *Acalypha indica* L., *Calotropis gigantea* (L.) W.T.Aiton, *Sida acuta* Burm. f., *Euphorbia hirta* L., *Euphorbia geniculata* Ortega, *Abutilon indicum* (Link) Sweet, etc.

**Survey for natural enemies**

Survey conducted to study the occurrence of natural enemies of *A. dispersus* indicated the occurrence of predators and parasitoids. Among the natural enemies, predators were more abundant in almost all localities and on different host species.

**Predator fauna**

Totally 28 species of predators recorded in coccinellid, chrysopid, drosophilid, lycaenid, mantodea and oxyopid were recorded during the survey **(Table 106)** It was interesting to note that the *Cybocephalus* spp., *Axinoscymnus puttarudriahi* Kapur and *Mallada astur* (Banks) were more abundant in Coimbatore, Erode, Trichy, Salem, Namakkal, Tiruppur and Bengaluru. throughout the study period. Both grubs and adults of *M. astur* were found preying upon all stages of *A. dispersus*. *Cybocephalus* spp. (34.98 per 5 plants), *A. puttarudriahi* (16.06), *Cryptolaemus montrouzieri* Muls. (10.07) and *Chilocorus nigritus* (Fabricius) (0.98) were more abundant in Namakkal district of Tamil Nadu. In Coimbatore, *M. astur* (38.47), *Menochilus sexmaculatus* Fab. (1.76), *Scymnus coccivora* Ayyar (1.42), preying mantis (1.78) and spiders (2.74) were found in more numbers. *Acletoxenus indicus* Malloch (3.25 per 5 plants) was recorded only from Bengaluru, Karnataka and *Mallada boninensis* Okamoto (5.05) was found more in Bengaluru. The occurrence of *M. boninensis* is the first report preying upon all stages of *A. dispersus* from Tamil Nadu and Karnataka.

**Table 105: New host plants of *A. dispersus***

| Places | Host species | |
|---|---|---|
| World | *Aegle marmelos* (L.) Corr.Serr. | *Lablab purpureus* (L.) Sweet |
| | *Amaranthus dubius* Mart. ex Thell. | *Leucas aspera* (Willd.) |
| | *Ardisia elliptica* Thunb. | *Limonia acidissima* L. |
| | *Aucuba japonica* Thunb. | *Luffa acutangula* (L.) Roxb. |
| | *Brassica oleracea* L. (Botrytis cultivar) | *Manilkara zapota* (L.) P.Royen |
| | *Brassica oleracea* L. (Capitata Group) | *Morinda citrifolia* |
| | *Cardia sebestena* L. | *Morinda tinctoria* Roxb. |
| | *Cassia grandis* L. | *Nerium oleander* L. |
| | *Cinnamomum verum* J.Presl | *Ocimum gratissimum* (L.) |
| | *Cleome hassleriana* Chodat | *Pennisetum purpureum* |
| | *Cleome viscosa* L. | *Phyla nodiflora* (L.) Greene |
| | *Convolvulus arvensis* L. | *Plectranthus amboinicus* (Lour.) Spreng. |
| | *Costus igneus* N.E.Br. | *Santalum album* L. |
| | *Cucurbita pepo* var. *styriaca* | Schumach |
| | *Datura discolour* Bernh. | *Senna auriculata* (L.) Roxb. |
| | *Dioscorea opposita* Thunb. | *Solanum xanthocarpum* Schrad. & Wendl. |
| | *Epipremnum aureum* (L.) Engl. | *Spinacia oleracea* L. |
| | *Erigeron* sp. | *Tecoma stans* (L.) Juss. ex Kunth |
| | *Euphorbia amygdaloides* L. | *Theobroma cacao* L. |
| | *Euphorbia ingens* E.Mey. ex Boiss. | *Trichosanthes dioica* Roxb. |
| | *Gomphrena globosa* L. | *Vicia faba* L. |
| | *Grevillea robusta* A.Cunn. ex R.Br. | *Vigna biflorus* (Lam.) Verdc. |
| | *Jacaranda mimosifolia* D.Don | *Zinnia peruviana* (L.) L. |
| | *Jasminum calophyllum* Wall. & G.Don. | *Ziziphus jujuba* Mill. |
| | *Jasminum flexile* L. | |
| India | *Achyranthes aspera* Linn. | *Eclipta prostrata* (L.) L. |
| | *Aleurites fordii* Hemsl. | *Persea americana* Mill. |
| | *Citrullus lanatus* (Thunb.) Matsum. & Nakai | *Sonchus oleraceus* L. |
| | *Cucumis sativus* L. | |
| Tamil Nadu | *Acalypha hispida* Burm. f. | *Euphorbia pulcherrima* Willd. ex Klotzsch |
| | *Artocarpus heterophyllus* Lam. | *Ficus religiosa* L. |
| | *Azadirachta indica* A.Juss. | *Ipomoea batatas* (L.) Lam. |

| | |
|---|---|
| *Benincasa hispida* Thunb. | *Jatropha* spp. |
| *Butea monosperma* (Lam.) Taub. | *Lagenaria siceraria* (Molina) Standl. |
| *Calotropis gigantea* (L.) W.T.Aiton | *Lawsonia inermis* L. |
| *Cardiospermum halicacabum* L. | *Momordica charantia* Descourt. |
| *Codiaeum variegatum* (L.) A.Juss. | *Moringa oleifera* Lam. |
| *Colocasia* spp. | *Sida acuta* Burm. |
| *Croton sparsiflorus* Morong | *Simarouba glauca* DC. |
| *Euphorbia geniculata* Ortega | *Syzygium cumini* (L.) Skeels. |

**Table 106: Predatory fauna of *A. disperses***

| Predator groups | Scientific Name | Order and Family |
|---|---|---|
| I. Chrysopids | *Mallada astur* (Banks) | Neuroptera, Chrysopidae |
| | *Mallada boninensis* Okamoto | Neuroptera, Chrysopidae |
| | *Chrysoperla zastrowi sillemi* (Esben - Petersen) | Neuroptera, Chrysopidae |
| | *Apterchrya* sp. | Neuroptera, Chrysopidae |
| | *Hemerobius* sp. | Neuroptera, Chrysopidae |
| II. Cybocephalid | *Cybocephalus* spp. | Coleoptera, Cybocephalidae |
| III. Coccinellids | *Cryptolaemus montrouzieri* Muls. | Coleoptera, Coccinellidae |
| | *Scymnus coccivora* Ayyar | Coleoptera, Coccinellidae |
| | *Pseudaspidimerus flaviceps* (Walker) | Coleoptera, Coccinellidae |
| | *Pseudaspidimerus trinotatus* (Thunberg) | Coleoptera, Coccinellidae |
| | *Chilocorus nigrita* (Fabricius) | Coleoptera, Coccinellidae |
| | *Menochilus sexmaculatus* Fab. | Coleoptera, Coccinellidae |
| | *Axinoscymnus puttarudriahi* Kapur | Coleoptera, Coccinellidae |
| | *Jauravia dorsalis* (Weise) | Coleoptera, Coccinellidae |
| | *Jauravia pallidula* Motschulsky | Coleoptera, Coccinellidae |
| | *Jauravia* sp. | Coleoptera, Coccinellidae |
| | *Anegleis cardoni* (Weise) | Coleoptera, Coccinellidae |
| | *Anegleis perrotteti* Mulsant | Coleoptera, Coccinellidae |
| | *Micrapis* sp. | Coleoptera, Coccinellidae |
| | *Microaspis discolor* (Fab.) | Coleoptera, Coccinellidae |
| | *Rodolia breviuscula* Weise | Coleoptera, Coccinellidae |
| | *Curinus coeruleus* (Mulsant) | Coleoptera, Coccinellidae |
| IV. Drosophilid | *Acletoxenus indicus* Malloch | Diptera, Drosophilidae |
| | *Triommato coccidivora* (Felt) | Diptera, Cecidomiidae |

| Predator groups | Scientific Name | Order and Family |
|---|---|---|
| V. Lepidoptera | *Spalgis epeus* Westwood | Lepidoptera, Lycaenidae |
| VII. Anthocorid | Unidentified | Hemiptera, Anthocoridae |
| VIII. Praying mantis | Unidentified | Dictyoptera, Mantodea |
| VI. Spiders | *Oxyopes* sp. | Acari, Oxyopidae |

**Parasitoid fauna**

Several host species were surveyed throughout Tamil Nadu and Karnataka for identifying the parasitoids attacking *A. dispersus*. *Encarsia guadeloupae* and *Encarsia* sp nr *meritoria* were the most abundant parasitoids in Coimbatore (25.50 and 28.25 per plant, respectively) on cassava. *E. guadeloupae* (25.67 per plant) and *E.* sp nr *meritoria* (29.00 per plant) were more abundant on cassava surveyed in Tamil Nadu and Karnataka **(Table 107).**

**Table 107: Distribution of parasitoids of *A. dispersus* on different host plants from Tamil Nadu and Karnataka.**

| Host species | ***A. dispersus* parasitoids per plant*** | |
|---|---|---|
| | ***E. gaudalopae*** | ***E. sp near meritoria*** |
| *Manihot esculenta* Crantz. | 25.67[a] (5.07) | 29.00[a] (5.39) |
| *Solanum melongena* L. | 11.67[c] (3.42) | 7.33[d] (2.71) |
| *Psidium guajava* L. | 6.33[de] (2.52) | 2.00[f] (1.41) |
| *Capsicum annum* L. | 6.33[de] (2.52) | 5.67[cde] (2.38) |
| *Morus alba* L. | 12.33[c] (3.51) | 7.67[d] (2.77) |
| *Carica papaya* L. | 7.33[d] (2.71) | 11.67[c] (3.42) |
| *Terminalia catappa* L. | 14.00[c] (3.74) | 1.67[f] (1.29) |
| *Musa* × *paradisiaca* L. | 4.33[def] (2.08) | 3.67[ef] (1.91) |
| *Cajanus cajan* (L.) Millsp. | 2.00[f] (1.41) | 1.00[f] (1.00) |
| *Gossypium hirsutum* L. | 19.33[b] (4.40) | 22.00[b] (4.69) |
| *Solanum lycopersicum* L. | 11.33[c] (3.37) | 13.67[c] (3.70) |
| *Annona squamosa* L. | 2.67[ef] (1.63) | 1.67[f] (1.29) |
| *Acalypha hispida* Burm. f. | 22.33[ab] (4.73) | 19.00[b] (4.36) |

| | | |
|---|---|---|
| *Tectona grandis* L.f. | 19.67[b] (4.43) | 12.33[c] (3.51) |
| *Cocos nucifera* L. | 5.00[def] (2.24) | 2.00[f] (1.41) |
| SEd | 1.8921 | 1.6327 |
| CD (P = 0.05) | 3.8758 | 3.3445 |

*Mean of three locations; significant at 1%; figures in parentheses are square root transformed values, means followed by a common letter(s) are not significantly different by DMRT (P = 0.05)

**Field evaluation of predators against *A. dispersus* on cassava.**

Two field experiments were carried out to evaluate the efficacy of seven predators *viz*., *Cybocephalus* spp., *A. puttarudriahi*, *C. montrouzieri*, *C. zastrowi sillemi*, *M. astur*, *S. coccivora* and *M. sexmaculata* against *A. dispersus* on cassava (var. Mulluvadi-1) .The field trials were conducted on seven months old cassava field during January to February 2014 at Kinathukadavu. Two releases of predator were made (60 days interval on cassava and at 30 days interval on brinjal). The treatment details are as follows: *Cybocephalus* spp. *A. puttarudriahi, C. montrouzieri,* released at 1500 beetles/ha., *C. zastrowi sillemi*, *M. astur* @ 1.0 lakh /ha*, S. Coccivora and M. Sexmaculata* @ 1500 beetles/ha.

Each treatment was separated by a distance of 25 m to avoid the movement of predators from one treatment to other and no insecticidal spray was given throughout the experimental period. The per cent reduction of *A. dispersus* population was calculated over control.

Among seven predators evaluated against *A. dispersus* on cassava, *M. astur* was found to be the most efficient predator in reducing the population of *A. dispersus* after 60 days of first (84.2 per cent) and second releases (97.0 per cent) followed by *Cybocephalus* spp. (79.8 per cent) which was on par with *C. montrouzieri* (78.3 per cent) in first and second releases. *Cybocephalus* spp. (95.5 per cent) was found to be the second best predator in reducing the population of *A. dispersus*. Sixty days after second release (DAR), all predators except *M. sexmaculata* were found to be efficient in reducing of *A. dispersus* (more than 80 per cent) population**.**

**Collection and identification of the parasitoids of *A. dispersus***

Extensive field surveys were conducted throughout Tamil Nadu and Karnataka to collect the parasitoids of *A. dispersus*. In cassava and brinjal, regular samplings were made on 10 leaves for observing the presence of parasitoids. The collected specimens were identified at Faculty of Agriculture, Annamalai University, Chidambaram, Tamil Nadu.

Three species of parasitoids were collected during the survey and the most promising parasitoid was *E. guadalopae* followed by *E.* sp nr *meritoria* in controlling the *A. dispersus* population**.**

**Parasitism of *E. guadeloupae* and *E.* sp. nr. *meritoria* on *A. dispersus***

Intensive survey and periodical sampling were done at monthly interval from November 2012 to December 2013 on cassava at Tamil Nadu Agricultural University (TNAU), Coimbatore to find out the parasitization level of *E. guadeloupae* and *E.* sp. nr. *meritoria*. Twenty leaf samples with late instar nymphs of *A. dispersus* were collected randomly and the morphological features were studied.

Periodical sampling to study the parasitization level of *Encarsia* spp. revealed that the per cent parasitism ranging from 18.84 to 88.78. The highest per cent parasitism was recorded during April 2013 (88.78) followed by May 2013 (84.48) and March 2013 (73.64). The lowest per cent parasitism was noticed during November (18.84) and December 2013 (19.42). Maximum per cent parasitoid emergence was recorded during March 2013 (99.02) followed by June 2013 (96.92). The lesser per cent parasitoid emergence was recorded during January 2013 (72.36).

**Field evaluation of parasitoids *viz.*, *E. guadeloupae, E.* sp. nr. *meritoria* and *E. Haitensis* against *A. dispersus* on cassava**

*E. guadeloupae*, *E.* sp. nr. *meritoria* and *E. haitensis* adults collected from cassava and guava at TNAU, Coimbatore were released at the rate of four parasitized pupae per plant on cassava (var. Mulluvadi-1) plants infested with nymphs of *A. dispersus*. Leaves at released plots (five leaves per plot) were tagged and examined periodically using a hand lens (15x) for colour change of the pupae.

Among the parasitoids, *E. guadalopae* was found to be the most effective parasitoid in the reduction of *A. dispersus* population both after 60 days of first (82.6 per cent) and second releases (96.0 per cent) followed by *E.* sp nr *meritoria* in both the releases (79.6 and 92.2 per cent, respectively) **(Table 108).** Sixty days after second release, all the three species of parasitoids were found to be more effective causing more than 90 per cent reduction in *A. dispersus* population.

**Table 108: Evaluation of parasitoids of *A. dispersus* on cassava (Location: Kinathukadavu, Coimbatore)**

| Predators | Pre count (No. per leaf) | Per cent reduction of *A. dispersus** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Days after release | | | | | | | |
| | | First release | | | | Second release | | | |
| | | 15 | 30 | 45 | 60 | 15 | 30 | 45 | 60 |
| *Encarsia guadeloupae* Viggiani | 211.4 | 18.3[a] (25.3) | 43.2[a] (41.1) | 62.9[a] (52.5) | 82.6[a] (65.4) | 90.2[a] (71.8) | 91.4[a] (72.9) | 94.3[a] (76.2) | 96.0[a] (78.53) |
| *Encarsia* sp nr *meritoria* Gahan | 211.2 | 14.2[ab] (22.16) | 35.7[b] (36.68) | 55.0[b] (47.88) | 79.6[b] (63.13) | 84.7[b] (66.97) | 88.9[b] (70.6) | 90.2[b] (71.7) | 92.2[b] (73.77) |
| *Encarsia* (?) *haitiensis* Dozier | 203.4 | 10.0[b] (18.46) | 30.5[c] (33.49) | 46.0[c] (42.7) | 73.3[c] (58.87) | 78.5[c] (62.40) | 78.2[c] (62.2) | 86.8[c] (68.66) | 90.2[c] (71.72) |
| Control | 212.6 | 0.0[c] (0.00) | 0.0[d] (0.00) | 0.0[d] (0.00) | 0.0[d] (0.00) | 0.0[d] (0.00) | 0.0[d] (0.00) | 0.0[d] (0.0) | 0.0[d] (0.00) |
| SEd | | 2.1795 | 1.2044 | 1.1878 | 0.3017 | 0.4585 | 0.451 | 0.334 | 0.5553 |
| CD (P = 0.05) | | 4.7487 | 2.6242 | 2.5881 | 0.6574 | 0.9989 | 0.9827 | 0.727 | 1.2098 |

* Mean of five replications; significant at 1%; figures in parentheses are arc sine transformed values; in a column, means followed by a common letter(s) are not significantly different by DMRT (P = 0.05)

**Entomopathogenic fungi against *A. disperses*, pathogenicity of entomopathogenic fungi against *A. disperses***

Bioassays were carried out at Department of Agricultural Entomology, Centre for Plant Protection Studies, TNAU, to evaluate the pathogenicity, ovicidal effect, and $LC_{50}$ of Entomopathogenic fungi against *A. dispersus*.

**Pathogenicity of Entomopathogenic Fungi against *A. dispersus***

Strains of different entomopathogenic fungi were assayed against *A. dispersus* nymphs by direct spray method in completely randomized design (CRD). Entomopathogenic fungi were sprayed with the help of atomizer over the nymphs of *A. Disperses* kept in Petri plates. The Petri plates were maintained at $25 \pm 1^0$C in an incubator.

The mortality of *A. dispersus* by entomopathogenic fungi was recorded at 3, 5, 7, 10, 13, and 15 days after treatment (DAT), by counting the dead cadavers and nymphs with fungal spores. All Entomopathogenic fungi caused high rates of pathogenicity among *A. dispersus* population. *A. dispersus* population infected by *B. bassiana* was distinctly red to red brown. Hyphal growth and sporulation of *P. fumosoroseus* were visibly greater and more rapid than those of the other Entomopathogenic fungi. *P. fumosoroseus* (P1 strain) caused significantly maximum mortality (80.4%) at 10 DAT as compared to other entomopathogenic fungi isolates **(Table 109).** *P. fumosoroseus* (P1 strain) produced 100% mortality to *A. dispersus* nymphs at 15 DAT.

**Table 109: Pathogenicity of entomopathogenic fungi against *A. dispersus* nymphs**

| Treatments | Per cent corrected mortality of *A. dispersus** | | | |
|---|---|---|---|---|
| | **3 DAT** | **7 DAT** | **10 DAT** | **15 DAT** |
| *B. bassiana* (B1 strain) | 7.44[bc] (15.83) | 14.79[de] (22.62) | 41.85[d] (40.31) | 93.45[b] (75.17) |
| *B. bassiana* (B2 strain) | 8.39[bc] (16.83) | 27.73[cd] (31.78) | 48.67[cd] (44.24) | 82.55[c] (65.31) |
| *L. lecanii* (L1 strain) | 13.04[bc] (21.17) | 39.26[bc] (38.80) | 59.22[bc] (50.32) | 97.03[ab] (80.07) |
| *M. anisopliae* (M1 strain) | 14.70[b] (22.55) | 42.12[abc] (40.47) | 62.09[b] (52.00) | 97.84[ab] (81.55) |
| *M. anisopliae* (M2 strain) | 8.63[bc] (17.08) | 47.22[ab] (43.41) | 55.72[bc] (48.28) | 80.07[c] (63.49) |
| *M. anisopliae* (M3 strain) | 13.52[bc] (21.58) | 48.55[ab] (44.17) | 65.54[b] (54.05) | 92.49[b] (74.09) |
| *P. fumosoroseus* (P1 strain) | 28.39[a] (32.20) | 56.74[a] (48.88) | 80.38[a] (63.71) | 100.00[a] (90.00) |
| Control | 0.00[c] (0.00) | 0.00[e] (0.00) | 0.00[e] (0.00) | 0.00[d] (0.00) |
| SEd | 6.4519 | 7.258 | 5.1145 | 3.0583 |
| CD (P = 0.05) | 13.6777 | 15.3866 | 10.8425 | 6.4833 |

Dose: $2 \times 10^9$ conidia per ml
DAT: Days After Treatment
*Mean of three replications; significant at 1%; figures in parentheses are arc sine transformed values; in a column, means followed by a common letter(s) are not significantly different by DMRT (P=0.05)

**Ovicidal effect of entomopathogenic fungi against *A. dispersus***

The ovicidal effect of Entomopathogenic fungi on *A. dispersus* eggs was assayed. Uniform age of *A. dispersus* eggs were taken from eggplant (*Solanum melongena* L.) leaf placed on 1.5% agar in a Petri dish. Entomopathogenic fungi were sprayed with help of automizer over the eggs of *A. dispersus* with three replications in CRD. All the treated Petri dishes were maintained at $25 \pm 1^0$C in an incubator and hatchability was recorded until no change for three consecutive days. Observations were made at 4, 6, 8, and 10 DAT.

*M. anisopliae* (M2 Strain) caused 37.3% egg mortality followed by *P. fumosoroseus* (P1 strain) (22.6%) at 8DAT. Very low ovicidal effect was observed in *B. bassiana* (B1 strain) (4.2%). The hatchability was suppressed by all the entomopathogenic fungi to some extent **(Table 110).** *L. lecanii* (L1 strain) produced lesser egg hatchability (23.2%) at 10DAT as compared to other fungi.

**Table 110. Effect of entomopathogenic fungi on the per cent egg hatchability and unhatched eggs of *A. dispersus***

| Treatments | Per cent egg hatchability (10 DAT)* | Per cent unhatched eggs (10 DAT)* |
|---|---|---|
| *B. bassiana* (B1 strain) | $90.48^{f}$ (72.02) | $0.00^{c}$ (0.00) |
| *B. bassiana* (B2 strain) | $71.67^{d}$ (57.84) | $5.00^{c}$ (12.92) |
| *L. lecanii* (L1 strain) | $23.19^{a}$ (28.79) | $60.87^{a}$ (51.28) |
| *M. anisopliae* (M1 strain) | $52.69^{b}$ (46.54) | $22.58^{b}$ (28.37) |
| *M. anisopliae* (M2 strain) | $82.46^{e}$ (65.24) | $5.26^{c}$ (13.26) |
| *M. anisopliae* (M3 strain) | $60.00^{c}$ (50.77) | $1.33^{c}$ (6.63) |
| *P. fumosoroseus* (P1 strain) | $51.11^{b}$ (45.64) | $26.67^{b}$ (31.09) |
| Control | $92.59^{f}$ (74.21) | $1.85^{c}$ (7.82) |
| SEd | 2.6682 | 3.1700 |
| CD (P = 0.05) | 5.6565 | 6.7201 |

Dose: 2 x $10^9$ conidia per ml

*Mean of three replications; significant at 1%; figures in parentheses are arc sine transformed values; in a column, means followed by a common letter(s) are not significantly different by DMRT (P=0.05)

**Median Lethal Concentrations ($LC_{50}$) of entomopathogenic fungi against *A. dispersus* nymphs.**

The median lethal concentrations ($LC_{50}$) of four entomopathogenic fungi, namely, *M. anisopliae* (M1 strain), *B. bassiana* (B1 strain), *L. lecanii* (L1 strain), and *P. fumosoroseus* (P1 strain), against *A. dispersus* nymphs was determined. Five doses (from $2 \times 10^5$ to $2 \times 10^9$ conidia $mL^{-1}$) were fixed for which dilutions were prepared with double distilled water. Uniform age of *A. dispersus* nymphs was taken from eggplant leaf placed on 1.5% agar in a Petri dish. Five concentrations of each respective entomopathogenic fungi was sprayed with the help of atomizer over the *A. dispersus* nymphs with three replications in CRD. All the treated Petri dishes were maintained at $25 \pm 1^0$C in an incubator.

The nymphs were individually examined under a stereo zoom binocular microscope at 40x magnification for verification of fungal infection. The median lethal concentrations ($LC_{50}$) and $LC_{95}$ values were estimated for *A. dispersus*. The $LC_{50}$ of *L. lecanii* (L1 strain), *P. fumosoroseus* (P1 strain), *M. anisopliae* (M1 strain) and *B. bassiana* (B1 strain) assessed for *A. disperses* population were $3.085 \times 10^8$, $8.189 \times 10^7$, $2.197 \times 10^8$, and $3.481 \times 10^8$ conidia $mL^{-1}$, respectively **(Table 111).** The $LC_{95}$ of *L. lecanii* (L1 strain), *P. fumosoroseus* (P1 strain), *M.anisopliae* (M1 strain), and *B. bassiana* (B1 strain) assessed for *A. dispersus* population were $2.513 \times 10^{13}$, $5.053 \times 10^{12}$, $1.506 \times 10^{13}$, and $3.442 \times 10^{13}$ conidia $mL^{-1}$, respectively. Log concentration probit mortality response of *A. disperses* to entomopathogenic fungi is depicted in Figures 3, 4, 5, and 6. In the present study, the lowest $LC_{50}$ and $LC_{95}$ were recorded by *P. fumosoroseus* as $8.189 \times 10^7$ and $5.053 \times 10^{12}$ conidiamL$^{-1}$, respectively, indicating higher virulence against *A. dispersus*.

**Table 111: $LC_{50}$ of entomopathogenic fungi against *A. disperses***

| Entomopath.fungi | Regression Equation | Calculated $\chi^2$ | $LC_{50}$ (ppm) | Fiducial limits | | $LC_{95}$ (ppm) | Fiducial limits | |
|---|---|---|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit | | Lower limit | Upper limit |
| *L. lecanii* | y = 0.357x + 1.979 | 0.3176 | 3.085 x $10^8$ | 3.541 x $10^7$ | 2.688 x $10^9$ | 2.513 x $10^{13}$ | 5.562 x $10^{10}$ | 1.135x $10^6$ |
| *P. fumosoroseus* | y = 0.351x + 2.206 | 0.3398 | 8.189 x $10^7$ | 4.926 x $10^6$ | 1.361 x $10^9$ | 5.053 x $10^{12}$ | 1.036 x $10^{10}$ | 2.465 x $10^{15}$ |
| *M. anisopliae* | y = 0.336x + 2.196 | 0.3493 | 2.197 x $10^8$ | 3.991 x $10^7$ | 1.209 x $10^9$ | 1.506 x $10^{13}$ | 6.926 x $10^{10}$ | 3.274 x $10^{15}$ |
| *B. bassiana* | y = 0.327x + 2.207 | 0.0448 | 3.481 x $10^8$ | 3.958 x $10^7$ | 3.061 x $10^9$ | 3.442 x $10^{13}$ | 9.624 x $10^{10}$ | 1.231 x $10^{16}$ |

**Bioefficacy of entomopathogenic fungi against *A. dispersus* on cassava**

The entomopathogenic fungi *viz*., *M. anisopliae*, *B. bassiana*, *L. lecanii* and *P. fumosoroseus* at 2 x $10^9$ conidia per ml were field evaluated against *A. dispersus* population on seven months old cassava (var. Mulluvadi-1). Two field trials were conducted. The first field trial was conducted during January to February 2014 at Kinathukadavu and the second trial was carried out during February to March 2014 at Pollachi, Coimbatore.

Each treatment of a trial was applied to five replicate plots arranged in a randomized block design (RBD). Pre-treatment observations on *A. dispersus* population were taken 24 h. before spraying, while post-treatment observations were taken 3, 7, 10 and 15 DAT in five leaves per plot. Two rounds of application were made at 15 days interval. Spray volume was 500-700 litres per ha. The per cent mortality of *A. dispersus* population were recorded and corrected with that in control as per Henderson and Tilton (1955)

In the first field experiment conducted at Kinathukadavu, Coimbatore, all fungal pathogens *viz*., *B. bassiana*, *M. anisopliae*, *L. lecanii* and *P. fumosoroseus* caused substantial reduction in *A. dispersus* population**.** The mortality increased with increase in time interval. *P. fumosoroseus* recorded significantly maximum mortality in both first (73.70 per cent) and second sprays (79.96 per cent) at 15 days after spray (DAS) as compared to other entomopathogenic fungi. Mortality was less in the treatment with *M. anisopliae* at 15 DAS in both first (59.36 per cent) and second sprays (65.51 per cent). A similar trend in efficacy was observed in the second field experiment conducted at Pollachi also **(Table 112).**

**Table 112: Bioefficacy of entomopathogenic fungi against *A. dispersus* on cassava (Location: Pollachi, Coimbatore)**

| Treatments | PTC | Per cent corrected mortality of *A. dispersus** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | First spray | | | | Second spray | | | |
| | | Days after treatment | | | | Days after treatment | | | |
| | | 3 | 7 | 10 | 15 | 3 | 7 | 10 | 15 |
| *B. bassiana* | 172.52 | 34.84[c] (36.17) | 40.59[c] (39.58) | 56.42[c] (48.69) | 68.13[c] (55.63) | 47.07[b] (43.32) | 56.83[b] (48.93) | 62.75[b] (52.39) | 71.95[c] (58.02) |
| *M. anisopliae* | 170.52 | 30.74[d] (33.67) | 37.15[d] (37.56) | 54.51[c] (47.59) | 65.70[d] (54.15) | 40.52[c] (39.53) | 55.35[b] (48.07) | 59.70[b] (50.59) | 68.71[c] (55.99) |
| *L. lecanii* | 173.28 | 37.15[b] (37.55) | 49.89[b] (44.94) | 61.63[b] (51.72) | 72.94[b] (58.66) | 51.99[a] (46.14) | 63.01[a] (52.54) | 70.25[a] (56.95) | 78.59[b] (62.44) |
| *P.fumosoroseus* | 171.20 | 44.39[a] (41.78) | 53.17[a] (46.82) | 67.53[a] (55.26) | 77.73[a] (61.84) | 53.37[a] (46.93) | 68.04[a] (55.57) | 76.60[a] (61.07) | 84.50 (66.82) |
| Control | 170.88 | 0.00[e] (0.00) | 0.00[e] (0.00) | 0.00[d] (0.00) | 0.00[e] (0.00) | 0.00[d] (0.00) | 0.00[c] (0.00) | 0.00[c] (0.00) | 0.00[d] (0.00) |
| SEd | - | 1.0723 | 1.4430 | 1.0395 | 1.0241 | 2.2698 | 2.6141 | 3.1587 | 1.6876 |
| CD (P = 0.05) | - | 2.2731 | 3.0590 | 2.2036 | 2.1710 | 4.8118 | 5.5418 | 6.6963 | 3.5776 |

Dose: 2 x $10^9$ conidia per ml

PTC: Pre Treatment Count (No. of *A. dispersus* per leaf)

*Mean of five replications; significant at 1% level; figures in parentheses are arc sine transformed values; in a column, means followed by a common letter(s) are not significantly different by DMRT (P = 0.05).

## 2.15. Tea Mosquito Bug

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

**Experimental details**:

Location : Experimental Tea garden, AAU, Jorhat / Kachagaral, Jorhat
Area : 1 hectare
Variety : TV -23
Replication : four
Plot size : One hectare area was divided into 20 equal plots
Year of commencement: 2013 -14

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

To evaluate *Beauveria bassiana* (IIHR strain), *B.bassiana* (Commercial product) and botanical insecticides (Pestoneem) against tea mosquito bug (*Helopeltis theivora*), an organic tea garden area of 1 ha was selected at AAU, Jorhat. For spraying Thiamethoxam @ 30g ai/ha against *H. theivora* a separate area of 0.2 ha was also selected at an isolated distance, about 1 km away at Kachagaral. Two rounds of sprays were applied maintaining an interval of 30 days in between the sprays. First spray schedule was taken up in July and second was in August 2013. The sprays were applied based on maximum abundance of pests.

**Methodology:**

Observation on pre treatment count was recorded and in case of post treatment counts of adults/10 plants (representing each replication) were recorded at 15 and 30 days intervals, after each spray. Eggs of *H. theivora* were also collected from each treatment and observed in the laboratory for emergence of natural enemies.

**Results**

Among the different treatments against *H. theivora* in tea, Thiamethoxam @ 30 gm ai/ha was found superior to *B. bassiana* (IIHR strain) in reducing the *H. theivora* population. However, the second best treatment was *B. bassiana* IIHR strain (15.75/10plants) after 30 days of second spray. No significant difference was noticed between the treatments with *B. bassiana* IIHR strain (15.75/10 plants) pestoneem (16.25/10 plants) and *B. bassiana* of commercial formulation (17.25 /10 plants) in their efficacies in reducing the *H. theivora* population (Table 114). An egg parasitoid of *H. theivora* was detected in the laboratory and it was suspected to be *Telenomus* sp. The specimens will be sent to NBAII for confirmation **(Table 113)**.

**Table 113: Efficacy of *Beauveria bassiana* (IIHR strain) on *Helopeltis theivora* in tea**

| Treatments | Pre treatment count (Adults/ 10 plants) | Post treatment count (Adults/10 plants) | | | |
|---|---|---|---|---|---|
| | | 15 days after Ist spray | 30 days after Ist spray | 15 days after IInd spray | 30 days after IInd spray |
| Thiamethoxam @ 30g ai/ha | 30.5 | 15.75[a] | 10.50[a] | 8.25[a] | 6.4 [a] |
| Pestoneem | 27.25 | 24.0[c] | 20.0[b] | 18.0[b] | 16.25 [b] |
| *Beauveria bassiana* (Commercial formulation) | 26.25 | 20.06[b] | 18.75 [b] | 19.75[c] | 17.25 [b] |
| B.b (IIHR strain) | 29.25 | 18.75 [b] | 17.75 [b] | 17.25 [b] | 15.75 [b] |
| Control | 26.75 | 29.5[d] | 31.5[c] | 33.0[d] | 26.75[c] |
| CV % | | 8.07 | 14.81 | 8.00 | 19.88 |
| CD ( =0.05) | NS | 1.89 | 3.11 | 1.67 | 3.54 |

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

## 2.16. Mealy Bugs

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

a. Fortnightly surveys were conducted in orchards/fields for mealy bug incidence. Infested plant parts were brought back to the laboratory and held under caged conditions for emergence of natural enemies.
b. Alternate host plants, if any, were recorded.
c. Crop - wise records were maintained for extent of damage by the mealy bug, level of natural enemies present, etc. to be maintained.
e. If invasive species of mealy bugs were observed during the surveys, it was to be brought to the notice of the Director, NBAII.

**Result:**

Regular surveys were conducted in orchards/ farmers fields in different locations for mealy bug incidence, alternate hosts and natural enemies. A stray incidence of papaya mealy bug *Paracoccus marginatus* was recorded on papaya, tapioca, mulberry and tomato in Coimbatore, Erode, Salem and Tiuppur Districts (**Table 114**) and a higher incidence of pink mealy bug *Maconellicoccus hirsutus* on mulberry, grapevine, tapioca, bhendi and Jatropa was recorded (**Table 115**) The occurrence of *Acerophagus papayae*, *Cryptolaemus montrouzieri*, *Stethorus* and *Spalgis epius* were found along with mealybugs. During the survey, a short tailed mealy bug was found together with *P.marginatus* colonizing papaya in two plantations. This mealybug was identified as the Jack Beardsley mealybug, *Pseudococcus jackbeardsleyi* Gimpel and Miller (Hemiptera: Pseudococcidae) by an integrated taxonomic approach. This appears to be the first report of *Pseudococcus jackbeardsleyi* in India and of papaya as a host of this pest.

**Table 114: Incidence of papaya mealybug on papaya and its natural enemies**

| Places surveyed | Period | *P.marginatus* incidence (%) | Natural Enemy/5 leaves | | | |
|---|---|---|---|---|---|---|
| | | | *A.papayae* | *Cryptolaemus* | *Stethorus* | *Spalgis epius* |
| Coimbatore | July 13 | 3.5 | 0 | 1 | 0 | 0 |
| | Aug 13 | 1.0 | 0 | 0 | 0 | 1 |
| | Sep 13 | 2.5 | 1 | 0 | 0 | 0 |
| | Oct 13 | 5.5 | 0 | 2 | 0 | 0 |
| | Nov13 | 3.0 | 2 | 0 | 0 | 1 |
| | Dec 13 | 7.0 | 2 | 1 | 1 | 2 |
| | Jan 14 | 8.5 | 5 | 3 | 2 | 0 |
| | Feb14 | 9.0 | 5 | 1 | 2 | 1 |
| Tiruppur | July 13 | 0.0 | 0 | 0 | 0 | 1 |
| | Aug 13 | 4.5 | 1 | 2 | 0 | 0 |
| | Sep 13 | 3.0 | 2 | 1 | 0 | 0 |
| | Oct 13 | 6.5 | 2 | 2 | 1 | 0 |
| | Nov13 | 5.0 | 2 | 0 | 1 | 2 |
| | Dec 13 | 7.5 | 5 | 1 | 0 | 1 |
| | Jan 14 | 8.0 | 3 | 1 | 2 | 0 |
| | Feb14 | 10.5 | 7 | 2 | 1 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Erode | July 13 | 3.0 | 0 | 0 | 0 | 1 |
| | Aug 13 | 7.0 | 2 | 1 | 1 | 1 |
| | Sep 13 | 8.5 | 3 | 0 | 0 | 0 |
| | Oct 13 | 4.0 | 1 | 0 | 0 | 0 |
| | Nov13 | 6.0 | 3 | 2 | 1 | 0 |
| | Dec 13 | 8.0 | 3 | 1 | 0 | 2 |
| | Jan 14 | 11.5 | 4 | 2 | 2 | 1 |
| | Feb14 | 8.5 | 2 | 0 | 0 | 1 |
| Salem | July 13 | 2.5 | 0 | 0 | 0 | 0 |
| | Aug 13 | 5.5 | 1 | 2 | 1 | 1 |
| | Sep 13 | 5.0 | 0 | 0 | 0 | 2 |
| | Oct 13 | 10.5 | 5 | 1 | 0 | 1 |
| | Nov13 | 8.5 | 2 | 0 | 2 | 0 |
| | Dec 13 | 6.0 | 2 | 0 | 1 | 2 |
| | Jan 14 | 11.5 | 4 | 2 | 1 | 1 |
| | Feb14 | 7.5 | 3 | 0 | 0 | 1 |

**Table 115: Incidence of mealybugs on various crops and their natural enemies**

| Places surveyed | Crop | Mealybug incidence (%) | | | | No. of Enemies/5 leaves | | |
|---|---|---|---|---|---|---|---|---|
| | | ***Phenacoccus solenapsis*** | ***Paracoccus marginatus*** | ***Ferrisia virgata*** | ***Maconellicoccus hirsutus*** | ***A.papayae*** | ***Cryptolaemus*** | ***Spalgis epius*** |
| Coimbatore | Mulberry | - | 0-6.5 | 0.0 | 2.5-19.0 | 0 – 1.5 | 0 – 2.0 | 1 |
| | Tapioca | - | 4.5-8.5 | 3.0-9.0 | 0.0 | 1.5 - 3 | 1.0 -4.0 | 2 |
| | Cotton | 0.5-3.0 | 0.0-1.5 | 0.0 | 1.5-3.0 | 0 | 0.5-1.5 | - |
| | Grapevine | - | 0.0 | 0.0 | 8.5-20.0 | 0 | 3.5 -7.5 | - |
| | Jatropa | - | 0.5-4.0 | 0.0 | 2.5-5.5 | 1.0 – 2.0 | 1.0 -2.5 | - |
| | Tomato | - | 1.5-4.0 | 0.0 | 0.0 | 0 – 1.5 | 2.0 -2.5 | - |
| Tiruppur | Mulberry | - | 3.0-8.5 | 0.0 | 5.0-13.5 | 1.0 -4.0 | 0.5 – 4.5 | 2 |
| | Tapioca | - | 6.5-11.0 | 5.5-12.0 | 0.0-1.5 | 2.5 – 5.5 | 1.0 – 2.5 | 1 |
| | Cotton | 2.5-4.5 | 0.0 | 0.0 | 1.5-3.5 | 0.0 | 0.5 -1.0 | - |
| | Bhendi | - | 0.0 | 0.0 | 2.5-5.5 | 0.0 | 0.0 | - |
| Erode | Mulberry | - | 1.5-6.0 | 0.0 | 3.5-13.0 | 3.0 -5.5 | 1.0 – 6.5 | 3 |
| | Tapioca | - | 4.0-8.5 | 5.5-14.0 | 1.0-2.5 | 5. 7.5 | 1.5 – 4.5 | 1 |
| | Cotton | 1.0-2.0 | 1.0-3.0 | 0.0-1.5 | 2.5-4.0 | 0 -2.5 | 0.0 -1.0 | - |
| | Bhendi | - | 0.0-1.5 | 0.0 | 3.0-8.0 | 0.0 | 0.0 | - |
| Salem | Mulberry | - | 1.5-5.0 | 0.0-1.5 | 5.5-18.0 | 3.5 - 6 | 2.5 -6.5 | - |
| | Tapioca | - | 3.0-10.5 | 4.5-12.5 | 2.0-3.5 | 3.0 -7.5 | 0.0 – 3.5 | 1 |
| | Cotton | 0.0-1.5 | 3.0-4.5 | 1.5-3.0 | 5.5-7.0 | 1.0 - 2 | 0.5 – 1.5 | - |
| | Bhendi | - | 1.0-2.5 | 0.0 | 2.0-6.5 | 0.5 – 1.5 | 0.0 – 0.5 | 1 |
| | Jatropa | - | 1.5-4.5 | 0.0 | 3.5-7.5 | 1.0 -3.0 | 1.5 – 3.5 | 2 |

## 2.17. Biological Suppression of Polyhouse Crop Pests

### 1. Biological control of leaf miner in chrysanthemum in Polyhouse conditions (TNAU)

$T_1$ Release of *Trichogramma chilonis* @ 50,000/ha
$T_2$ *Beauveria bassiana* $10^8$ cfu /ml
$T_3$ *Verticillium lecanii* $10^8$ cfu /ml
$T_4$ *Metarhizium anisopliae* $10^8$ cfu /ml
$T_5$ *Hirsutella thompsonii* $10^8$ cfu /ml
$T_6$ Triazophos 2ml / l
$T_7$ Control

No of release / spray one at 60 DAP
Design : RBD
Plot size : 4 x 5 m
Replication : Four
Variety : red gold
Date of Planting : 03 – 06 - 2014
Date of Harvest : 09 – 10- 2014
Farmer name : S.Venkatesh
Location : Elkhill Farm, Ooty

Observations :

- Population of the pest from 10 randomly selected plants before treatment as well as 10 days after each treatment.
- Record leaf damage.
- Yield per plot

The results revealed that among the treatments Triazophos at 2 ml/l. was significantly superior in reducing the leafminer population and leaf damage coupled with high yield. Next to chemical treatment, *Beauveria bassiana* and *Metarhizium anisopliae* at $10^8$ cfu /ml were moderately effective in managing the leafminer damage. The parasitoid *Trichogramma chilonis* @ 50,000/ha and the fungal pathogens *Verticillium lecanii* and *Hirsutella thompsonii* at $10^8$ cfu /ml were on a par with control **(Table 116)**.

**Table 116: Biological control of leaf miner in chrysanthemum in poly house conditions.**

| Treatments | Pretreatment (number /plant) | 10 DAT (number /plant) | Mean Leaf damage(%) | Yield kg/ plot |
|---|---|---|---|---|
| Release of *Trichogramma* | 24.6 [a] | 33.7[c] | 40.0[c] | 41.0[c] |
| *Beauveria* $10^8$ cfu /ml | 23.8 [a] | 25.6[b] | 32.7[b] | 44.3[b] |
| *Verticillium* $10^8$ cfu /ml | 25.1 [a] | 32.6[c] | 39.5[c] | 40.6[c] |
| *Metarhizium* $10^8$ cfu /ml | 24.0 [a] | 28.4[b] | 33.2[b] | 43.7[b] |
| *Hirsutella* $10^8$ cfu /ml | 25.2 [a] | 33.4[c] | 42.6[c] | 39.9[c] |
| Triazophos 2ml / l | 24.8 [a] | 6.3[a] | 7.4[a] | 50.1[a] |
| Control | 25.8 [a] | 38.8[d] | 42.2[c] | 40.6[c] |

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

**2. Evaluation of anthocorid predator, *Blaptosthetus pallescens* against spider mites in poly houses (PAU, ANGRAU)**

**ANGRAU - Hyderabad**

Crop: Carnation
Microplot size: 2.0 m X 2.0m
Design: RBD @ 4 replications

**Treatments**

T1: 10 anthocorids per plant (4-5 releases)
T2: 20 anthocorids per plant (4-5 releases)
T3: Standard Chemical insecticide
T4: Untreated Control

**Observations:**

- Mite population was recorded from 10 randomly selected plants before spray
- Mite population from 10 randomly selected plants 7 days after spray (no.of mites per leaf/flower from 5 randomly selected flowers and top five leaves per plant
- No.of Leaves/flowers with yellow specks or webbing on each plant and per cent leaf damage by mites were computed
- Yield to be recorded.

**Status:** The impact of *Blaptostethus* was visible in suppressing spider mites. The trial is in progress

**PAU - Ludhiana:**

<u>**On Okra**</u>

The experiment on evaluation of anthocorid predator, *Blaptostethus pallescens* against mite, *Tetranychus urticae* on okra (variety Pusa Sawani) was conducted at Entomological Research Farm, PAU, Ludhiana. The okra was sown in the field in the month of July, 2013 at the farm. The small insect net cages (4x4x4 feet) were installed in the field and the mite was released to establish on the plants in these cages.

There were following five treatments:

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

There were three replications per treatment and five plants per replication. As the mite was established very late on the crop due to rains, only two releases of predator at weekly interval and two sprays of acaricides at 10 days interval could be made. Therefore, the experiment will be repeated in the current year and okra crop has already been sown in the first week of

March, 2014. As soon as the incidence of spider mite is noticed, the experiment will be conducted again. The experiment is in progress and the results will be submitted after completion of the experiment.

The result of evaluation of anthocorid predator, *Blaptostethus pallescens* against mite, *Tetranychus urticae* on okra during 2013 is mentioned in Table 118. When the 6-7 days old nymphs of *B. pallescens* were released for two times at weekly interval on the brinjal plants under insect net condition, it was observed that the population of mites significantly reduced on the plants (**Table 117**). Among anthocorid predators, the release of *B. pallescens* @ 30 nymphs/ m row was found best (9.71 mites/ plant) and it was at par with chemical control (4.35 mites/ plant), but significantly better than *B. pallescens* @ 20 nymphs/ m row (13.46 mites/ plant) and *B. pallescens* @ 10 nymphs/ m row (16.09 mites/ plant). The later two were at par with each other. All the releases of predators and spray of chemical on the okra were significantly better than control, where the population of mite was comparatively very high (51.64 mites/ plant). It was concluded that *B. pallescens* @ 30 nymphs/ plant along with chemical control (Omite 300 ml/ acre) can be included in the IPM of two-spotted spider mite, *T. urticae* on okra in net house condition.

**Table 117: Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mite *Tetranychus urticae* on okra in insect net house condition during 2013**

| Treatments | Number of mite population/ plant | | | |
|---|---|---|---|---|
| | Before release | After release* | | |
| | | 1st | 2nd | Mean |
| **Blaptostethus pallescens* @ 10 nymphs/ plant | 36.66 | 24.86[c] | 7.33[b] | 16.09[b] |
| **B. pallescens* @ 20 nymphs/ plant | 33.00 | 18.86[bc] | 8.06[b] | 13.46[b] |
| **B. pallescens* @ 30 nymphs/ plant | 38.33 | 13.73[b] | 5.70[ab] | 9.71[ab] |
| **Chemical control (Omite @ 300ml/ acre) | 33.33 | 6.00[a] | 2.70[a] | 4.35[a] |
| Control (untreated) | 33.66 | 57.86[d] | 45.53[c] | 51.64[c] |
| CV | - | 9.99 | 13.89 | 10.08 |

***Two releases at seven days interval. **Two sprays at ten days interval**

**<u>On brinjal</u>**

The experiment on evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mite, *Tetranychus urticae* on brinjal (variety Punjab Sadabahar) is being conducted at Entomological Research Farm, PAU, Ludhiana.

There are following five treatments:

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

The low incidence of spider mites is noticed and the weekly data is being recorded. When the incidence of mites reach the desired level, the experiment will be conducted by installing big insect net cages (9x7x6 feet) in the field. The experiment is in progress and the results will be submitted after the completion of the experiment.

**On chilli**

The experiment on evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mite, *Tetranychus urticae* on chilli is being conducted at Entomological Research Farm, PAU, Ludhiana.

There are following five treatments:

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

The chilli nursery has been transplanted in the field in the first week of March, 2014. The experiment will be conducted by installing the big insect net cages in the field. The experiment is in progress and the results will be submitted after the completion of the experiment.

**3. Evaluation of efficacy of predators against cabbage aphids in polyhouses (SKUAST)**

As a result of 5 weekly release of predators @ 5/plant *viz*, 2$^{nd}$ instar grubs of *Coccinella septempunctata; C. undecimpunctata; C.z. sillemi; Adalia tetraspilota* and *Hippodamia variegata* against (*B.brassicae*) on cabbage, a noticeable decline in aphid population were obtained. However, maximum decline was recorded from 5 weekly release of 2$^{nd}$ instar grubs of *Coccinella septempunctata* which ranged from 94.25 to 13.50/10 leaves while as in Dichlorovas treated plot, the population of aphid declined from 92.00 to 4.50/10 leaves as compared to untreated which ranges from 98.75 to 106.00/ leaves. Maximum percentage of aphid population reduction over control (68.20%) was recorded when 2$^{nd}$ instar grubs of *C. septempunctata* were released @5 /plant which was statistically superior to treatments. The percentage reduction of aphid population of 82.34 % was recorded against Dichlorovas treated plot which was statistically higher to predatory treatments.

The maximum percentage of leaf infestation (37.50%) was recorded in the treatment with 2$^{nd}$ instar grubs of *Coccinella undecimpunctata* @ 5/plant and minimum (17.50%) was recorded in the treatment with 2$^{nd}$ instar of grubs of *C.septempunctata* @ 5/plant after release. The percentage leaf infestation (12.50%) was recorded in Dichlorovas treatment @ 1ml/L as compared to untreated check 52.25%. The maximum yield/plot (23.75kg) was obtained in pesticidal treatment which was statistically similar to *C.septempunctata* treated plot (23.50kg) and lowest (17.50kg) was in untreated check.

**4. Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mite in rose under polyhouse condition. (YSPUHF, SKUAST)**

**SKUAST - Srinagar**

As a result of 4th release of predatory mite /plant, the maximum number of mites (14.30/10plants) was recorded in 30 predatory mites/plant /release. The maximum decline in population of mites/10 plants was recorded (3.83/10 plants) in Abamectin (0.3ml/L) treatment followed by treatment with Azadirachtin (3ml/L) (13.7/10 plants). Among the predatory treatments, the minimum mean population (28.00/10 plants) of mites was recorded in 30 predatory mites/plant/release treatment followed by 33.2/10 plants in the 20 predatory mites/plant/release and maximum number of mites were recorded 37.7/10 plants in 10 predatory mites/plant/release treatment. In pesticidal treatments, the minimum mite population (12.07/10 plants) was recorded in the Abamectin followed by 28.7/10 plants in the Azadirachtin treatment. Minimum percentage reduction of mite population was recorded (59.2%) in 10 predatory mites/plant/release treatment which was statistically similar to the treatment with Azadirachtin (3ml/L) (68.9/10 plants). After treatment, the minimum percentage leaf damage/10plants was recorded (26.0/10 plants) in the treatment were 30 predatory mites/plant/ were released and maximum was recorded 38.0 /10 plants in the treatment with 10 predatory mites/plant/release. In Abamectin treated plot, the minimum percentage of leaf damage which was recorded as 20.0/10 plants. As a result of predatory and pesticidal treatments, it was observed that the treatment with 30 predatory mites/plant/release was found to be most effective and statistically similar to the treatment of Azadirachtin (3ml/L). The maximum yield/plot (1173 flowers) were recorded in 30 predatory mites/plant/release treatment which was statistically similar to the yield recorded in pesticidal treatment (Azadirachtin 3ml/L).

**YSPUHF - Solan**

An experiment was conducted to evaluate Predatory mite, *Neoseiulus longispinosus* against *Teyranychus urticae* on carnation under polyhouse conditions. *N. longispinosus* was evaluated at predator: prey ratio of 1:10, 1:20 and 1:30 in comparison with Neem Baan (1500 ppm; 3ml/l) and fenazaquin (0.0025%) which is the standard recommended insecticide for the control of phytophagous mites. The above treatments were also compared with untreated control. In total 3 releases of predatory mites (at each predator: prey ratio) at 7 days interval were made during June, 2012. Similarly three sprays each of NeemBaan (3ml/l) and fenazaquin (0.0025%) at 7 days interval were made. Each treatment was replicated 4 times in a randomized block design. Data on mite population was recorded before spray/release and 7days after final release/spray. Since the pre treatment mite population was significantly different in different plots, the data on mite population was converted to per cent reduction in mite population over pretreatment count, which was further converted to per cent reduction over control after applying Abbott's correction. Results of the experiment (**Table 118**) indicated that among different bio-pesticides or bio-agents, *N. longispinosus* at 1:10 predator: prey ratio was the best resulting in 91.2 per cent reduction in mite population over untreated control which was also on par with the chemical treatment i.e. fenazaquin (0.0025%) which caused 92.1 per cent reduction of the mite population over control. Other bio-control agents like, *N. longispinosus* at predator: prey ratio of 1:20 and 1:30 and Neem Baan (1500ppm; 3ml/L) resulted in 69.3, 61.0 and 53.6 per cent reduction in mite count over control, respectively. Among these treatments, *N. longispinosus* at predator: prey ratio of 1:20 and 1:30 were statistically on par with each other and significantly superior to Neem Baan (1500ppm; 3ml/L).

**Table 118: Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mites in carnation under polyhouse condition.**

| SN | Treatment | Reduction(%) in mite population over control |
|---|---|---|
| 1 | *N. longispinosus* (1:30) | 61.0 (51.4) [b] |
| 2 | *N. longispinosus* (1:20) | 69.3(56.5) [b] |
| 3 | *N. longispinosus* (1:10) | 91.2(73.2) [a] |
| 4 | NeemBaan (1500 ppm;3ml/L) | 53.6(47.1)[c] |
| 5 | Fenazaquin (0.0025%) | 92.1(74.2)[a] |
| | CD(p=0.05) | 6.38 |
| | CV (%) | 19.8 |

Figures in parentheses are arc sine transformed values

**5. Evaluation of entomopathogenic fungi against mite, *Tetranychus urticae* on capsicum/bell pepper under protected conditions (PAU)**

The experiment is being conducted in net house located at Entomological Research Farm PAU Ludhiana. The capsicum crop has been transplanted in February, 2014. Till date no incidence of spider mite is recorded and the experiment is in progress.

**6. Evaluation of biocontrol agents against sap sucking insect pests of ornamentals/ vegetables in polyhouses. (YSPUHF, ANGRAU)**

**ANGRAU - Hyderabad**

**Treatments:**

1. *Beauveria bassiana*@ $10^8$ CFU/ml T4
2. *Metarrhizium anisopliae* @ $10^8$ CFU/ml
3. *Hirsutella thompsonii*@ $10^8$ CFU/ml
4. *Verticill lecanii*@ $10^8$ CFU/ml
5. Release of coccinellid beetle (*Cryptolaemus montrouzieri*)
6. Release of anthocorid predator 10 bugs/plant
7. Standard insecticide
8. Untreated check

Crop : Carnation
Design : RBD
Plot size : 2X 3m
Replications : 4

**Observations :**

- Population of the pest from 10 randomly selected plants before treatment as well as 5 and 7 days after each treatment
- Leaf damage
- Yield per plot

**Status:** There was considerable reduction in the sucking pest population both in terms of incidence and damage. Trial is in Progress

**YSPUHF - Solan**

The experiment is in progress

**7. Validation of BIPM of thrips on capsicum under polyhouse (IIHR)**

The experiment was carried out on F1 hybrid Indra. The experiment included three treatments as given below. The effectiveness of two formulations of entomopathogens (IIHR isolates) of *M. anisopliae* and *B.bassiana* against *S. dorsalis* on capsicum F1 hybrid, Indra. Spraying of the entomo-pathogens at weekly intervals was carried out with spotting upward curling of terminal leaves, which recorded about 1-2 thrips / tap. Population /plant of rating of terminal leaves due to thrips infestation were recorded. Maintenance of four shoot level was carried out to sustain the crop for a longer period.

**Results**

**Thrips/ plant population**

- Weekly spraying of formulation of M. *anisopliae*@ 1 ml/2L or *B. bassiana* @ 10ml/L recorded 70 % reduction in thrips/plant as over control. A mean population of 1.5 and 1.7 thrips/plant were recorded in the biological control treatments as against 6.8 thrips/plant in control which resulted in a maximum of 70 per cent reduction in thrips population as compared to control. Similarly biological control treatments recorded a mean rating of 1.8 -2.0 as compared to 3.3 recorded in control **(Table 119)**.

**Rating of plants in relation to thrips damage**

Rating of damaged plants in relation to thrips damage was followed by the method developed by Dr. N.K. Krishna Kumar .1995 (Yield loss in Chili and Sweet pepper due to *Scirtothrips dorsalis* Hood (Thysanotpera: Thripidae) Pest Management in Horticultural Ecosystem) 61-69.pp

- 0= no symptoms,
- 1= young terminal leaves showing eruptions in the inter veinal area,
- 2= terminal leaves showing upward curling along the leaf margin,
- 3= severe upward curling of terminal leaves and a few basal leaves,
- 4= stunted growth with most leaves severely curled,
- 5= plants showing total defoliation

**Table 119: Field efficacy of entomopathogen formulations on *S. dorsalis* on capsicum under polyhouse conditions**

| S. No | Treatments | No. of thrips/ plant | % reduction over control | Rating of plant based on damage to thrips |
|---|---|---|---|---|
| 1 | *M. anisopliae* @1x$10^7$ spores/ml (liquid formulation ) | 1.9 | 70 | 1.8 |
| 2 | *B. bassiana* @1x$10^7$ spores/ml ( liquid formulation ) | 1.5 | 69 | 2.0 |
| 3 | Control | 6.8 | - | 3.3 |

## 2.18. Biological Suppression of Storage Pests

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

*Uscana* sp obtained from NBAII, Bangalore could not survive in Mau (UP) conditions and hence the experiment could not be carried out. However very recently, the experiment was taken up at Bangalore centre and is in progress

### 2. Evaluation of anthocorid predators against storage pests in rice (ANGRAU)

Anthocorid bugs could effectively control the *Corcyra cephalonica* larvae where bins in which the bugs were released recorded lesser moth population. Nymphs of the bug *Xylocoris flavipes* performed better than those of *Blaptostethus pallescens* in minimizing the moths. Survivability of *X. flavipes* was more in the treatments where 20 nymphs were released followed by the bins where 30 nymphs were released (**Table 120**).

**Table 120: Evaluation of Anthocorid predators against storage pests in Rice**

| S. No. | Treatments | No.of moths emerged (mean of 4 replications) | No. of live Anthocorid bugs (mean of 4 replications) |
|---|---|---|---|
| 1. | T1 Release of 10 *Blaptostethus pallescens* nymphs | 88.4 | 4.3 |
| 2. | T2 Release of 20 *Blaptostethus pallescens* nymphs | 76.1 | 9.59 |
| 3. | T3 Release of 30 *Blaptostethus pallescens* nymphs | 73.9 | 5.2 |
| 4. | T4 Release of 10 *Xylocoris flavipes* nymphs | 76.4 | 10.79 |
| 5. | T5 Release of 20 *Xylocoris flavipes* nymphs | 71.1 | 14.6 |
| 6. | T6 Release of 30 *Xylocoris flavipes* nymphs | 65.1 | 11.8 |
| 7. | T7 Infested grain with no Anthocorid predators | 92.6 | - |

## 2.19. Biological Suppression of Weeds

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

*Chromolaena odorata*, a problematic weed of Western Ghats , Karnataka and Tamil Nadu was not found in Bastar area of Chhattisgarh a decade back. But in a short span, it has invaded large area of forest, community and waste land in and around Bastar region. In Bastar region, all the teak and eucalyptus plantations were severely infested with *C. odorata***.**

To manage this weed by biological control agent , about 3000 galls infested with gall fly (*C. connexa* ) collected from of Bengaluru were released in the Jagdalpur area in 2012. Survey done in 2013 revealed the non-establishment of bioagents in any of the released sites. At one site, there was a fire in the eucalyptus plantations, which might be the region of non-establishment of the bioagent. Therefore, again in September 2013, 1500 infested galls were collected from Bangaluru and released in the three different sites of Jagdalpur area. Survey done during December 2013 revealed the presence of gall fly at one site indicating the start of establishment process. There were 2-7 galls in one square meter area.

Efforts were made to mass multiply the bioagent at Jabalpur (Madhya Pradesh) in net house conditions. *Chomolaena odorata* were grown from the root stock collected from Jagdalpur (Chhattisgarh) area. When grown, about 15 gall flies were released in the net house. After two months, about 13 galls were observed in the net house. This indicated that mass multiplication *C. connexa* can be done in net houses at Jabalpur. The collected gall flies will be released in Jagdalpur and other area.

## 2.20. Enabling Large Scale Adoption of Proven Biocontrol Technologies

### 1. Rice - AAU-J, KAU, PAU, OUAT

### AAU-J

Large scale adoption of proven bio control based IPM package in rice was carried out in the farmer's field at two villages, one at P**irakota (location I)** of Jorhat district and other at **Rajabahar (Location II)** of Golaghat district, covering an area of 30 ha each. The variety was **Ranjit** for both the locations and the crop was transplanted in the last week of July, 2013. The BIPM package as per technical programme was evaluated in comparison with farmer's practice (chemical control) where chlorpyrifos/ quinalphos @ 375 g.ai/ha was applied. Four rounds of chemical sprays were applied at 15 days interval in the farmer's fields.

The BIPM package comprised of
(a) Seedling root dip treatment with *Pseudomonus fluorescens* @ 2 % solution,
(b) Application of *Beauveria bassiana* @ $10^{13}$ spores/ha against sucking pests,
(c) Erection of bird perches @ 10 no.s /ha,
(d) Six releases of *T. japonicum* @ 1,00,000 lakhs /ha at weekly interval starting from 25 DAT against *Scirpophaga* spp. and *Cnaphalocrocis* spp.,
(e) Spray of Botanicals ( Pestoneem @ 3ml/lit) against sucking pests and
(f) Spray of *P. fluorescens* 10g/lit against foliar diseases

Disease incidence was negligible during the cropping seasons. Population of skippers, hairy caterpillar and case worm were negligible (<1%). Statistical analysis was carried out using 't' test and the results are given below.

**Results:**

No significant differences were observed in the population of *Nephotettx* sp. /hill and per cent leaves damaged due to *Cnaphalocrocis* sp. in IPM plot as well as farmers' practice at both the locations. However, on an average, the *Nephotettx* spp. /hill were minimum (1.70/hill) in farmers practice at 65 days after treatment (**Table** 121) where as it was 2.10/hill in BIPM package. But, in case of *Cnaphalocrocis* sp., mean per cent incidence at 65 DAT was 4.00 in BIPM plot as against 4.12 in farmers practice respectively (**Table** 122). The per cent incidence of dead heart in two locations varied from 2.62 to 2.93 in BIPM package and 3.76 to 4.04 in farmers practice at 65 DAT which is significantly superior to farmers practice. Similar trend was also obtained in case of WEH incidence. The pooled mean per cent WEH (of two locations) was 2.7 in BIPM package and 3.21 in farmers' practices was compared. When the grain yield of two locations was compared, maximum yield was contributed by BIPM package (range 4745.75kg/ha to 4768.5 kg/ha) whereas in farmers practice, the yield ranged between 3876.4kg/ha to 3874.0kg/ha with a significant differences between the two practices (**Table 123**). Highest cost-benefit ratio (1:6.10) was also observed in BIPM package (**Table126**).

The population of spiders (**Table** 124) and coccinellids (**Table** 125) was uniformly higher throughout the crop period in the BIPM plots compared to farmers practice. On an average higher number of spider population (1.40spider/$m^2$) was recorded in IPM plots as against farmers' practices (0.4/$m^2$) at 65 DAT. The coccinellid population was also high at 65 DAT in BIPM plots, which was recorded as 2.15 as against 0.6/ m2 in farmers' practice. The investigation revealed that IPM package was superior in respect of low occurrence of pests and thus increasing the crop yield.

**Table 121: Observation of *Nephotettix* sp./hill at Pirakota and Rajabahar**

| Treatment | Precount | | | Post count | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean no. of *Nephotettix* sp./hill | | | Mean no. of *Nephotettix* sp. /hill at 45 DAT | | | Mean no. of *Nephotettix* sp. /hill at 65 DAT | | |
| | Loc I | Loc II | Mean | Loc I | Loc II | Mean | Loc I | Loc II | Mean |
| IPM | 6.2 | 5.9 | 6.0 | 3.9 | 3.7 | 3.8 | 2.0 | 2.2 | 2.1 |
| Farmer's practice | 6.4 | 5.7 | 6.0 | 3.7 | 3.5 | 3.6 | 1.8 | 1.7 | 1.7 |
| t- value Remarks | -0.280 NS | 0.396 NS | - | 0.490 NS | 0.497 NS | - | 0.688 NS | 1.523 NS | |

**Table 122: Observation of *Cnaphalocrosis* spp./hill at Pirakota and Rajabahar**

| Treatment | 45DAT | | | 65 DAT | | |
|---|---|---|---|---|---|---|
| | Mean no. of *Cnaphalocrosis* spp. / hillafter Ist spray | | | Mean no. of *Cnaphalocrosis* spp. /hill after IInd spray | | |
| | Loc I | Loc II | Mean | Loc I | Loc II | Mean |
| IPM | 4.55 (12.31) | 4.84 (12.64) | 4.61 | 3.94 (11.39) | 4.07 (11.62) | 4.61 |
| Farmer's practice | 4.68 (12.49) | 4.97 (12.85) | 4.82 | 3.89 (10.97) | 4.36 (11.78) | 4.12 |
| t- value Remarks | -1.059 NS | -0.40 NS | - | 0.825 NS | 0.483 NS | - |

**Table 123: Observation on per cent Dead heart, White ear head and grain yield (Kg/ ha)**

| Treatment | Dead heart % | | | | | | WEH% | | | Grain yield (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 DAT | | | 65 DAT | | | | | | | | |
| | Loc I | Loc II | Mean | Loc I | Loc II | Mean | Loc I | Loc II | Mean | Loc I | Loc II | Mean |
| IPM | 3.67 (11.02) | 4.27 (11.89) | 3.97 | 2.62 (8.79) | 2.93 (9.36) | 2.77 | 2.67 (9.38) | 2.73 (9.50) | 2.70 | 4745.0 | 4768.5 | 4756.8 |
| Farmer's practice | 4.19 (11.78) | 4.41 (12.10) | 4.30 | 3.76 (11.13) | 4.04 (11.59) | 3.9 | 3.0 (9.96) | 3.42 (10.65) | 3.21 | 3876.4 | 3874.0 | 3875.2 |
| t- value Remarks | -1.953 NS | -0.542 NS | - | -2.239 S | -2.107 S | - | -5.011 S | -7.617 S | - | 23.910 S | 32.110 S | - |

**Table 124: Observation on spider population/m$^2$ in rice**

| Treatments | 45 DAT (spider/ m$^2$) | | | 65 DAT (spider/ m$^2$) | | |
|---|---|---|---|---|---|---|
| | Loc I | Loc II | Mean | Loc I | Loc II | Mean |
| IPM package | 0.90 | 0.80 | 0.85 | 1.30 | 1.50 | 1.40 |
| Farmers' practice | 0.60 | 0.70 | 0.65 | 0.40 | 0.40 | 0.4 |
| 't' value | 1.053 | 1.034 | | 4.025 | 3.973 | |
| Remarks | NS | NS | | S | S | |

**Table 125: Observation on coccinellids population/m$^2$ in rice**

| Treatments | 45 DAT (coccinellids/ m$^2$) | | | 65 DAT (coccinellids/ m$^2$) | | |
|---|---|---|---|---|---|---|
| | Loc I | Loc II | Mean | Loc I | Loc II | Mean |
| IPM package | 0.90 | 1.00 | 0.95 | 2.30 | 2.00 | 2.15 |
| Farmers' practice | 0.40 | 0.60 | 0.5 | 0.60 | 0.60 | 0.6 |
| 't' value | 2.060 | 1.50 | | 6.326 | 3.772 | |
| Remarks | NS | NS | | S | S | |

**Table 126: Cost benefit ratio (mean of two locations)**

| 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 ) | C:B ratio |
|---|---|---|---|---|---|---|
| IPM plot | 4756.75 | 881.55 | 61,837.75 | 10125.00 | 57,537.00 | 1:6.10 |
| Chemical control | 3875.20 | | 50,377.60 | 14500.00 | 44,377.00 | 1:3.47 |

**Rs. 13/kg of rice grain**

**KAU - Thrissur (Adat model)**

Location: Thrissur (Cherpu, Avinissery, Paralam, Chiyyaram and Chazhur Panchayaths)
Season : December 2013 to March 2014
Area : 100 ha
Variety : Jyothi & Uma

**The practices followed in IPM**

- Seed treatment with *Pseudomonas* @ 10g/kg of seeds
- *Trichogramma japonicum* @ 1 lakh/ha was released from 20 days after transplanting and 40 days after sowing. Five releases were made at 10 days interval.

- Sprayed *Pseudomomas* @ 2% against foliar diseases.
- In some plots neem oil was sprayed at tillering stage against sucking pests.
- Sprayed neem oil 0.5% against rice bugs.

The practices followed in conventional farming

- Seed treatment with *Pseudomonas* @ 10g/kg of seeds
- Flubendamide @ 50 ml/ha against rice stem borer and leaf folder

Observations on the population of pests and natural enemies were recorded before and after the release of parasitoids. Statistical analysis was carried out using 't' test and the results are given in **Table 127** .There was no significant difference in grain weight in IPM and conventional farming. Coccinellid population was significantly high in IPM. **In paddy, IPM is being practiced in all the districts of Kerala.**

**Table 127: Observations on pests, natural enemies and yield**

| Observations | IPM | Conventional | t value | Significance |
|---|---|---|---|---|
| **Dead heart %** | | | | |
| Pre count | 4.08 | 5.30 | -0.369 | NS |
| Post count I | 1.22 | 1.19 | 0.028 | NS |
| Post count II | 0.78 | 0.80 | 0.261 | NS |
| **Leaf roller incidence %** | | | | |
| Pre count | 0.71 | 1.22 | -0.517 | NS |
| Post count I | 0.26 | 0.28 | 0.894 | NS |
| Post count II | 0.24 | 0.29 | 0.613 | NS |
| **Coccinellid /hill** | | | | |
| Pre count | 0.12 | 0.16 | 0.000 | NS |
| Post count I | 0.36 | 0.12 | 1.543 | NS |
| Post count II | 0.92 | 0.12 | 0.767 | S* |
| **Spider count/hill** | | | | |
| Pre count | 0.2 | 0.2 | -0.283 | NS |
| Post count I | 0.32 | 0.12 | 0.070 | NS |
| Post count II | 0.16 | 0.12 | 1.00 | NS |
| **White earhead %** | 2.03 | 2.01 | 0.029 | NS |
| **Rice bug incidence%** | 1.49 | 1.06 | 1.514 | NS |
| **Grain weight kg/ha** | 7637.5 | 7685.0 | -0.105 | NS |

S* Significant at 5% level NS-Non Significant

**OUAT**

**BIPM adopted**

- Seed treatment with *Pseudomonas* @ 8g/kg of seeds/seedling.
- Spray of *Beauveria bassiana* $10^{13}$ spores/ha against sucking pests.
- Bird perches erected @10/ha.
- Release of *Trichogramma japonicum* @ 1 lakh/ha when either the leaf folder or stem borer occurrence is noticed.

- Releases to be initiated as soon as the moth activity is seen. Six releases made at weekly intervals.
- Spray of *Bt* @2kg/ha, 2 sprays applied at 15 day intervals.
- Spray of *Pseudomonas fluorescens* @ 1.5 kg/ha against foliar diseases.
- Spray of Neemazol @ 2.5 lit./ha twice at 45 and 60 DAT.

**Farmers' practice**

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

**Results**

The data in **Table 128** indicated that the IPM practice was superior to the farmers' practice in all locations. Dead heart and white earhead ranged between 4.1– 5.6% and 6.9 – 7.9% in IPM package while in farmers' practice the corresponding figures were 7.9 – 11.4% and 11.2 – 15.4% respectively. Leaf folder, case worm and skipper population in IPM and Non-IPM plots ranged between 5.3 – 6.1%, 1.2– 2.5%, 1.2 – 2.5% and 7.1 – 13.4%, 2.0 – 4.4%, 2.3 -4.8% respectively. The GLH population in IPM fields were 4.0/hill as against 8.0 – 9.8/hill in non IPM fields. It was observed that the beneficial fauna like spiders and ladybirds were more in number in IPM plots which ranged from 4.6 – 5.7/hill and 2.2 – 4.9/hill whereas, the corresponding population in non IPM plots were 0.8 – 2.0/hill and 0.5 – 0.9/hill. Yields obtained in IPM plots were significantly higher than the non IPM plots. The farmers obtained a net profit ranging from ₹ 15,930 to ₹19,380/ha by following IPM over farmers' practice in different locations.

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

**Table 128: Incidence of insect pests of paddy in IPM and Non –IPM fields during Kharif-2013**

| Treatments | Dead Heart (%) | White ear ( % ) | Leaf folder ( % ) | Case worm (% ) | Skipper ( % ) | GLH/Hill | Spider/Hill | Lady bird/Hill | Yield (kg/ha) | C : B Ratio | Net Return over Farmer's Practice ( ₹/ha ) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Location 1: Gobindpur ( 50 Acres )** | | | | | | | | | | | |
| IPM Package | 4.8 | 7.2 | 5.3 | 2.5 | 1.2 | 5.1 | 5.7 | 4.9 | 4682 | 1: 3.8 | 17,415 |
| Farmers'Practice | 7.9 | 11.2 | 7.1 | 4.2 | 2.3 | 8.0 | 2.0 | 0.9 | 3521 | 1: 2.6 | |
| **Location 2 : Kaimati ( 50 Acres )** | | | | | | | | | | | |
| IPM Package | 4.1 | 6.9 | 5.6 | 1.2 | 1.9 | 4.0 | 4.6 | 3.1 | 4379 | 1: 2.9 | 19,380 |
| Farmers'Practice | 10.2 | 13.3 | 14.1 | 2.0 | 4.5 | 9.8 | 0.8 | 0.7 | 3087 | 1: 1.8 | |
| **Location 3 :Bhuban ( 50 Acres )** | | | | | | | | | | | |
| IPM Package | 5.6 | 7.9 | 6.1 | 2.4 | 3.1 | 4.5 | 5.0 | 2.2 | 4490 | 1: 3.1 | 15,930 |
| Farmers'Practice | 11.4 | 15.4 | 13.7 | 4.4 | 4.8 | 8.2 | 1.1 | 0.5 | 3428 | 1: 2.4 | |

## PAU - Ludhiana

Large scale demonstration of biocontrol based IPM in *Basmati* Rice was carried out at two locations in village Saholi in district Patiala on variety *Pusa* 1121 in an area of 10 ha each. The crop was transplanted during the 4th week of July and harvested in first week of November. In IPM plots, 7 releases of *T. chilonis* and *T. japonicum* were made each @ 1,00,000/ha at weekly interval, starting 30 DAT. In farmers practice two applications of cartap hydrochloride (Padan 4G) were given @ 25kg/ha, at 40 and 60 DAT. In addition, 2 sprays of Chlorpyriphos 20 EC and Triazophos 40 EC were also applied in farmers practice to control incidence of leaf folder.

The incidence of leaf folder varied from 6.6 to 7.5 and 3.8 to 4.3 per cent at both the locations in IPM and farmers practice, respectively. The mean incidence of leaf folder was 7.1 per cent and 4.1 per cent in IPM plot and farmers practice, respectively (**Table 129**). The incidence of stem borer varied from 2.4 to 2.9 and 1.2 to 1.7 per cent at all the locations in IPM and farmers' practice, respectively. The mean dead hearts in IPM and farmers practice was 2.7 and 1.5 per cent respectively. The mean incidence of white ears in IPM was 5.9 per cent as compared to 4.1 per cent in farmers practice. The incidence of plant diseases was negligible during the crop season,; hence observations on plant diseases could not be assessed. The mean yield in IPM and farmers practice was 39.2 and 42.0 q/ha, respectively.

It can be concluded that IPM (7 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000 /ha) proved as effective as chemical control for the management of leaf folder and stem borer infesting *Basmati* rice. The cost benefit analysis showed the net return of Rs. 1,01,775/- in IPM package as compared to Rs. 1, 07,070/- in farmer's practice (**Table 131**).

**Table 129: Large-scale demonstration of IPM for rice pests and diseases in farmer's field (Village *Saholi*) during 2013.**

| **Treatments** | **Mean per cent dead hearts due to stem borers** | | |
|---|---|---|---|
| | Location – I | Location-II | Mean |
| IPM | 2.4 | 2.9 | **2.7** |
| Farmers practice | 1.7 | 1.2 | **1.5** |
| | **Mean per cent white ears due to stem borers** | | |
| IPM | 6.3 | 5.4 | **5.9** |
| Farmers practice | 4.6 | 3.5 | **4.1** |
| | **Mean Per cent leaf folder damaged leaves** | | |
| IPM | 6.6 | 7.5 | **7.1** |
| Farmers practice | 3.8 | 4.3 | **4.1** |
| | **Yield (q/ha)** | | |
| IPM | 40.1 | 38.2 | **39.2** |
| Farmers practice | 42.5 | 41.5 | **42.0** |

**Table 130: Cost Benefit analysis (2013)**

| **Treatments** | **Yield(kg/ha)** | **Additional yield over IPM package (kg/ha)** | **Value of yield/ha (Rs)** | **Cost of Cultivation (Rs/ha)** | **Net return (Rs/ha)** |
|---|---|---|---|---|---|
| IPM package | 3915 | - | 117450* | 15675 | 101775 |
| Farmer's practice | 4200 | 285 | 126000* | 18900 | 107070 |

*Rs 30/kg of seeds (In 2013, the market price of *Pusa* 1121 was quite high)

## 2. Sugarcane-MPKV, OUAT & PAU

### MPKV: Demonstration of temperature tolerant strain of *Trichogramma chilonis* against early shoot borer in *Suru* planting of sugarcane

Demonstration on effectiveness of *T. chilonis* TTS against ESB in sugarcane was conducted on the farm of Agronomy, College of Agriculture, Pune. Planting of sugarcane cv. Co 265 @ 25,000 setts/ha was done on 28/01/2013 over 1.0 ha with at 90 x 30 cm plant spacing. Nucleus culture of the parasitoid was obtained from the NBAII, Bangalore and mass cultured in the Biocontrol laboratory. The treatments comprised eight releases of *T. chilonis* TTS @ 50,000 adults/ha at weekly interval, farmers' practice- three sprays of chlorpyriphos 0.05% and untreated control. The control plot was maintained at 200 m distance from parasitoid released plot. Each treatment plot was divided into 10 subplots as replicates. Release of parasitoids started from 30/3/2013. The pre-release observations on infestation of ESB (% dead hearts) and number of tillers per clump were recorded at 15 spots in each subplot. Similarly, post counts of dead hearts and number of tillers at each spot were recorded at 15 days interval from initiation of parasitoids' release up to 4 months old crop. Yield was recorded on per plot basis and converted into MT per ha. Data on per cent dead hearts and number of tillers per clump were transformed to arc sin and $\sqrt{x+0.5}$ values respectively, before statistical analysis.

The results in **Table 131** indicated that eight releases of *T. chilonis* TTS @ 50,000 parasitoids/ha at weekly interval starting from 45 days after emergence of shoots was significantly superior to untreated control in reducing the ESB infestation (6.8% dead hearts) and increased number of tillers (11.5 tillers/clump) as well as cane yield (144.3 MT/ha). It was, however, statistically comparable with chemical control.

**Table 131: Efficacy of *T. chilonis* TTS against ESB on sugarcane**

| Treatment | Dead hearts (%) | | No. of tillers/clump | | Yield (MT/ha) |
|---|---|---|---|---|---|
| | Pre-count | Post count | Pre-count | Post count | |
| T1: *T. chilonis* @ 50,000 parasitoids/ha | 12.69$^{a}$ | 6.81$^{a}$ | 9.07$^{a}$ | 11.53$^{a}$ | 144.3$^{a}$ |
| T2: Farmers practice- chlorpyriphos 0.05% | 13.01$^{a}$ | 7.13$^{a}$ | 8.97$^{a}$ | 11.20$^{b}$ | 143.1$^{a}$ |
| T3: Untreated control | 12.76$^{a}$ | 16.71$^{b}$ | 8.81$^{a}$ | 6.98$^{c}$ | 130.5$^{b}$ |
| **CD (p = 0.05)** | **NS** | **1.90** | **NS** | **0.29** | **4.55** |

### OUAT: Large-scale Demonstration on the use of *T.chilonis* against early shoot borer and internode borer of Sugarcane in Farmers' field

The crop was planted in the month of November-December; 2012. First release of *T.chilonis* was made on 5$^{th}$ December after taking pre-release ESB infestation which ranged from 12.9 to 18.2 % and 11.3 to 12.2%. Release of *T.chilonis* for ESB continued till 2$^{nd}$ week of April, 2013. Observation on incidence of ESB was recorded each week starting from 2$^{nd}$ week of December till the 4$^{th}$ week of April, 2013.The mean incidence of ESB ranged from 7.2 to 8.7%, in *T.chilonis* released plots. On the contrary, the incidence of ESB ranged from 27.4 to 35.8% in the fields where no parasitoids have been released and farmers took their own control measures of pesticide application. Parasitoid release resulted in significant reduction of ESB population as compared to pesticide application (**Table 132**).

Similarly, internode borer incidence was also least in parasitoid released plots (11.84% and 14.38%) as compared to 27.45% and 33.33% in farmers practice. As regards to Top Shoot Borer, the incidence before release of parasitoid was 4.0 to 5.7 %. The pest incidence was least in parasitoid treatment (2.8% to 4.2%) as compared to the fields where no parasitoid was released (7.3% to 9.1%) (**Table 132**).

The yield was higher (144.7 t/ha to 155.2t/ha) in parasitoid released plots whereas, it was 109.5 t/ha to 111.6 t/ha in farmers practice (**Table 132**).

**Table 132: Incidence of borer pests of sugarcane in *T.chilonis* released demonstration fields and farmers' fields during 2013-14**

| Treatment | Early shoot borer (%) | | Internode borer (%) | Top Shoot Borer (%)# | Yield (t/ha) |
|---|---|---|---|---|---|
| | Pre release | Post release | | | |
| Release of *T.chilonis* after 45 DAG @ 50,000/ha at weekly intervals. Total of 10-12 releases will be made | Location: Niladeipur ( 50 Acres) | | | | |
| | 12.9 | 7.2 | 11.84 | 2.8 | 144.7.7 |
| | Location:Motori (50 Acres) | | | | |
| | 18.2 | 8.7 | 14.38 | 4.2 | 155.2 |
| Farmers' practice of pesticide application. | Location: Niladeipur ( 50 Acres) | | | | |
| | 11.3 | 27.4 | 27.45 | 7.3 | 109.5 |
| | Location:Motori (50Acres) | | | | |
| | 12.2 | 35.8 | 33.33 | 9.1 | 111.6 |

**PAU - Ludhiana: Enabling large scale adoption of proven biocontrol technologies against early shoot borer, top borer & stalk borer of sugarcane in collaboration with sugar mills**

**i. Field releases of *Trichogramma chilonis* (temperature tolerant strain-tts) against early shoot borer, *Chilo infuscatellus*.**

Large scale demonstration of effectiveness of *T. chilonis* (tts) against early shoot borer, *Chilo infuscatellus* over an area of 1000 acres was carried out in collaboration with two sugar mills of the state i.e. Doaba Co- operative Sugar Mills Ltd. Nawanshahar and Morinda Co- operative Sugar Mills Ltd. Morinda. The egg parasitoid, *T. chilonis* was released during mid - April to end – June at 10 days interval @ 50,000 per ha per release.

The incidence of *C. infuscatellus* at Nawanshahar and Morinda in released fields was 3.9 and 0.8 per cent, respectively (**Table 133**). The corresponding figures in control fields were 8.1 and 1.9 per cent. The reduction in damage over control in these two mills was 51.9 and 57.9 percent, respectively. Hence the mean reduction was 54.9 per cent.

It can be concluded that in large-scale demonstration, eight releases of *T. chilonis* (tts) @ 50,000 per ha at 10 days interval during mid-April to end June reduced the incidence of early shoot borer by 54.9 per cent.

**Table 133: Demonstration of *Trichogramma chilonis* (Temp. tolerant strain) against *Chilo infuscatellus* in two sugar mills of Punjab during 2013.**

| Mill area | Area covered (acres) | Incidence of *C. infuscatellus* (post release) | | |
|---|---|---|---|---|
| | | IPM* | Non Adopted | Reduction (%) over control |
| Doaba Co-op Sugar Mills Ltd, Nawanshahar | 500 | 3.9 | 8.1 | 51.9 |
| Morinda Co-op sugar Mills Ltd, Morinda | 500 | 0.8 | 1.9 | 57.9 |
| Total/ Mean | 1000 | 2.6 | 5.00 | 54.9 |

**Note:**
1. Eight releases of *T. chilonis* were made @ 50,000/ha at 10 days interval during April to end June.
2. Pretreatment incidence was 1.2 percent to 1.4 percent at Nawanshahr, but it was nil at Morinda.

**ii. Use of *Trichogramma chilonis* for the suppression of stalk borer *Chilo auricilius* in collaboration with sugar mills.**

Large scale demonstration of effectiveness of *T. chilonis* against stalk borer, *Chilo auricilius* over an area of 3500 acres was carried out in collaboration with two sugar mills of the state i.e. Doaba Co- operative Sugar Mills Ltd. Nawanshahar and Morinda Co-operative Sugar Mills Ltd. Morinda (**Table** 134). The egg parasitoid, *T. chilonis* was released from July to October in all the two mill areas at 10 days interval @ 50,000/ha. The incidence of *C. auricilius* at Nawanshahar and Morinda in IPM fields was 8.0 and 1.5 per cent respectively. The corresponding figures in control fields were 16.5 and 3.1 per cent. The reduction in damage over control in these two mills was 51.5 and 53.1 percent, respectively. Hence the mean reduction was 52.3 per cent. 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 52.3 per cent.

**Table 134: Large-scale demonstration of biocontrol based IPM against stalk borer, *Chilo auricilius* on sugarcane in three sugarcane mills in Punjab during 2013-14**

| Mill area | Area covered (acres) | Incidence of *C. auricilius* | | |
|---|---|---|---|---|
| | | IPM* | Non Adopted | Reduction (%) over control |
| Doaba Co-op Sugar Mills Ltd, Nawanshahar | 1500 | 8.0 | 16.5 | 51.5 |
| Morinda Co-op sugar Mills Ltd, Morinda | 2000 | 1.5 | 3.1 | 53.1 |
| Total/ Mean | 3500 | 4.7 | 9.8 | 52.3 |

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

**iii. Use of *Trichogramma japonicum* for the suppression of top borer, *Scirpophaga excerptalis*) in sugarcane.**

**a) Demonstration conducted by PAU alone**

Large-scale demonstrations of effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried out at village Paddi Khalsa (Distt Jalandhar). It was compared with chemical control and untreated control. The parasitoid, *T. japonicum* was released 8 times at 10 days interval from April to June @ 50,000 per ha. In chemical control, phorate (Thimet 10G) @ 30kg/ha was applied during last week of June. The incidence of top borer and yield was recorded from six locations in each treatment. The egg masses of *S. excerptalis* were collected to record percent parasitization.

The data presented in **Table 135** revealed that the incidence of top borer in control (12.8%) was significantly higher than in biocontrol and chemical control. The incidence recorded in chemical control (4.9%) was at par with *T. japonicum* released fields (5.2%). The reduction in incidence over control was 59.4 and 61.7 per cent in biocontrol and chemical control, respectively. The mean parasitism of eggs of *S. excerptalis* in biocontrol field was 44.2 per cent as compared to 2.6 percent in chemical control and 3.2 per cent in control (**Table 135**). The yield in control (764.2 q/ha) was significantly lower than biocontrol fields (836.0q/ha) and chemical control (852.0 q/ha), the latter two were at par with each other.

It can be concluded that eight releases of *T. japonicum* at 10 days interval during April to June @ 50,000 per ha per release were as effective as chemical control for the control of top borer.

**b. Demonstration in collaboration with sugar mills**

Large scale demonstration of effectiveness of field releases of *T. japonicum* against top borer, *Scirpophaga excerptalis* over an area of 1000 acres was carried out in collaboration with two sugar mills of the state i.e. Doaba Co- operative Sugar Mills Ltd. Nawanshahar and Morinda Co- operative Sugar Mills Ltd. Morinda (**Table 136**). The egg parasitoid, *T. japonicum* was released from mid April to end June, at 10 days interval @ 50,000 per ha per release. The incidence of *S. excerptalis* at Nawanshahar and Morinda in Trichogrammatids released fields was 7.1 and 0.7 per cent, respectively. The corresponding figures in control fields were 14.5 and 1.5 per cent. The reduction in damage over control in these two mills was 51.0 and 53.3 percent, respectively. Hence the mean reduction was 52.2 per cent.

It can be concluded that per release 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 52.2 per cent.

**Table 135: Large scale demonstration of field releases of *Trichogramma japonicum* against *Scirpophaga excerptalis* at village Paddi Khalsa (Distt Jalandhar) in Punjab during 2013-14.**

| Treatments | Incidence of *Scirpophaga excerptalis* (%) | Per cent reduction over control | Per cent parasitism | Yield (q/ha) |
|---|---|---|---|---|
| *T. japonicum* | 5.2[a] | 59.4 | 44.2 | 836.0[a] |
| Phorate 10G @30kg/ha | 4.9[a] | 61.7 | 2.6 | 852.0[a] |
| Control | 12.8[b] | | 3.2 | 764.2[b] |

- Six releases of *T. japonicum* were made @ 50,000/ha.
- Pre-release incidence was less than one per cent.

**Table 136: Large scale demonstration of *Trichogramma japonicum* against *Scirpophaga excerptalis* in collaboration with sugar mills in Punjab during 2013-14**

| Mill area | Area covered (acres) | Incidence of *C. auricilius* (post release) | | |
|---|---|---|---|---|
| | | IPM* | Non Adopted | Reduction (%) over control |
| Doaba Co-op Sugar Mills Ltd, Nawanshahar | 500 | 7.1 | 14.5 | 51.0 |
| Morinda Co-op sugar Mills Ltd, Morinda | 500 | 0.7 | 1.5 | 53.3 |
| Total/ Mean | 1000 | 3.9 | 8.0 | 52.2 |

**3. Maize**

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

The demonstration of biological control of maize stem borer, C*hilo partellus* was given at village Chaggran in Hoshiarpur district on 10 ha area. The sowing of maize hybrid PMH 1 was done on 21[st] of June 2013. The demonstration area was divided into three blocks representing three treatments each having three replications. A buffer zone of three meter was maintained for each treatment. The treatments were release of *Trichogramma chilonis* @ 1,00,000 parasitoids/ha at 15 days after germination (Biocontrol package), farmers practice and untreated control. The required number of tricho cards depending upon the dose per hectare were cut into smaller pieces and attached to the underside of maize leaves on 10 - 15 day old maize crop and at different spots in each plot. For recovery of *T. chilonis,* five egg clusters (having 40 eggs per cluster) of *C. partellus* were attached to the central whorl of the maize plants at different places in the field, one day after release of the parasitoids and were collected 24 hours later and brought to biocontrol laboratory to observe for adult parasitoid emergence. The recovery was also observed in the untreated control and farmers practice treatments to observe for natural parasitization or any dispersal of the parasitoids. Observations on leaf injury and dead hearts were recorded at 30 and 45 days after sowing and yield was recorded at harvest. The data was recorded from 100 plants selected at random from each plot (**Table 137**).

Significantly lower leaf damage was recorded in plots with release of *Trichogramma chilonis* @ 1,00,000 parasitoids/ha on 15 days old crop (6.8 %) as compared to the untreated control (24.8 %) (**Table 137**). However, it was on par with farmer's practice of two sprays of fenvalerate 20 EC and deltamethrin 2.8 EC on 20 & 25 days old crop (5.4 %). Dead heart formation caused by maize stem borer was minimum (3.1 %) in farmers practice plots followed by single release of *T. chilonis* (5.2 %) on 15 days old crop but significantly lower than untreated check (16.7 %). The parasitization rate of *C. partellus* eggs was significantly higher in plots with releases of parasitoids (33.5 %) in comparison to untreated check (10.6 %). The minimum parasitization (3.4 %) was observed in chemical control. The yield was significantly higher in releases of parasitoid (49.3 q $ha^{-1}$) in comparison to untreated check (40.5 q $ha^{-1}$) but comparable to farmer's practices (52.2 q $ha^{-1}$). Overall results shows that biological control of maize stem borer, *C. partellus* using *T. chilonis* brings much better results in comparison to control treatments and comparable to farmers practices. The net return over control in Biocontrol package was Rs 10360/- as compared to 13190/- in farmer practice (**Table 138**).

**Table 137: Effect of *Trichogramma chilonis* releases on incidence of *Chilo partellus* and yield in *Kharif* maize during 2013**

| Treatments | Leaf injury (%) | Dead hearts (%) | Per cent parasitization | Yield (q $ha^{-1}$) |
|---|---|---|---|---|
| Biocontrol package | $6.8^{a}$ | $5.2^{a}$ | $33.5^{a}$ | $49.3^{a}$ |
| Farmers Practice | $5.4^{a}$ | $3.1^{a}$ | $3.4^{c}$ | $52.2^{a}$ |
| Untreated control | $24.8^{b}$ | $16.7^{b}$ | $10.6^{b}$ | $40.5^{b}$ |
| CV (%) | 9.16 | 9.55 | 5.08 | 3.46 |

**Table 138: Cost Benefit analysis (2013)**

| Treatments | Yield (kg/ha) | Additional yield over control (kg/ha) | Value of additional yield/ha (Rs) | Cost of treatment (Rs/ha) | Net return over control (Rs/ha) |
|---|---|---|---|---|---|
| Biocontrol package | 4930 | 880 | 10560 | 200 | 10360 |
| Farmer's practice | 5220 | 1170 | 14040 | 850 | 13190 |
| Untreated control | 4050 | - | - | -- | - |

*Rs 12/kg of seeds

## 4. Coconut

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

**Area :** 1500 ha homestead coconut garden

This work was undertaken under the CDB funded project. Selection of 1500 ha area covering Krishnapuram, Devikulangara, Kandalloor panchayaths and Kayamkulam Municipality was done with the help of officials of Krishi Bhavan, Department of Agriculture, Kerala for implementing the project. Base line data indicated that average holding size is 0.28ha with less than 0.16 ha for 52% farmers. Average number of coconut palms /holding is 31.0 to 48.8 in various locations of which 23% are juvenile (<3years) and 24% young pre bearing stage. Potential breeding sites (0.68/holding) include dead palms (77%) (0.52/holding), cow dung pits (17%) (0.11/holding) and compost (6%) (0.05 /holding). Knowledge test developed indicted that the pre project knowledge level was 28% with regard to identification of pest/symptoms and management practices.

Farmer Field School (FFS) was one of the main technology transfer methods adopted in this programme. FFS programmes in 3 panchayaths were launched with active cooperation of Dept. of Agriculture and local panchayaths. Technological know how on integrated pest management of coconut was imparted to the farmers in the project area through training programmes and regular FFS sessions. Ten FFS sessions were conducted. Topics included Identification of pests & diseases, biological control of rhinoceros beetle, palm health management, prophylactic leaf axil filling, *Trichoderma* for disease management, leaf rot and stem bleeding management, use of pheromone traps, management of red palm weevil and basin management using cover crops and mulching. Training programmes (12 no.s) were conducted on IPM and IDM of coconut. Basin management with cowpea was undertaken in 142 gardens through the FFS participants. Extension interventions include exhibitions, information booklet, CD on black beetle and single sheet handouts on specific problems. Post-treatment observations in the project area indicated 30-51% reduction in rhinoceros beetle incidence and 57.3 to 69.6% reduction in per cent leaf damage over a period of 16 months (Fig 3.)

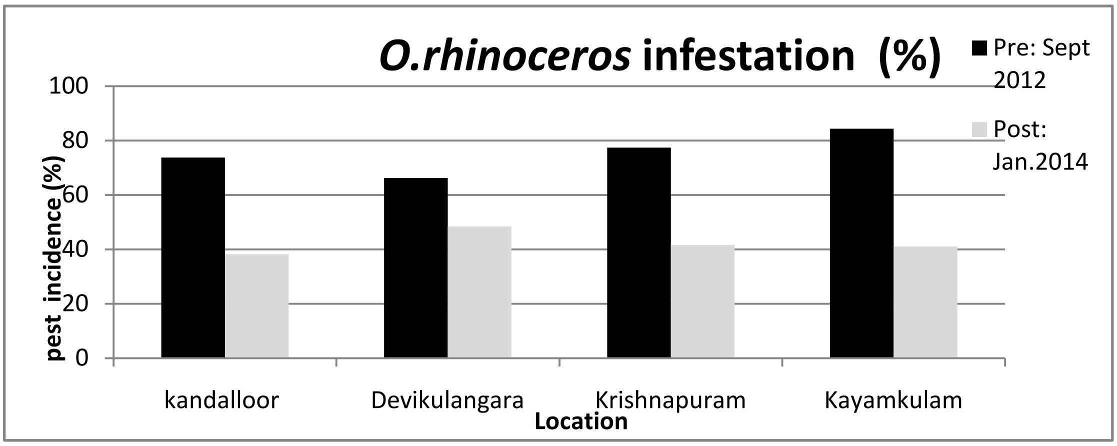


**Fig. 3 Rhinoceros beetle incidence in coconut palms in 4 locations of Alappuzha Dist, Kerala**

### Large scale demonstration for control of Coconut caterpillar in coastal Odisha (OUAT)

Release of *Goniozus nephantidis* and *Bracon brevicornis* was done in two coastal districts of Odisha covering 12 villages. There was substantial reduction in the infestation of coconut caterpillar in the villages where *G. nephantidis* and *B. brevicornis* were released (**Table 139**). Farmers of the neighbouring villages have seen the results and are interested in adopting biocontrol.

**Table 139: Release of *Goniozus nephantidis* and *Bracon brevicornis* in two coastal districts of Odisha**

| District | Village | No. of palms covered | No. of parasitoids (*G. nephantidis/B.brevicornis*) released |
|---|---|---|---|
| Puri | Villideuli | 570 | 5281 |
| | Bishnupur | 780 | 9774 |
| | Deulisahi | 934 | 12534 |
| | Chandradeipur | 759 | 8959 |
| Khurda | Pandiabili | 467 | 4812 |
| | Tirimal | 589 | 5431 |
| | Tailasahi | 741 | 8046 |
| | Sadangi | 415 | 4960 |
| | Singhabramhapur | 1245 | 17590 |
| | Jamukoli | 5890 | 43689 |
| | Kalupada | 7262 | 52979 |
| | Tailasahi | 7072 | 52187 |
| | Deulisahi | 6391 | 36990 |
| | Chhenua | 9289 | 65128 |
| | **Total** | **42404** | **328360** |

## 5. Brinjal

### BIPM in Brinjal (OUAT)

**Area covered :100 Acres**

### BIPM

- Pheromone traps erected @ 25/ha after 15 DAP
- Weekly release of Egg parasitoid *Trichogramma chilonis* @50,000/ha / week after 20 DAP ( total of 15 releases ) (released till the final harvest)
- Two spray Bt ( Dipel) @2 ml/l at 10 days intervals at peak flowering

### Farmers' practice

- Rynaxypyr (Coragen) @0.3ml/l at fortnightly intervals or other insecticide application as per availability.

**Results:** Data in **Table** 140 indicated that, the shoot and fruit borer incidence was significantly low in IPM plots ranging between 11.3 to 13.1 % and 19.9 to 22.2 % respectively in different locations whereas, it was 27.6 to 28.4 % and 38.3 to 47.1% respectively in farmers' practice. Consequently the yield was also higher in the IPM plots ranging from 19,429 kg/ha to 19,742 kg/ha in different locations with the cost: benefit ratio of 1:4.4 to 1: 5.3 whereas, the yield in farmers practice plots ranged from 10,121 kg/ha to 12,329 kg/ha with C:B ratio of 1:4.8 to 1: 5.5 in different locations. The IPM practice produced net return over the farmers practice in the range of ₹ 1,06,830 to ₹ 1,24,800 indicating the superiority of IPM package over the farmers' practice.

**Table 140 : Incidence of shoot and fruit borer and yield of brinjal in IPM and Non IPM fields during Kharif, 2013.**

| Treatments | Shoot borer incidence ( % ) | Fruit borer incidence ( % ) | Marketable fruit Yield Kg/ha | C:B ratio | Net return over Farmers' practice (₹/ha) |
|---|---|---|---|---|---|
| **Location : Bimbal( 50 Acres )** | | | | | |
| IPM package | 11.3 | 22.2 | 19,429 | 1: 4.8 | 1,24,800 |
| Farmer's practice | 28.4 | 47.1 | 11,109 | 1: 2.4 | |
| **Location : Achutpur ( 50 Acres )** | | | | | |
| IPM package | 13.1 | 19.9 | 19,742 | 1: 5.5 | 1,06,830 |
| Farmer's practice | 27.6 | 38.3 | 12,620 | 1: 3.4 | |

## 3. Functioning of the co-ordinated project

### 3.1. Staff position

| Sl. No. | Name | Designation | Joining date | Date of leaving |
|---|---|---|---|---|
| **National Bureau of Agriculturally Important Insects, Bangalore** | | | | |
| 1 | Dr. Abraham Verghese | Director | 04.04.2013 | Continuing |
| 2 | Dr. Prashanth Mohanraj | HOD Biosystematics | 07.04.2001 | Continuing |
| 3 | Dr. (Ms) Chandish R. Ballal | HOD Insect Ecology | 06.02.1985 | Continuing |
| 4 | Dr. S. K. Jalali | HOD Molecular Entom. | 06.02.1985 | Continuing |
| 5 | Dr. N. Bakthavatsalam | Principal Scientist, Ento. | 01.10.1994 | Continuing |
| 6 | Dr. B. Ramanujam | Principal Scientist, Path. | 11.12.2000 | Continuing |
| 7 | Dr. (Ms.) K. Veenakumari | Principal Scientist, Ento. | 07.04.2001 | Continuing |
| 8 | Dr. (Ms.) J. Poorani | Principal Scientist, Ento. | 01.08.1996 | Continuing |
| 9 | Dr. M. Nagesh | Principal Scientist, Nem. | 29.01.2001 | Continuing |
| 10 | Dr. A. N. Shylesha | Principal Scientist, Ento | 04.08.2007 | Continuing |
| 11 | Dr. T. Venkatesan | Principal Scientist, Ento | 29.10.1994 | Continuing |
| 12 | Dr. P. Sreerama Kumar | Principal Scientist, Path. | 31.07.1995 | Continuing |
| 13 | Dr. K. S. Murthy | Principal Scientist, Ento | 04.04.2001 | Continuing |
| 14 | Dr. Sunil Joshi | Principal Scientist, Ento | 04.11.1994 | Continuing |
| 15 | Dr. R. Rangeshwaran | Principal Scientist, Micr. | 05.03.1997 | Continuing |
| 16 | Dr. T. M. Shivaling Swamy | Principal Scientist, Ento. | 2009 | Continuing |
| 17 | Dr. G. Siva Kumar | Senior Scientist, Micr. | 2009 | Continuing |
| 18 | Dr. Mohan | Senior Scientist, Ento. | 01.06.2012 | Continuing |
| 19 | Dr. Mahesh Yandigeri | Senior Scientist, Micr. | 04.06.2012 | Continuing |
| 20 | Dr. M. Pratheepa | Senior Scientist, CS | 23.09.1999 | Continuing |
| 21 | Dr. Deepa Bhagat | Senior Scientist, OC | 30.03.2007 | Continuing |
| 22 | Dr. Gandhi Gracy | Scientist, Ento. | 2009 | Continuing |
| 23 | Dr. Ankitha Gupta | Scientist, Ento. | 2010 | Continuing |
| 24 | Mr. K.J. David | Scientist, Ento. | 28.12.2011 | Continuing |
| 25 | Mrs. S. Salini | Scientist, Ento. | 28.12.2011 | Continuing |
| 26 | Dr. Jagdesh Patil | Scientist, Ento. | 2012 | Continuing |
| **Central Tobacco Research Institute, Rajahmundry** | | | | |
| 1. | Sri. S. Gunneswara Rao | Scientist SG (Ent.) | 16-2-1993 | Continuing |
| **Central Plantation Crops Research Institute, Regional Station, Kayangulam** | | | | |
| 1 | Dr. (Ms.) Chandrika Mohan | Principal Scientist (Ent.) | 01.04.1996 | Continuing |
| **Indian Agricultural Research Institute, New Delhi** | | | | |
| 1 | Dr. B. Paul | Senior Scientist (Ent.) | 2012 | |
| **Indian Institute of Sugarcane Research, Lucknow** | | | | |
| 1 | Dr. Arun Baitha | Senior Scientist (Ent.) | 01.10.2006 | Continuing |
| **Indian Institute of Horticultural Research, Bangalore** | | | | |
| 1. | Dr. A. Krishnamoorthy | Princ. Scientist (Ent.) | 1977 | Continuing |
| 2 | Dr. P. N. Ganga Visalakshy | Senior Scientist (Ent.) | 1987 | Continuing |
| **Directorate of Weed Science Research, Jabalpur** | | | | |
| 1 | Dr. Sushil Kumar | Princ. Scientist (Ent.) | 2006 | Continuing |
| **Directorate of Soybean Research, Indore** | | | | |
| 1 | Dr. Y. Sridhar | Senior Scientist (Ent.) | 2013 | Continuing |
| **National Centre for Integrated Pest Management, New Delhi** | | | | |
| 1 | Dr. Ajanta Birah | Senior Scientist (Ent.) | 2013 | Continuing |
| **Directorate of Sorghum Research, Hyderabad** | | | | |
| 1 | Dr. V.R. Bhagwat | Princ. Scientist (Ent.) | 2013 | Continuing |
| **Directorate of Seed Research, Mau** | | | | |
| 1 | Dr. Arvind Nath singh | Senior Scientist (Ent.) | 2013 | Continuing |
| 2 | Dr. Raghavendra | Scientist (Ent.) | 2013 | Continuing |

| | | | | |
|---|---|---|---|---|
| **Central Institute of Sub-Tropical Horticulture, Lucknow** | | | | |
| 1 | Dr. H. Kesava Kumar | Scientist (Nematology) | 2013 | Continuing |
| 2 | Dr. Gundappa | Scientist (Ent.) | 2013 | Continuing |
| **Directorate of Rice Research, Hyderabad** | | | | |
| 1 | Dr. Chitra Shanker | Princ. Scientist (Ent.) | 2013 | Continuing |
| **Indian Institute of Vegetable Research, Varanasi** | | | | |
| 1 | Dr. Jaydeep Halder | Scientist (Ent.) | 2013 | Continuing |
| **Anand Agricultural University, Anand** | | | | |
| 1 | Dr. D. M. Mehta | Principal Res. Scientist | 01-07-2012 | Continuing |
| 2 | Dr. (Mrs.) Harsha. N. Shelat | Asst. Res. Sci. (Micro) | 01.03.2013 | Continuing |
| 3 | Dr.P. H. Godhani | Asso. Res. Scientist | 20-09-2012 | Continuing |
| **Acharya N. G. Ranga Agricultural University, Hyderabad** | | | | |
| 1 | Dr. S. J. Rahman | Prin. Scientist & Head | 19.02.2007 | Continuing |
| 2 | Smt. G.Anitha | Scientist (Ent.) | 06.01.2009 | Study leave |
| **Assam Agricultural University, Jorhat** | | | | |
| 1 | Dr. D. K.Saikia | Principal Scientist (Ent.) | 23.03.2001 | Continuing |
| 2. | Dr. (Mrs) Anjumoni Devi | Junior Scientist (Ent.) | 20.12.2012 | Continuing |
| **Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar** | | | | |
| 1 | Dr. J. Kumar | Dean | 2008 | Continuing |
| 2 | Dr. Anand Kumar Tewari | Professor, Pl. Pathology | 2012 | Continuing |
| **Kerala Agricultural University, Thrissur** | | | | |
| 1. | Dr. K. R. Lyla | Professor (Ent.) | 23-11-95 | Continuing |
| 2. | Smt. C.V. Vidya | Asst. Prof. (Ent.) | 26-05-11 | Continuing |
| **Mahatma Phule Krishi Vidyapeeth, Pune** | | | | |
| 1 | Dr. R. V. Nakat | Entomologist | 21/8/2007 | Continuing |
| 2 | Dr. S.M. Galande | Asst. Entomologist | 2013 | Continuing |
| **Punjab Agricultural University, Ludhiana** | | | | |
| 1. | Dr Jaspal Singh Virk | Entomologist | 15.3.2003 | Continuing |
| 2. | Dr Neelam Joshi | Microbiologist | 8.5.1997 | Continuing |
| 3. | Dr Rabinder Kaur | Asstt. Entomologist | 20.12.2004 | Continuing |
| 4. | Sh. Sudhendu Sharma | Asstt. Entomologist | 1.1.2009 | Continuing |
| 5. | Dr Parminder Singh Shera | Asstt. Entomologist | 7.3.2014 | Continuing |
| **Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar** | | | | |
| 1. | Dr. Akhtar Ali Khan | Associate Professor | June 2013. | Continuing |
| 2. | Mr. Sajad Mohi-ud-din | Assistant Professor | June 2013. | Continuing |
| **Tamil Nadu Agricultural University, Coimbatore** | | | | |
| 1. | Dr. P. Karuppuchamy | Professor (Ent.) | 02.07.2007 | Continuing |
| 2. | Dr. M. Kalyanasundaram | Professor (Ent.) | 16.05.2007 | Continuing |
| **Dr. Y.S. Parmar University of Horticulture and Forestry, Solan** | | | | |
| 1 | Dr Usha Chauhan | Senior Entomologist | June, 2009 | Continuing |
| 2 | Dr. P. L. Sharma | Entomologist | 16.05.2008 | Continuing |
| **Central Agricultural University, Pasighat** | | | | |
| 1 | Dr. K. Mamocha singh | Asso. Prof. (Ent.) | 2007 | Continuing |
| **Maharana Pratap University of Agriculture & Technology, Udaipur** | | | | |
| 1 | Dr. B. S. Rana | Asso. Prof. (Ent.) | 2007 | Continuing |
| **Orissa University of Agriculture & Technology, Bhubaneshwar** | | | | |
| 1 | Dr. B.K. Mishra | Dean Agriculture | 2007 | Continuing |
| **University of Agriculture Sciences, Raichur (Voluntary Centre)** | | | | |
| 1 | Dr. Arunkumar Hosmani | Asso. Prof. (Ent.) | 2007 | Continuing |

## 3.2. Budget for AICRP on Biocontrol 2013-14 (Rupees in Lakhs)

### AICRP on Biocontrol, NBAII, Bangalore

| Head | Plan (Rs. in lakhs) | Non-Plan | Total (Rs. in lakhs) |
|---|---|---|---|
| Pay & Allowances | 282.13 | - | 282.13 |
| Recurring Contingencies | 28.01 | - | 28.01 |
| TA | 9.86 | - | 9.86 |
| Other charges including Equipment | 0.00 | - | 0.00 |
| TSP | 0.00 | - | 0.00 |
| **Total** | **320.00** | **-** | **320.00** |

### AAU-Anand

| Item of Expenditure | ICAR Share (75 %) | State Share (25 %) | Total Amount (Rs) |
|---|---|---|---|
| Pay and allowances | 30,55,000/- | 10,18,333/- | 40,73,333/- |
| Rec. Contingencies | 2,25,000/- | 75,000/- | 3,00,000/- |
| T.A | 1,22,000/- | 40,667/- | 1,62,667/- |
| TOTAL | **34,02,000/-** | **11,34,000/-** | **45,36,000/-** |

### AAU-Jorhat

| Head | Budget allotted (Lakhs) | Expenditure (Rs) | ICAR -75% | State 25% | Remarks |
|---|---|---|---|---|---|
| 1. Pay and allowances | 20.49 | Officers 23,64,533.00<br>Estt 11,64,608.00<br>35,29,141.00 | 26,46,855.75 | 8,82,285.25 | Some bills are under process |
| 2. TA | 0.82 | 87,007.00 | 65,255.25 | 21,751.75 | |
| 3. Recurring Contingencies | 1.51 | 2,01,000.00 | 1,50,750.00 | 50,250.00 | |

### KAU-Thrissur

| Sl. No. | Item | Budget (Rs. in lakhs) | Expenditure (Rs.) |
|---|---|---|---|
| 1. | Pay & allowances | 24.89 | 3227022.00 |
| 2. | TA | 1.10 | 57959.00 |
| 3. | Contingencies | 2.00 | **199183.00** |
| | **Total** | **27.99** | **3484164.00** |

### MPKV – Pune

| Sr. No. | Items | Sanctioned and allotted grants (in lakh) | Total expenditure (Rs. in lakh.) |
|---|---|---|---|
| 1 | Est. charges (Pay & allow.) | 29.41 | 29,75,058.00 |
| 2 | Recurring contingencies including T. A. | 3.00 | 2,94,547.00 |
| 3 | Non-recurring contingencies | - | |
| | **Total** | **32.41** | **32,69,605.00** |
| | ICAR share (75%) | 24.31 | 24,52,204.00 |
| | State share (25%) | 8.10 | 8,17,401.00 |

**PAU-Ludhiana**

ICAR Share

| Sub Head | Revised Estimate (RE) 2013-14 (Lakhs) | Remittance Upto March, 2014 | Expenditure upto 31st March, 2014 |
|---|---|---|---|
| Pay and Allowances | **48.50** | **-** | **48.50** |
| Travelling Allowances | **2.20** | **-** | **1.00** |
| Recurring Contingency | **4.00** | **-** | **4.00** |
| Total | 54.70 | 43.24 | 53.50 |

**3.3. Problems encountered during the year**

**AAU-Jorhat**

1. Recruitment of a laboratory attendant is very essential for the mass production of biotic agents.
2. A separate fund for POL is essential for the local as well as outside tours
3. Replacement of old vehicle: a new vehicle may please be provided for conducting different survey programmes, demonstration trials etc. in different agroclimatic zone of Assam

**CPCRI-Kayangulam:** Shortage of manpower for executing the work.

**KAU-Thrissur:** The posts of Technical Assistant and Farm Officer are vacant.

**MPKV- Pune :**

1. Survey and collection of natural enemies from different agro-ecological zones, demonstrations and field trials on farmer's fields are required to carry out in time. The University vehicle may not be available in time because of College activities. Hence, separate provision may be made in budget for hiring the vehicle.
2. Maintenance of polyhouse and purchase of planting material, pots, soil/medium for beds, engaging labour units, etc. become very expensive. Hence, an additional recurring contingent grants are required for conducting trials in polyhouse crops.

**SKUAST-Kashmir**

1. Availability of grants at the end of financial year (2013-14) restricted the field work. Moreover, late allotment of some survey based experiments i.e. during the 2nd week of July' 2012, could not be done as per programme, which however will be conducted during current year, 2013.

# 4. General

## 4. 1. Meteorological data (2013-14)

### AAU-Jorhat

| Month, 2012-13 | Temperature ($^0C$) | | | RH% (mean) | No. Of rainy days | Total rainfall (mm) |
|---|---|---|---|---|---|---|
| | Max. | Min. | Mean | | | |
| March-13 | 29.2 | 16.8 | 23.0 | 68.0 | 9 | 64.8 |
| April-13 | 28.3 | 18.6 | 23.45 | 78.0 | 11 | 148.9 |
| May -13 | 30.2 | 23.5 | 26.85 | 81.5 | 22 | 324.3 |
| June-13 | 33.2 | 25.4 | 29.3 | 80.5 | 17 | 303.7 |
| July-13 | 32.8 | 25.8 | 29.3 | 84.0 | 23 | 493.6 |
| August13- | 32.5 | 25.8 | 29.15 | 84.5 | 22 | 386.1 |
| September-13 | 32.5 | 24.4 | 28.45 | 81.5 | 8 | 83.2 |
| October-13 | 29.9 | 22.2 | 26.05 | 82.5 | 9 | 156.9 |
| November-13 | 27.4 | 13.8 | 20.6 | 78.5 | 0 | 0 |
| December-13 | 24.1 | 11.4 | 17.75 | 79.5 | 1 | 1.0 |
| January-14 | 23.8 | 10.1 | 16.95 | 74.5 | 2 | 1.1 |
| February-14 | 24.7 | 12.2 | 18.45 | 76.0 | 4 | 36.1 |

### CPCRI - Kayangulam

| Month | Temperature | | Humidity (%) | | Wind (km/ h) | Sun shine (h/day) | Rain (mm) | No .of rainy days | Evapor ation (mm) |
|---|---|---|---|---|---|---|---|---|---|
| | Max (°C) | Min (°C) | FN | AN | | | | | |
| March 2013 | 34.5 | 24.5 | 91 | 65 | 1.4 | 8.4 | 27.8 | 1 | 3.6 |
| April | 34.4 | 25.1 | 92 | 64 | 1.7 | 8.0 | 68.6 | 4 | 3.6 |
| May | 30.4 | 25.0 | 92 | 73 | 1.2 | 6.3 | 242.9 | 15 | 3.3 |
| June | 29.5 | 23.3 | 93 | 83 | 1.1 | 3.1 | 753.8 | 23 | 2.7 |
| July | 29.5 | 23.1 | 93 | 82 | 1.2 | 4.0 | 736.1 | 30 | 2.7 |
| August | 30.6 | 23.9 | 93 | 72 | 1.6 | 6.2 | 80.6 | 7 | 3.1 |
| September | 30.1 | 23.7 | 93 | 77 | 1.2 | 6.1 | 301.0 | 16 | 3.1 |
| October | 31.8 | 23.7 | 92 | 82 | 1.2 | 6.8 | 128.9 | 14 | 3.4 |
| November | 32.4 | 24.7 | 94 | 83 | 0.8 | 6.6 | 188.5 | 7 | 3.4 |
| December | 33.4 | 23.6 | 93 | 78 | 1.0 | 7.8 | 6.5 | 1 | 3.3 |
| Jan. 2014 | 34.3 | 21.6 | 91 | 72 | 1.3 | 9.0 | 0.0 | 0 | 3.6 |
| Feb. 2014 | 34.0 | 22.7 | 90 | 70 | 1.6 | 9.1 | 7.6 | 1 | 3.7 |

### KAU-Thrissur

| Month | Temperature $^OC$ | | Relative Humidity (%) | Rainfall (mm) |
|---|---|---|---|---|
| | Min. | Max. | | |
| April 2013 | 25.1 | 34.9 | 71 | 0 |
| May | 25.2 | 33.6 | 71 | 99.1 |
| June | 22.7 | 28.5 | 90 | 1031.8 |
| July | 22.7 | 28.4 | 91 | 932.3 |
| August | 22.9 | 29.9 | 84 | 305.9 |

| | | | | |
|---|---|---|---|---|
| September | 22.2 | 30.0 | 85 | 344.1 |
| October | 22.6 | 30.8 | 83 | 369.8 |
| November | 23.9 | 32.6 | 73 | 82.0 |
| December | 22.3 | 31.9 | 61 | 0.5 |
| January 2014 | 23 | 32.9 | 51 | 0 |
| February | 22.9 | 34.7 | 56 | 0 |
| March | 24.7 | 37.9 | 55 | 0 |

## MPKV-Pune

| Met. week | $T_{max}$ $^0$C | $T_{min}$ $^0$C | RH-I (%) | RH-II (%) | Rain (mm) | Rainy days | BSS (hrs) |
|---|---|---|---|---|---|---|---|
| 1 | 32.0 | 15.1 | 93.3 | 27.1 | 0.0 | 0 | 8.9 |
| 2 | 30.1 | 10.4 | 94.7 | 32.3. | 0.0 | 0 | 8.6 |
| 3 | 31.3 | 11.5 | 92.6 | 32.0 | 0.0 | 0 | 8.0 |
| 4 | 31.1 | 11.4 | 94.4 | 27.4 | 0.0 | 0 | 8.5 |
| 5 | 31.7 | 14.7 | 82.3 | 33.3 | 0.0 | 0 | 7.0 |
| 6 | 31.4 | 14.7 | 89.9 | 35.6 | 0.0 | 0 | 8.0 |
| 7 | 32.4 | 11.4 | 90.5 | 22.1 | 0.0 | 0 | 9.8 |
| 8 | 33.5 | 12.6 | 84.7 | 22.1 | 0.0 | 0 | 9.9 |
| 9 | 34.2 | 12.4 | 80.9 | 15.9 | 0.0 | 0 | 9.7 |
| 10 | 35.2 | 13.4 | 71.4 | 19.1 | 0.0 | 0 | 9.5 |
| 11 | 35.6 | 16.7 | 72.9 | 19.1 | 2.8 | 1 | 8.5 |
| 12 | 35.7 | 16.1 | 62.9 | 16.7 | 0.0 | 0 | 9.4 |
| 13 | 36.2 | 17.3 | 61.9 | 18.7 | 0.0 | 0 | 8.6 |
| 14 | 36.8 | 16.6 | 58.1 | 14.4 | 0.0 | 0 | 9.9 |
| 15 | 38.7 | 20.1 | 49.7 | 15.4 | 0.0 | 0 | 9.5 |
| 16 | 35.5 | 19.1 | 68.3 | 22.4 | 0.0 | 0 | 10.8 |
| 17 | 38.4 | 22.6 | 55.4 | 20.3 | 0.0 | 0 | 10.1 |
| 18 | 39.4 | 23.8 | 47.9 | 20.1 | 0.0 | 0 | 10.1 |
| 19 | 38.2 | 23.2 | 57.4 | 22.3 | 0.0 | 0 | 10.1 |
| 20 | 36.7 | 24.7 | 65.9 | 30.0 | 0.0 | 0 | 8.1 |
| 21 | 36.5 | 24.9 | 67.3 | 37.0 | 0.0 | 0 | 8.7 |
| 22 | 35.7 | 24.3 | 69.0 | 35.0 | 0.8 | 0 | 9.0 |
| 23 | 33.1 | 22.7 | 83.4 | 55.0 | 93.5 | 4 | 4.3 |
| 24 | 28.6 | 22.8 | 85.3 | 74.0 | 111.2 | 4 | 1.4 |
| 25 | 29.2 | 22.7 | 83.0 | 69.0 | 20.1 | 1 | 4.5 |
| 26 | 27.8 | 22.3 | 87.6 | 78.1 | 36.6 | 4. | 1.3 |
| 27 | 28.1 | 22.3 | 88.6 | 76.3 | 13.8 | 2 | 2.7 |
| 28 | 26.9 | 21.9 | 86.9 | 78.6 | 39.2 | 3 | 1.6 |
| 29 | 26.2 | 21.8 | 90.7 | 88.4 | 45.8 | 5 | 1.0 |
| 30 | 25.7 | 21.7 | 92.4 | 87.6 | 81.9 | 7 | 0.4 |
| 31 | 26.2 | 21.4 | 88.7 | 85.9 | 48.3 | 5 | 2.4 |
| 32 | 27.7 | 21.4 | 86.4 | 71.7 | 2.9 | 1 | 3.4 |
| 33 | 28.4 | 22.0 | 87.7 | 69.1 | 2.1 | 0 | 4.6 |
| 34 | 28.2 | 21.7 | 84.3 | 66.9 | 2.7 | 0 | 4.0 |
| 35 | 27.9 | 20.1 | 86.9 | 59.4 | 2.2 | 0 | 5.1 |
| 36 | 29.9 | 20.6 | 86.7 | 61.7 | 14.1 | 2 | 6.2 |
| 37 | 30.8 | 21.4 | 90.6 | 62.3 | 120.2 | 6 | 4.3 |
| 38 | 28.8 | 21.4 | 88.0 | 68.7 | 82.5 | 2 | 3.6 |
| 39 | 28.3 | 21.1 | 85.0 | 66.7 | 4.9 | 1 | 3.5 |
| 40 | 30.4 | 21.3 | 88.4 | 60.0 | 14.1 | 2 | 7.2 |
| 41 | 30.0 | 20.3 | 86.1 | 57.6 | 0.0 | 0 | 7.5 |
| 42 | 32.2 | 20.2 | 89.1 | 46.1 | 17.7 | 1 | 7.1 |
| 43 | 31.8 | 19.9 | 88.4 | 49.3 | 2.8 | 1 | 7.5 |
| 44 | 31.8 | 18.1 | 86.6 | 43.0 | 0.0 | 0 | 8.5 |
| 45 | 30.2 | 15.8 | 88.9 | 40.0 | 0.0 | 0 | 7.9 |
| 46 | 29.2 | 12.5 | 91.9 | 35.6 | 0.0 | 0 | 9.0 |
| 47 | 31.2 | 14.0 | 91.9 | 37.0 | 0.0 | 0 | 9.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 48 | 29.8 | 18.5 | 94.0 | 53.4 | 14.6 | 1 | 6.2 |
| 49 | 29.8 | 18.5 | 94.0 | 53.4 | 0.0 | 0.0 | 9.0 |
| 50 | 29.1 | 13.1 | 93.6 | 35.7 | 2.1 | 0.1 | 6.3 |
| 51 | 29.3 | 7.3 | 94.1 | 25.7 | 0.5 | 0.1 | 7.8 |
| 52 | 29.5 | 8.5 | 94.4 | 31.3 | 0.0 | 0.0 | 9.5 |
| 1 | 29.0 | 12.2 | 91.9 | 40.9 | 0.0 | 0.0 | 8.6 |
| 2 | 30.2 | 12.0 | 93.9 | 33.7 | 0.0 | 0.0 | 8.9 |
| 3 | 29.8 | 12.7 | 92.4 | 36.7 | 0.0 | 0.0 | 7.9 |
| 4 | 29.2 | 14.5 | 90.4 | 39.7 | 0.0 | 0.0 | 6.2 |
| 5 | 29.7 | 11.3 | 93.1 | 34.1 | 0.0 | 0.0 | 8.9 |
| 6 | 32.0 | 10.6 | 89.6 | 20.3 | 0.0 | 0.0 | 9.5 |
| 7 | 30.0 | 12.8 | 88.0 | 29.5 | 0.0 | 0.0 | 9.5 |
| 8 | 31.5 | 15.0 | 89.4 | 34.7 | 0.0 | 0 | 4.6 |
| 9 | 30.6 | 14.0 | 87.3 | 33.4 | 0.0 | 0 | 5.1 |
| 10 | 31.2 | 16.4 | 87.3 | 33.7 | 0.3 | 0 | 5.5 |
| 11 | 34.7 | 18.5 | 83.6 | 27.1 | 0.2 | 0 | 6.0 |

## PAU-Ludhiana

| Month | Temperature ($^0$C) | | RH (%) | | Total Rainfall (mm) | Sunshine (hrs.) |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Morning | Evening | | |
| April, 2013 | 34.2 | 18.3 | 65 | 24 | 4.4 | 9.1 |
| May, 2013 | 40.5 | 23.0 | 50 | 26 | 1.2 | 9.7 |
| June, 2013 | 35.6 | 27.2 | 77 | 53 | 296.4 | 7.5 |
| July, 2013 | 35.0 | 27.7 | 82 | 64 | 1110.2 | 6.5 |
| August, 2013 | 33.0 | 26.4 | 89 | 70 | 252.2 | 5.4 |
| September, 2013 | 33.0 | 23.5 | 88 | 62 | 25.3 | 6.7 |
| October, 2013 | 31.4 | 20.2 | 91 | 49 | 36.2 | 5.3 |
| November, 2013 | 25.9 | 10.2 | 92 | 37 | 4.6 | 6.9 |
| December, 2013 | 17.3 | 3.9 | 93 | 44 | 2.8 | 7.1 |
| January, 2014 | 17.5 | 7.0 | 96 | 62 | 55.5 | 4.5 |
| February, 2014 | 19.4 | 8.2 | 94 | 62 | 36.7 | 5.3 |

## SKUAST-Srinagar

| Month | Standard Week | Maximum Temperature ($^0$C) | Minimum Temperature ($^0$C) | Rainfall (mm) | Maximum Humidity (%) | Minimum Humidity (%) | Sun shine (hrs) |
|---|---|---|---|---|---|---|---|
| January | 1 | 8.43 | -4.57 | 0.0 | 96 | 70.14 | 6.09 |
| | 2 | 7.36 | -2.24 | 11.0 | 93.57 | 75.86 | 3.47 |
| | 3 | 6.93 | -1.0 | 78.4 | 90.42 | 66.14 | 2.91 |
| | 4 | 4.86 | -4.49 | 0.0 | 91.0 | 73.86 | 2.87 |
| February | 5 | 9.64 | -1.57 | 6.4 | 90.43 | 66.86 | 2.14 |
| | 6 | 10.14 | -2.44 | 34.6 | 91.00 | 58.43 | 5.90 |
| | 7 | 11.14 | 1.27 | 7.8 | 83.57 | 62.57 | 4.01 |
| | 8 | 8.36 | 0.67 | 53.20 | 84.43 | 62.86 | 1.59 |
| March | 9 | 12.01 | 1.07 | 35 | 86.86 | 54.43 | 5.46 |
| | 10 | 18.93 | 3.14 | 0.0 | 77.71 | 40.57 | 7.04 |
| | 11 | 15.36 | 4.39 | 13.0 | 88.14 | 55.71 | 3.37 |
| | 12 | 16.50 | 4.40 | 38.60 | 77.57 | 51.86 | 4.03 |
| | 13 | 19.43 | 5.34 | 0.0 | 81.57 | 49.14 | 6.31 |
| April | 14 | 17.07 | 4.74 | 29.0 | 68.14 | 62.0 | 5.64 |
| | 15 | 21.93 | 5.71 | 9.8 | 77.71 | 54.57 | 7.56 |
| | 16 | 16.57 | 6.60 | 65.40 | 87.86 | 65.43 | 3.71 |
| | 17 | 19.79 | 9.26 | 31.40 | 86.71 | 55.71 | 3.56 |
| May | 18 | 21.00 | 7.14 | 4.20 | 80.14 | 51.43 | 5.67 |
| | 19 | 21.79 | 9.50 | 14.0 | 88.29 | 57.14 | 5.13 |
| | 20 | 26.21 | 8.86 | 8.6 | 76.00 | 41.0 | 9.67 |
| | 21 | 27.14 | 12.07 | 32.20 | 76.57 | 49.43 | 7.23 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 22 | 26.57 | 8.69 | 13.0 | 77.0 | 41.29 | 9.24 |
| June | 23 | 31.86 | 14.61 | 0.0 | 73.0 | 46.71 | 11.44 |
| | 24 | 25.21 | 15.61 | 61.20 | 91.0 | 66.71 | 3.94 |
| | 25 | 31.14 | 14.50 | 3.40 | 72.0 | 40.0 | 11.34 |
| | 26 | 29.10 | 17.61 | 32.20 | 81.0 | 52.14 | 8.41 |
| July | 27 | 31.23 | 15.76 | 15.8 | 78.57 | 45.86 | 8.70 |
| | 28 | 29.00 | 16.42 | 35.2 | 81.57 | 51.43 | 8.27 |
| | 29 | 31.14 | 18.34 | 8.0 | 74.29 | 48.57 | 8.34 |
| | 30 | 32.71 | 18.47 | 3.2 | 71.86 | 44.14 | 9.83 |
| August | 31 | 30.5 | 19.27 | 18.4 | 79.71 | 56.29 | 6.39 |
| | 32 | 32.07 | 19.14 | 6.2 | 77.14 | 47.00 | 7.31 |
| | 33 | 21.74 | 16.86 | 158.6 | 90.14 | 84.00 | 0.21 |
| | 34 | 30.36 | 17.07 | 3.4 | 75.28 | 62.57 | 9.34 |
| September | 35 | 28.64 | 15.77 | 0.6 | 83.86 | 60.57 | 5.60 |
| | 36 | 29.57 | 13.39 | 7.8 | 79.57 | 51.71 | 8.37 |
| | 37 | 23.79 | 13.57 | 21.0 | 86.86 | 67.29 | 3.39 |
| | 38 | 28.93 | 9.04 | 0.0 | 81.00 | 48.00 | 9.26 |
| | 39 | 28.21 | 11.67 | 2.4 | 85.29 | 63.43 | 8.27 |
| October | 40 | 29.00 | 11.70 | 0.0 | 85.43 | 45.57 | 8.34 |
| | 41 | 24.71 | 12.87 | 11.6 | 88.53 | 65.00 | 4.46 |
| | 42 | 23.36 | 6.39 | 0.0 | 84.86 | 54.14 | 6.79 |
| | 43 | 23.00 | 3.33 | 0.0 | 81.86 | 67.71 | 7.03 |
| November | 44 | 15.57 | 2.23 | 17.6 | 85.71 | 72.00 | 2.96 |
| | 45 | 13.64 | 2.77 | 8.80 | 82.0 | 70.43 | 3.00 |
| | 46 | 15.57 | -2.48 | 0.0 | 85.14 | 38.43 | 6.30 |
| | 47 | 16.66 | -1.21 | 0.0 | 86.86 | 72.43 | 2.60 |
| December | 48 | 14.86 | -3.30 | 0.0 | 89.86 | 75.71 | 4.00 |
| | 49 | 12.86 | -2.43 | 0.0 | 88.29 | 62.57 | 1.13 |
| | 50 | 10.17 | -4.04 | 0.0 | 93.86 | 69.00 | 2.80 |
| | 51 | 9.29 | -0.79 | 10.2 | 85.29 | 67.43 | 2.69 |
| | 52 | 8.64 | -1.58 | 2.4 | 89.86 | 76.43 | 3.89 |

**UAS- Raichur**

| 2013 | Std. Week | Max T ($^o$ C) | Max T ($^o$ C) | RF (mm) | R Day | RH I (%) | RH II (%) |
|---|---|---|---|---|---|---|---|
| July 16-22 | 29 | 30.4 | 23.1 | 48.4 | 3 | 87 | 74 |
| July 23-29 | 30 | 30.9 | 21.9 | 30.0 | 3 | 83 | 59 |
| July 30-5 | 31 | 32.3 | 22.4 | 15.9 | 1 | 79 | 58 |
| Aug 6-12 | 32 | 32.7 | 22.8 | 0.0 | 0 | 80 | 55 |
| Aug 13-19 | 33 | 29.4 | 24.1 | 49.5 | 3 | 91 | 69 |
| Aug 20-26 | 34 | 32.5 | 21.6 | 2.2 | 0 | 83 | 48 |
| Aug 27-2 | 35 | 35.1 | 23.0 | 34.6 | 2 | 82 | 54 |
| Sept 3-9 | 36 | 30.4 | 22.0 | 83.6 | 4 | 93 | 69 |
| Sep10-16 | 37 | 31.1 | 23.0 | 96.6 | 3 | 93 | 66 |
| Sep17-23 | 38 | 30.2 | 22.1 | 59.8 | 4 | 92 | 73 |
| Sep 24-30 | 39 | 31.6 | 21.3 | 10.0 | 2 | 87 | 64 |
| Oct 1-7 | 40 | 30.8 | 21.8 | 30.0 | 1 | 88 | 64 |
| Oct 8-14 | 41 | 31.8 | 22.4 | 1.7 | 0 | 82 | 69 |
| Oct 15-21 | 42 | 32.5 | 21.1 | 0.0 | 0 | 80 | 55 |
| Oct 22-28 | 43 | 28.3 | 21.9 | 65.2 | 4 | 96 | 82 |
| Oct29- Nov- | 44 | 31.3 | 20.3 | 0.0 | 0 | 84 | 54 |
| Nov 5-11 | 45 | 31.7 | 18.9 | 0.0 | 0 | 80 | 46 |
| Nov 12-18 | 46 | 29.6 | 15.1 | 0 | 0 | 72 | 40 |
| Nov 19-25 | 47 | 31.2 | 17.0 | 0 | 0 | 80 | 42 |
| Nov 26-Dec 2 | 48 | 31.3 | 18.7 | 1.2 | 0 | 87 | 48 |

## 4.2. Visitors

### AAU- Anand

1. Dr. B. Ramanujam, Principal Scientist, NBAII, Bangalore visited on 17-19 Jan. 2014

### AAU- Jorhat

1. Dr. N. Bakthavastalam, Principal Scientist, NBAII, Bangalore visited on 28-04-2013
2. Director of Research AAU, Jorhat visited Biological control laboratory, Department of Entomology, AAU, Jorhat on 12th July , 2013
3. A group of students (28 nos) from Kokrajhar Govt. College from Department of Zoology on 20.8.2013 visited the biological control laboratory.
4. A group of farmers (65Nos) from Golaghat district visited the laboratory on 03.11.2013
5. A team of Probationary officers (32 nos) from Tea Board visited biological control laboratory on 10.11.2013
6. Research Monitoring Team, AAU, Jorhat visited biological control laboratory on 21.02.2014

### ANGRAU-Hyderabad

1. Dr. G.S. Dhillon, Vice Chancellor, PAU, Ludhiana - on 25.10.2013 – for active collaboration between ANGRAU Centre and PAU for commercialization of Technologies.
2. Dr. Abraham Verghese, Director, NBAII, Bangalore on 20.3.2014 – for reviewing progress of work and also visit to Experimental plots at ARS, Tandur (Rangareddy Dist.), A.P.

### GBPUAT Pantnagar

1. Dr. B. Ramanujam, Principal Scientist, NBAII, Bangalore visited on 17-19 Jan. 2014

### MPKV-Pune

1. Dr. Mohamed Saeed Alkhalila, AAU, Sudan visited the lab. on 01/4/2013 and discussed mass culturing of bioagents and activities of Biocontrol lab.
2. Dr. (Ms.) Chandish Ballal, Principal Scientist, Division of Ecology, NBAII, Bangalore visited the lab. on 18/4/2013 and observed the mass culturing of bioagents and host insects and discussed the progress of research.
3. Dr. P. P. Dhar, Professor in Agril. Entomology, BCKVV, Nadia (W.B.) visited the Biocontrol Lab. on 26/4/2013 and discussed mass production of bioagents and entomofungal pathogens as well as research activities.
4. Dr. B. R. Kawathekar, Retd. Professor in Agril. Entomology, MAU, Parbhani visited the Biocontrol lab. on 15/05/2013.
5. Dr. Anand Narangalkar, Head, Dept. of Entomology, Dr. B. S. K. K. V., Dapoli visited the Biocontrol lab. on 20-21st July, 2013.
6. Dr. U. M. Waghmare, Head, Dept. of Entomology, M. K. V., Parbhani visited the Biocontrol lab. on 3/08/2013.

7. Dr. R. S. Pandit, Department of Zoology, University of Pune along with 15 M.Sc. students visited this lab. on 05/08/2013 for observing the bioagents and their mass production.
8. Dr. Kusumkar Sharma, ADG (HRD) ICAR, New Delhi visited the Biocontrol Laboratory on 14th September 2013 and observed the research activities of the centre.
9. Prof. M. M. Anwar, Former Director N.R.C. on Seed Spices and Prof. of Research Management, NARAM, Hyderabad visited the Biocontrol lab. on 10th October, 2013 and observed the research activities of the centre.
10. Dr. G. Subbaiah, Associate Dean, College of Agriculture, Bapatla (A.P.) and took the review of Bioagent production activity in this laboratory on 08/11/2013.
11. Dr. P. Rajendra Prasad, Professor and Head, Department of Entomology, S. V. Agriculture College, Tirupathi (A.P.) visited the Biocontrol Laboratory on 08/11/2013. and reviewed the work on production of bioagents and their use in IPM of various crops.
12. Prof. R. Subhash Reddy, Agriculture Microbiology, ANGRAU, Rajendranagar, Hyderabad visited the biocontrol laboratory and discussed the use of bioagents in IPM programme on 08/11/2013.
13. Dr. Abraham Verghese, Project Co-ordinator and Director, NBAII, Bangalore visited the Biocontrol laboratory on 13 and 14 November 2013 and reviewed the progress of research work assigned to the centre for the year 2013-14. He along with staff of the project conducted, experimental plot visit as well as field visit to the papaya orchards surrounding Pune for observing the PMB infestation and its natural enemies
14. Shri. P. A. Sathe, Regional Deputy Director (Sugar), Pune visited the Biocontrol Laboratory on 13/11/2013 and took the review on use of bioagents in IPM on sugarcane
15. Mr. Alex Taa, Koppert Biological Systems, India visited the Biocontrol laboratory on 20/11/2013 and exchanged the information on role of bioagents in IPM of various crops.
16. Dr. Ram Niwas, Professor and Head, Department of Meteorology, CCS, HAU, Hissar visited the Biocontrol lab. on 06/12/2013.
17. Mr. Uday Narayan Bhat, Koppert Biological Systems India visited the Biocontrol lab. on 13/12/2013 and discussed about the collaborative trial in polyhouse crops, A. C. Pune
18. S(Krish) Permalloo, Divisional scientific officer, Entomology Division, Ministry of Agro-Industry and Food Security, Reduit, Mauritius visited the biocontrol laboratory and discussed the use of bioagents in IPM programme with special emphasis on control of papaya mealy bug in Mauritius with the staff of this centre on 19/12/2013.
19. Dr. G. Prasad Rao, Dean (Retd.) KAU visited the biocontrol laboratory and discussed the use of bioagents in IPM programme on 23/12/2013.
20. Dr. H.R. Sardana, Principal Scientist, NCIPM, Pusa, New Delhi visited Biocontrol laboratory on 09.01.2014.
21. Shri. Shivaji Chamkire and Shri. K.D. Lambe, Influx AgroTech Pvt. Ltd., Pune has visited the Biocontrol laboratory on 10.01.2014.

**KAU – Thrissur**

1. Dr. N.K. Krishnakumar, Deputy Director General (Hort.), ICAR New Delhi visited the scheme on 13/03/14.
2. Dr. Abraham Verghese, Director, NBAII, Bangalore visited the scheme on 01/06/13 and 06/03/14.
3. Dr. Chandish Ballal, Principal Scientist Dr. Lalitha and Smt. Sasikala Kadam visited the scheme on 12/11/13.

4. Dr. K. Prathapan, Director, State Horticulture Mission-Kerala visited the scheme on 30/12/13.

**PAU-Ludhiana**

| S.N | Name | Date of visit |
|---|---|---|
| 1. | Pakistan delegation from University of Faisalabad, Pakistan | November 30, 2012 |
| 2. | B. Sc Agri students from the Baba Farid College, Bathinda | March 30, 2013 |
| 3 | Dr. Dr. T. Venkatesan, P.S Entomology, NBAII | Sept. 29-30 2013 |

**OUAT, Bhubaneswar**

1. Dr.Prashant Mohanraj, Principal Scientist, NBAII, Bangalore visited on 19-21 November 2013
2. Dr. Abraham Verghese, Director, NBAII, Bangalore visited on 3-4 Dec. 2013

**TNAU –Coimbatore**

1. At regular intervals, students are hosted to the Laboratory from all over the country in partial fulfillment of their curricular aspects regarding biological control.
2. Dr. T.P. Rajendran, ADG (PP), ICAR, New Delhi visited Biocontrol Laboratory of the Dept. on 20.06.2013 and the activities were highlighted.
3. Dr.N.K.Krishnakumar, DDG (Horti.), ICAR, New Delhi visited on 22.01.2014 to inaugurate of national symposium on “Emerging Trends in Eco-friendly IPM” on January 22, 2014.
4. Dr.Abraham Verghese, Director, NBAII, Bengaluru visited Biocontrol Laboratory, Biosystematics Laboratory, Pheromone Lab. And Toxicology Laboratory of the Dept. on 24.01.2014 and the activities were highlighted. He presented a lead paper in national symposium on “Emerging Trends in Eco-friendly IPM” conducted during January 22-24, 2014.
5. Dr. J. Poorani, Pricipal Scientist, NBAII, Bangalore visited the department on 22.01.2014 and presented a lead paper in national symposium on “Emerging Trends in Eco-friendly IPM”
6. Dr.S.Chelliah, Former Director,TRRI and Director of Research,TNAU visited on 27.1.2014 to deliver motivation lecture to staff and students.
7. Dr.S.Sithanantham, Director, SABRC visited the department at frequent intervals to discuss with collaborative projects in biological control.
8. Dr. Stephen Samuel, Entomologist, Regional Coffee Research Station, Thandigudi visited the department on 3.3.2014.

## 4.3. Miscellaneous Information

### i. Awards/ Honours /Recognition:

**NBAII**

**Team Award** (S.K. Jalali, T. Venkatesan, R. Rangeshwaran, S. Sriram, K. Srinivasamurthy, G. Sivakumar & Abraham Verghese) in Recognition of Development and Adoption of Stress Tolerant Natural Enemeies" Technologies under NAIP-ICAR at Field Day at KVK, Dharmapuri, TamilNadu on 22nd Feb. 2014 by Society for Biocontrol, Bangalore

**Deepa Bhagat-Recipient of 'Fellow of CHAI** on 28.05.2013' awarded by Confederation of Horticulture Associations of India, New Delhi– 110078, India

**Best Paper Awards**

1. Ballal, C. R. Joshi, S., Bhaskaran, T. V. and Lakshmi, L. (2013) Production protocols for indigenous ichneumonid parasitoids *Campoletis chlorideae* Uchida and *Eriborus argenteopilosus* (Cameron). presented during the IOBC *MRQA 13^th^ workshop on "Emerging Opportunities for the Mass Production and Quality Assurance of Invertebrates"*, Bangalore, India, 6-8 November, 2013.
2. Deepa bhagat Best paper presentation at the International conference on water quality and management for climate resilient agriculture 28$^{th}$ - 31$^{st}$ May, 2013 at Jain Irrigation, Jalgaon, Maharastra for the paper entitled "Release pattern of an infochemical, linalool under simulated climate change scenario" Deepa Bhagat., N, Bakthavatsalam., R. Srinivasa.
3. Hemalatha, B.N, T. Venkatesan, S.K. Jalali, B. Reetha and Abraham Verghese; Endosymbiotic yeast, a dietary source for improved production of *Chrysoperla zastrowi sillemi*. 35-36 pp. 2013. 13th Workshop of the IOBC Global Working Group on Mass Rearing and Quality Assurance, Mövenpick Hotel & Spa, Bangalore, India November 6–8,2013.
4. Joshi, S., Ballal, C. R. And Lakshmi, B. L. (2013) Development of a novel mass production technique for *Brumoides suturalis* (Fabricius) (Coleoptera: Coccinellidae), a predator of mealybugs. Presented during the IOBC *MRQA 13$^{th}$ workshop on "Emerging Opportunities for the Mass Production and Quality Assurance of Invertebrates"*, Bangalore, India, 6-8 November, 2013.
5. Lalitha, Y., Ballal, C. R. and Patel, V. N. (2013) Quality assessment of mass reared *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) based on field performance. Presented during the IOBC *MRQA 13$^{th}$ workshop on "Emerging Opportunities for the Mass Production and Quality Assurance of Invertebrates"*, Bangalore, India, 6-8 November, 2013.
6. Ramya, S.L., Venkatesan, T., Jalali, S.K. Srinivasa Murthy, K. 2014. Biochemical mechanism of insecticide resistance in field populations of diamondback moth, *Plutella xylostella*. In 2$^{nd}$ International Conference on Agricultural and Horticultural Sciences, at Hyderabad during 03-05 November 2014
7. Venkatesan, T., S. Mahiba Helen, S.K. Jalali, K. Srinivasa Murthy and Y. Lalitha. 2013. Rearing and evaluation of pesticide tolerant populations of *Chrysoperla zastrwi sillemi*. Pp. 57-58. 13th Workshop of the IOBC Global Working Group on Mass Rearing and Quality Assurance, Mövenpick Hotel & Spa, Bangalore, India November 6–8, 2013.

**IIHR-Bangalore**

**Best paper awards (oral presentation )**

1. Ganga Visalakshy.PN. Darshana C N, Swathi .C and Krishnamoorthy.A. 2013.Efficacy of formulations of *Metarhizium anisopliae* for the control of mango inflorescence hopper presented presented *in* Emerging Trends in Eco-friendly Pest Management, Centre for Plant Protection Studies Tamil Nadu Agricultural University,Coimbatore – 641 003, held from . Jan.22-24, 2014 .
2. Gaga Visalakshy.PN. Swathi .C and Darshana C N, 2013. Eco- friendly management of tea mosquito bug *Helopeltis antonii* on horticultural crops – possible alternatives *in* International Conference on Plant Biochemistry, Biotechnology on Food and

Nutritional Security and XII Convention of Indian Society of Agriculture Biochemists (Dec 11-14, 2013). Sri Venkateswara University, Tirupati.

**MPKV-Pune**

1. Dr. R. V. Nakat, Entomologist received the award " Krishi Gourav Puraskar" of Bharat Krishik Samaj , Maharashtra at Jalgaon, on 18/01/2013. .

**ii. Education and Training**

**AAU-Anand**

**P.G. Teaching**

The Scientists working under the AICRP on Biological Control are also engaged in Post Graduate teaching and as well as acting as guide. Following courses are taught to the P.G. students.

| Sr. No. | Name of Teacher | Course No. | Credits | PG Students | |
|---|---|---|---|---|---|
| | | | | M. Sc. | Ph. D. |
| 1 | Dr. D.M. Mehta | ENT-507 | 1+1 | 0 | 1 |
| | | ENT-514 | 1+1 | | |
| | | ENT-602 | 1+1 | | |
| | | ENT-612 | 2+0 | | |
| 2 | Prof. Mrs. H N Shelat | **UG** Ag.Micro 8.2 | 1+3 | 6 | 0 |
| | | **PG** Ag.Micro 502 | 3+1 | | |
| | | Ag. Micro 511 | 1+1 | | |
| | | Ag. Micro 508 | 2+1 | | |
| | | Ag. Micro 512 | 2+0 | | |
| | | Ag. Micro 506 | 2+1 | | |
| | | Ag. Micro 504 | 2+1 | | |
| | | Ag. Micro 602 | 2+0 | | |
| | | Ag. Micro 603 | 2+0 | | |
| | | Ag. Micro 604 | 2+0 | | |
| | | Ag. Micro 501 | 2+1 | | |
| | | Ag. Micro 505 | 2+1 | | |
| | | Ag. Micro 591 | 1+0 | | |
| | | Ag. Micro 599 research | 20 | | |
| 3 | Dr.P.H.Godhani | SST 511 | 1 + 1 | 1 | |

**<u>Extension Services and activities</u>**

**1.** Technical guidance on "Biological control" was provided to the farmers, extension officers, students and other visitors visited Biocontrol Research Laboratory.

**Number of visitors visited the BCRL Anand during the year**

| Sr. no | visitors | Total |
|---|---|---|
| 1 | VIPs | 3 |
| 2 | Govt. officers | 10 |
| 3 | Farmer | 527 |
| 4 | Student | 231 |
| | **Total** | **771** |

- Technical guidance regarding Biological Control of crop pests was provided through lectures to the extension officers and farmers in various training programs organized by Directorate of Extension Education, AAU, Anand, State Department of Agriculture, Govt. of Gujarat and NGOs.
- Participated and arranged exhibition during Krushi mela, farmer's meeting and other special occasions as per the directives received from Directorate of Extension Education, AAU, Anand and Extension education Institute.

**Extension activities:**

**Following talks were delivered to farmers /extension workers by Dr. D. M. Mehta in training programmes organized by various agencies.**

| Sr. no | Date | Topic | Trainee | Training organized by |
|---|---|---|---|---|
| **1** | 17-10-2013 | Biological control of crop pests and visit of Biological Research Laboratory | Farmers | Dept. of Entomology, BACA, Anand |
| 2 | 29-11-2013 | ,, | Farmers | Dept. of Entomology, BACA, Anand |
| 3 | 2-12-2013 | Biological control of crop pests | Students of BRS college | Dept. of Horticulture, BACA, Anand |
| 4 | 10-12-2013 | Biological control of crop pests and visit of Biological Research Laboratory | Farmers | Dept. of Entomology, BACA, Anand |
| 5 | 24-12-213 | ,, | Farmers | Dept. of Entomology, BACA, Anand |
| 6 | 2-1-2014 | Role of Bio-control agents in IPM & Exposure visit to bio-control lab, BACA, Anand | Officers of line depts../scientists of SAUs, ICAR Institutes/SAMETI/ATMA/NGOs | Extension Education institute, Anand |
| **7** | 30-1-2014 | Biological control of crop pests | Students of BRS college | Dept. of Agronomy, BACA, Anand |

**Following talks were delivered to farmers /extension workers by Dr. P. H. Godhani in training programmes organized by various agencies.**

| S.N | Date | Topic | Trainee |
|---|---|---|---|
| 1 | 12-1-2014 | Biological control of crop pests and visit of Biological Research Laboratory | Farmers |
| 2 | 13-2-2014 | ,, | Farmers |
| 3 | 18-1-2014 | ,, | Farmers |
| 4 | 29-1-2014 | ,, | Farmers |

**Details of Khedut Shibirs arranged during 2013-14**

| Sr. no | Date | Village & Taluka | No. of farmers attended |
|---|---|---|---|
| 1 | 18/1/14 | Runaj<br>Ta. Sojitra | 61 |

**AAU-Jorhat**

**Teaching**

1. Dr.D.K.Saikia, principal Scientist conducted advance course of Biological Control (ENT 507), Classification of Insects (ENT 504) to P.G.Studies
2. One M.Sc (Agri) student is being carried out P.G. research work under the guidance of Dr. D.K.Saikia,
3. Dr. D.K.Saikia is guiding two Ph.d student and title of the programme are 'Evaluation of local varieties of Assam against yellow stem borer ( *Scirpophaga incertulas*) and leaf folder (*Cnaphalocrosis medinalis*) and ecology of their trichogrammatid egg parasitoids' and 'Population dynamics of Sugarcane plassy borer, *Chilo tumidicostalis* (Lapidoptera: Pyralidae) Dr. D.K.Saikia , Principal Scientist act as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide, 'Insect Ecology and Toxicology ) offered to B.Sc. (Agri) students
4. Dr. D.K.Saikia , Principal Scientist impart coaching to UG students for JRF examination
5. Dr. D.K.Saikia , Principal Scientist act as external question setter for the UG course 'Insect Ecology &Principles of pest management' (ENT-202), Nagaland University, Medziphema, Nagaland
6. Dr. D.K.Saikia , Principal Scientist act as a Lead Scientist in Technology Mission (MM1) for IPM on Vegetables
7. Dr. D.K.Saikia act as a Co- investigator in the Biopesticides programme under DBT –AAU, Centre
8. Dr.D.K.Saikia attended XXII Biological worker's group meeting held at NBAII, Bangalore on $24^{th}$ and $25^{th}$ May, 2013.
9. Dr. Anjumoni Devee, Jr. scientist, act as a course instructor in different UG courses like Insect Morphology and Taxonomy (Ent213) , Ecology and Integrated pest Management and beneficial Insects (Ent 223), Pests of crops, stored grain and their management (Ent 313), and PG courses like Classification of Insects (Ent 504), Insecticides Toxicology (Ent 508), Commercial Entomology (Ent 519), Advance Insecticides Toxicology (Ent 607) and Advance IPM (Ent 612).
10. Dr. Anjumoni Devee, Jr. scientist, act as a course instructor for Experiential learning programme (Apiculture and Pesticides and plant protection equipments) offered to B.Sc. (Agri) students
11. Under the guidance of Dr. Anjumoni Devee, three M.Sc (Agri) student is being carried out P.G. research work
12. Dr. Anjumoni Devee, Jr. scientist act as external question setter for the UG course 'Pest of Horticultural crops and their management' (ENT-302), Nagaland University, Medziphema, Nagaland
13. Dr. Anjumoni Devee, Jr. scientis, attended XXII Biological worker's group meeting held at NBAII, Bangalore on $24^{th}$ and $25^{th}$ May, 2012.

14. Dr. Anjumoni Devee, Jr. scientist act as a resource person on " On line learning and teaching" Courses organized by ARIS cell, AAU Jorhat for Teachers and Scientists of B.N. College of Agriculture, Biswanath Chariali, AAU, on 12th -14th May, 2013
15. Dr. Anjumoni Devee, Jr. scientist impart coaching to UG students for JRF examination

**Training obtained**

1. Dr. Anjumoni Devee, Jr. scientist, obtained Training on 'Teaching Excellence" organized by Teaching Excellence Unit, AAU, Jorhat under AIP, from 29th to 30th Oct. 2013

**Training Imparted**

1. **Training on IPM with special reference to use of bioagent/ biopesticides in vegetables(*Kharif* & *Rabi*) rice and sugarcane**

| Programme | Place | Resource person | Date | Trainee |
|---|---|---|---|---|
| Integrated pests and diseases management of Oil seeds crop | Conference Hall, Dhansiri Hostel, AAU, Jorhat | Dr.D.K.Saikia | 19.6.2013 | Farmers, Kamrup district |
| Famers Scientist Interaction | Krishak Samaroh, Golaghat Govt. H.S.School | Dr. D.K.Saikia | 28.08.2013 & 29.08.2013 | Farmers. Golaghat,Sivsagar and Jorhat District |
| Role of Biopesticides and bio agents in Horticultural crops | Biological Control Laboratory, AAU, Jorhat | Dr. D.K.Saikia | 15.10.2013 | Students, Kokrajar Govt. College |
| Farmers Scientist Interaction | Farmers Day,Rice Research Station, Titabar, AAU, Jorhat | Dr.D.K.Saikia | 6.11.13 | Farmers, Golaghat and Jorhat district |
| Integrated pests and diseases management of Vegetables | Conference Hall ,Director of Extension Education, AAU,Jorhat | Dr.D.K.Saikia | 11.11.13 | Farmers, Sivsagar district, . |
| IPM of Sugarcane pests | Sugarcane Research Station, Buralikson, AAU, Jorhat | Dr. D.K.Saikia | 21.11.13 | Farmers, Golaghat district |
| Calculation and preparation of spray chemicals & IPM in Horticultural Crops | Conference Hall, Directorate of Extension Education, AAU, Jorhat | Dr.D.K.Saikia | 08.03.2014 | SMS, KVK, AAU, Jorhat |
| Role of beneficial insects, microbs and other fauna in balance agro ecosystem | Assam Graamin Bikash Bank, Bhogdoi Bhawan, Jorhat | Dr.D.K.Saikia | 14.3.2014 | Farmers , Majuli, Jorhat district |
| Common insect pests and diseases of the | Assam gramin Bikash Bank, | Dr. D.K.Saikia | 15.03.2014 | Farmers, Majuli, Jorhat |

| | | | | |
|---|---|---|---|---|
| major crops (Vegetables,Rice and Sugarcane) | Bhogdoi Bhawan, Jorhat | | | district |
| Production of organic vegetables | Allengmara L.P. school | Dr. A. Devee | 22.06.2013 | Farmers, Allengmara, Jorhat |
| Insect pest management in organic vegetables | Betbari M.E. School | Dr. A. Devee | 08.07.2013 | Farmers, Betbari, Sivsagar |

**Television/ Radio Programme**

1. Dr.D.K.Saikia attended three nos. of Phone in programme on Role of Bio agent against various insect pests of vegetables broadcasted by All India Radio, Dibrugarh, on 10.08.2013, 21.10.2013 and 15.11.2013.

**ANGRAU-Hyderabad**

**Education:** B.Sc. (Ag.), M.Sc.(Ag.) and Ph.D. students of College of Agriculture, Rajendranagar, Hyderabad were trained different methodologies in rearing of different natural enemies and culturing & field use of microbial formulations.

**CPCRI-Kayangulam**

**Trainings conducted for Farmers /students / NGOs:**

1. On campus training was imparted to 30 Agricultural officers from Alappuzha district sponsored by Kerala Centre for Pest management, Moncompu on 'Integrated pest and disease management in coconut' on 20-06-2013.
2. Training session on the "Field delivery of Green muscardine fungus, *Metarhizium anisopliae* for the biological suppression of rhinoceros beetle" to a coconut farmer's group (CPS) at Bharanikava, Kattanam on 26-07-2013.
3. On campus hands on training imparted on the 'Mass production of *M. anisopliae* with emphasis on the farm-level production technologies and field delivery mechanisms' to a group of 50 farmers from Cherthala particularly farm womenon 17-02-2014

**TOT programmes for Agricultural Officers and farmers by Chandrika Mohan, Principal Scientist (Agrl. Entomology):**

1. Functioned as resource person in the Farmers seminar and awareness campaign on 'Biological suppression of coconut black headed caterpillar' sponsored by Dept. of Agriculture, Kerala at Paruthikkuzhi, Trivandrum on 20 April 2013.
2. Handled a class on 'Biocontrol of pests of coconut' in farmers seminar at Devikulangara Krishi Bhavan on 13/8/2013
3. As resource person handled session on 'Pest and Disease management in coconut' for Agricultural assistants training programme at RATTC, Kazhakkoottam on 25/9/2013.
4. Functioned as resource person for the ATMA 2013-14 sponsored farmers seminar on "Pest management in coconut" held at Kanjikuzhi Krishi Bhavan held on 17/12/2013.

5. Functioned as resource person and handled class on ‘Biocontrol for pest management to members of Green land farmers club, Thumpamon, Idukki district as a part of exposure visit to CPCRI, Kayamkulam on 22/2/2014.

**GBPUAT-Panthnagar**

**Farmers’ training programme:** Time to time demonstration and training programmes were conducted at farmer’s field as well as on university campus. A total of 770 farmers were trained by conducting 9 trainings on various crops viz. wheat, rice, tomato, pulses and vegetables for successful application of biocontrol technologies under organic farming/IDM. During large scale field demonstrations 7 quintals of bioagent (PBAT-3) was distributed among the farmers.

**KAU-Thrissur**

| S.N | Date of training | Venue | Beneficiaries |
|---|---|---|---|
| | 17/08/13 | Thrissur Corporation | Farmers |
| 2 | 22/10/13 | Eriyad Krishi Bhavan | Farmers –ATMA plus |
| 3 | 22/11/13 | Koorkkenchery KB | Students of Polyclinic in connection with school garden under ATMA |
| 4 | 12/12/13 | Vandazhy KB | Farmers’ field school |
| 5 | 01/01/14 | Cherpu KB | Farmers’ field school |
| 6 | 25/01/14 | Kattur KB | Farmer’s field school |
| 7 | 05/02/14 | Vallachira KB | ATMA- FFS |
| 8 | 02/14 | Koorkkenchery KB | ATMA farmers |
| 9 | 13/03/14 | ARS, Mannuthy | Trainees of Agrl. Research station |

**MPKV-Pune**

**i) Trainings**

1. Dr. R. V. Nakat conducted Semester End Theory Examination and worked as Senior Supervisor at Saikripa College of Agriculture, Ghargaon, Tal: Srigonda, Dist: Ahmednagar from 15/04/2013 to 26/04/2013.
2. D. S. Pokharkar, Entomologist of the project worked as SMS of the RAWE programme and attended Orientation Programme on 06/06/2013.
3. R.V. Nakat, Entomologist, attended the qualifying *Viva-voce* examination of Ph. D. student, Department of Entomology, MPKV, Rahuri on 12/09/2013.
4. Dr. S.M. Galande, Asstt. Entomologist, evaluated the answerbooks of Semester End Theory exam of M.Sc. (Agri.) Course No. ENT-512, Pest of Horticultural and Plantation Crops from 15-18 September, 2013.
5. Dr. S.M. Galande, Asstt. Entomologist, conducted the theory classes of Course No. ENTO 353, Crop Pests and Stored Grain Pests and their Management.

6. Dr. S.M. Galande and Shri. A. S. Dhane organized and also attended the Training Programme on Cyzypyr Pesticide Technology Transfer for Crop Management on 25.09.2013 at College of Agriculture, Pune.
7. . R.V. Nakat, Entomologist, attended the qualifying examination of Ph. D. students, Department of Entomology, MPKV, Rahuri on 14/10/2013.
8. Dr. S.M. Galande, Asstt. Entomologist conducted the Semester End Practical Examination of Course No. ENTO 353 and ENTO 242 at College of Agriculture, Wadala Dist . Solapur on 18$^{th}$ and 19$^{th}$ October, 2013.
9. R.V. Nakat, Entomologist, conducted the Semester End Theory Examination of III and V semester for the Academic year 2013-14 and worked as Sr. Supervisor at College of Agriculture Business Management, Narayangaon, Tal. Junnar Dist. Pune during 21$^{st}$ and 31$^{st}$ October, 2013.
10. Dr. S.M. Galande, Asstt. Entomologist, conducted the Semester End Theory Examination of III and V semester for the Academic year 2013-14 and worked as Jr. Supervisor at College of Agriculture, Akluj Dist. Solapur during 26$^{th}$ and 29$^{th}$ Oct., 2013.
11. Dr. R. V. Nakat, worked as Senior Supervisor for conducting the Semester End Theory Examination at College of Agriculture Business Management, Narayangaon from 11-23 November, 2013.
12. Dr. S.M. Galande, Asstt. Entomologist, evaluated the Semester End Theory Examination papers of Course No. ENTO 353 at College of Agriculture, Pune during 16-27 November, 2013.
13. Dr. S. M. Galande and staff of AICRP on Biocontrol conducted Experiential Learning Programme on mass production of bioagents and Biopesticides of final year VIII Sem. B.Sc (Agri.) students.
14. Shri. A. S. Dhane has conducted lectures for students of final year B.Sc (Agri.) Experiential Learning Programme allotted to Agricultural Biotechnology.
15. Dr. R.V. Nakat, Dr. S.M. Galande and Shri. A. S. Dhane attended the 71$^{st}$ Board of studies meeting held at Entomology Section, College of Agriculture, Pune on 27.01.2014.
16. Shri. A. S. Dhane worked as Course Assistant for two day training programme on “Structural Pest Management Level 1” jointly organized by Mahatma Phule Krishi Vidyapeeth, Rahuri and Pest Management Association, India during 22-23February, 2014.
17. Shri . S.M Galande along with 21 students of experiential lerning programme on mass production of bioagents and Biopesticides of final year VIII Sem. B.Sc (Agri.) Programme on mass production of bioagents and Biopesticides of final year VIII Sem. B.Sc (Agri.) students at NBAII, Bangalore and CSRTI, Mysore during 12-19 march, 2014.

**ii) Extension development activities / Training Imparted: (MPKV, Pune)**

1. Dr. R.V. Nakat delivered talk on Biological Management of Sugarcane White Grub to the trainee of Govt. of Maharashtra Officers (70 Nos.) at College of Agriculture, Kolhapur on 20/06/2013 and live specimens of bioagents and samples of Biopesticides were kept in exhibition.
2. Dr. D. S. Pokharkar Entomologist of the project delivered lecture on Biological control of mealy bugs in Grapevine to trainee (26) at MRDBS, Manjari, Pune on 23/06/2013.
3. Dr. R.V. Nakat Entomologist of the project delivered the talk on Use of Biopesticides in Polyhouse to the 30 trainees of Hi-Tech Floriculture, College of Agriculture, Pune on 07/09/2013.

4. Dr. R.V. Nakat delivered lecture on Destructive Insect pest Act: Domestic Quarantine to 70 officer trainees of Department of Agriculture and Horticulture, Govt. of Maharashtra at National Horticulture Training Centre, Talegaon on 10/09/2013.
5. Dr. R.V. Nakat, Entomologist of the project gave 3 days practical training on "Mass production of Bioagents and Biopesticides" to the scientists of Regional Fruit Research Station, Vengurla under Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli from 16-18 September, 2013.
6. Dr. S.M. Galande, Asstt. Entomologist, delivered the talk on "Mass production of Bio agents and Bio pesticides to the 50 trainees of Hi Tech Project on 24th October, 2013.
7. Shri. A. S. Dhane, JRA of the project delivered a lecture on Biological control of pests on different crops to 50 participants of Farmer's Study Tour organized by Taluka Agriculture Officer, Dhule on 12/11/2013.
8. The live specimens of bioagents were kept in National level farmers exhibition, "Agrowon Agri Expo – 2013", at College of Agriculture Ground, Pune during 22-27, November, 2013.
9. Dr. S.M. Galande, Asstt. Entomologist of the project delivered a lecture on Biological control of pests on different crops to 55 women trainees from Farmers Training Centre, Anand (Gujrat) on 29/11/2013.
10. The live specimens of bioagents were kept in National level farmers exhibition, "KISAN – 2013", at HAL, Pimpri, Pune during 11-17, December, 2013.
11. Shri. A. S. Dhane, JRA of the project delivered a lecture on Biological control of pests on different crops to 30 B.Sc. final year students of Modern College, Shivajinagar on 06/12/2013.
12. Dr. R.V. Nakat delivered lecture on Domestic Quarantine to 40 officer trainees of Department of Agriculture and Horticulture, Govt. of Maharashtra National Horticulture 13 Training Centre, Talegaon on 24/02/2014.

**Radio Talk: (MPKV, Pune)**

13. Dr. S. M. Galande delivered the talk on IPM of Guava Fruit Fly on AIR, Pune on 15/08/2013.
14. Dr. S. M. Galande delivered the talk on IPM of Gram Pod Borer on AIR, Pune on 24/10/2013.

**TV Programme (MPKV, Pune)**

1. Dr. R. V. Nakat, Entomologist recorded the T.V. Programme on Management of Pest of Kharif crop using Bioagent and Biopesticides under the programme Sheti Mazi Fayadyachi on Doordarshan, Mumbai on 25/06/2013.

## PAU-Ludhiana

**Post/under graduate teaching:**

| **Teacher** | **No. of courses taught** | |
|---|---|---|
| | **PG** | **UG** |
| Dr Jaspal Singh Virk | 2 | - |
| Dr Neelam Joshi | 3 | 3 |
| Dr Naveen Aggarwal | 1 | 2 |
| Dr Rabinder Kaur | - | 2 |
| | **No. of PG Students Guiding/Guided** | |
| | **Ph. D.** | **M.Sc.** |
| Dr Neelam Joshi | - | 3+1 |
| Dr Naveen Aggarwal | 1 | 1 |
| Dr Rabinder Kaur | - | 1+2 |

**Lectures and Training**

| Title of Lectures | Event, Date and Venue |
|---|---|
| **Dr Jaspal Singh Virk** | |
| 1. Introduction to biological control agents<br>2. Introduction to *Trichogramma* and mass production of *Trichogramma* for its use in biological control programs | 1. "Hands-on Training Programme on Mass Culturing of Biological Control Agents" to the scientists and lab staff of biocontrol laboratories under NHM of Punjab and officers from Sugar mill Dhuri on September 23-24, 2013 at Department of Entomology, PAU Ludhiana<br>2. Training Programme on "Mass Production of Natural Enemies" to agricultural Development Officers, Mansa on 20-21st February, 2014 at Department of Entomology, PAU Ludhiana |
| **Dr Neelam Joshi** | |
| Introduction to laboratory equipments for the mass production of pathogens of insect pests.<br>1.Pathogens of insect pests and their mass multiplication for their use in biological control programs<br>2.Introduction to insect pathogens and mass multiplication of mycopathogens.<br>3.Practical demonstration of laboratory equipment used for mass production of entomopathogens | 1.Hands-on Training Programme on Mass Culturing of Biological Control Agents" to the scientists and lab staff of biocontrol laboratories under NHM of Punjab and officers from Sugar mill Dhuri on September 23-24, 2013 at Department of Entomology, PAU Ludhiana.<br>2.Training Programme on "Mass Production of Natural Enemies" to agricultural Development Officers, Mansa on 20-21st February, 2014 at Department of Entomology, PAU Ludhiana |
| **Dr Naveen Aggarwal** | |
| 1. Introduction to *Zygogramma* and mass production of *Zygogramma* for its use in biological control programs.<br>2. Practical demonstration of rearing of *Zygogramma* in the laboratory | 1.Field day on "Management of Carrot Weed through Biocontrol Agent in Punjab" on 1st August, 2013 at village Nanoki, Nabha (Patiala).<br>2. Training programme on "Management of Carrot Weed through Biocontrol Agent in Punjab" on 2nd August, 2013 at Department of Entomology, PAU Ludhiana.<br>3.Training Programme on "Mass Production of Natural Enemies" to agricultural Development Officers, Mansa on 20-21st February, 2014 at Department of Entomology, PAU Ludhiana |
| **Dr Rabinder Kaur** | |
| 1. An Introduction to biocontrol agents of congress grass and its mass production.<br>2. Introduction to methods of mass production of egg parasitoid *Trichogramma* and its host insect.<br>3. Practical demonstration of rearing of egg parasitoid *Trichogramma* and its host insect in the laboratory.<br>4. Introduction to coccinellids | 1. Field day on "Management of Carrot Weed through Biocontrol Agent in Punjab" on 1st August, 2013 at village Nanoki, Nabha (Patiala).<br>2. Training programme on "Management of Carrot Weed through Biocontrol Agent in Punjab" on 2nd August, 2013 at Department of Entomology, PAU Ludhiana.<br>3. Hands-on Training Programme on Mass Culturing of Biological Control Agents" to the scientists and lab staff of biocontrol laboratories under NHM of Punjab and officers from Sugar |

| | |
|---|---|
| predators and mass production of coccinellids for its use in biological control programs | mill Dhuri on September 23-24, 2013 at Department of Entomology, PAU Ludhiana.<br>4. Training Programme on "Mass Production of Natural Enemies" to agricultural Development Officers, Mansa on 20-21st February, 2014 at Department of Entomology, PAU Ludhiana |

The biocontrol group at PAU has organized training camps and field day related to biocontrol agents. The detail of these events as below:

1. An awareness programme on "Management of carrot weed through biocontrol agent in Punjab" on 1st August 2013 at village Nanoki, Nabha (Patiala) in collaboration with Punjab State Council of Science and Technology Chandigarh.
2. In continuation of the above programme, one day training programme on "Management of Carrot Weed through Biocontrol Agent in Punjab" in Department of Entomology, PAU, Ludhiana on 2nd August, 2013 for the entomologists of Farmers' Advisory Services (FASS) of Amritsar, Gurdaspur, Jalandhar and Patiala.
3. **"**Hands-on Training Programme on Mass Culturing of Biological Control Agents" was organized on September 23-24, 2013 for the scientists and supporting staff of biocontrol laboratories (NHM) from Abohar, Bathinda, Dhuri, Gurdaspur and Ludhiana.
4. Training Programme on "Mass Production of Natural Enemies" on 20-21st February, 2014 for the Agricultural Development Officers, Dhuri.

**SKUAST-Kashmir,**

### Trainings imparted

1. Acted as instructor in "Biological control of Crop Pests and weeds".
2. Demonstrated on spot use of apple burlapping, for trapping and killing of overwintering codling moth, at Bagh-e Khomini, Hardass and Chanigund of district Kargil during July 2013.
3. Demonstrated on spot use and benefits of pheromone traps for mass destruction of codling moth, at Kargil (Kharrol, Chanigund, Mangmore) and Leh (Khalsi) during July 2013.
4. Imparted information to orchardists regarding disposal of codling moth infested fruits to reduce codling moth population in above mentioned orchards during July 2013.

### Organization of Review Meeting

1. Successfully organized Review Meeting of "State Specific Technology Project (SSTP)" Department of Science and Technology (DST)" held at SKUAST-Kashmir on 29th August, 2013 in the capacity of Chairman.
2. Successfully organized Review Meeting on "National Science and Technology Information Management System" of Department of Science and Technology (DST) held at SKUAST-Kashmir on 27th to 28th February 2014 in the capacity of Organizing Secretary and got appreciations form DST.

**TNAU-Coimbatore**

**Trainings imparted**

Regular hands on trainings were offered for extension functionaries, farmers and entrepreneurs on biocontrol aspects.

**Training imparted during the year**

| Sl.No | Date | Title of the Training | Beneficiary / Participants |
|---|---|---|---|
| 1 | 24 &25.9.2013 | Dr.P.Karuppuchamy, Professor attended the Group meeting of ICAR- medicinal and aromatic plants and acted as Chairman of Plant Protection session | Scientists of the workshop |
| 2 | 16.11.2013 | Mass production, use, release and evaluation of biocontrol agents. | Scientists from all over the country. |
| 3 | 20.12.2013 | Identification of phytophagous and predatory mites and management of phytophagous mites | Extension officials, Dept of Agriculture at AC & RI, Trichy |
| 4 | 31.1.2014 | Identification of phytophagous and predatory mites and management of phytophagous mites | Extension officials, Dept of Agriculture at AC &RI, Madurai |
| 6 | 10.3.2014 | Biological control of sugarcane pests | Extension officials, Dept of Agriculture |
| 7 | 03-02-2014 | Integrated Pest Management of Floriculture pests | Farmers of Sathyamangalam |
| 8 | 07-02-2014 | Tea mosquito bug and its natural enemies | Tea officials at Valparai |
| 9 | 14-02-2014 | Insect pest Management in cut flowers | Farmers at Ooty. |

**Recommendations passed onto farmers through crop production guide, impact of technologies among farmers and other stakeholders**

1) Biological control of papaya mealy bug by release of parasitoid *Acerophagus papaya*e is included in the crop production guide 2012 for the management of *Paracoccus marginatus.*

   **Technology developed- Mass multiplication and release of parasitoid *Acerophagus papaya***

   Mass multiplication technology was standardized in the Biocontrol Laboratory, Department of Agrl. Entomology, TNAU, Coimbatore for large scale laboratory production of parasitoid involving host insect culture, parasitoid production techniques, storage, transportation, adult diet requirement and method of release. Mass multiplication of mealybug parasitoids was immediately taken up in TNAU from Agricultural and Horticultural colleges, 36 research stations and 14 Krishi Vigyan Kendras on a war footing manner and the effective parasitoid *viz., Acerophagus papayae* was released throughout Tamil Nadu. About 50,00,000 parasitoids were mass multiplied within a period of 2 years and released in farmers field @ 100 parasitoids / field / village or block in more than 1000 locations **at free of cost.**

**Outcome:** Results indicated that parasitoid *A. papayae* was very effective in reducing more than 95% of mealybug population in almost all fields compared to unreleased field. Recovery studies of the parasitoids from the released sites showed that the parasitoids were working very well by producing their progenies with good searching capacity.

**Impact**: The parasitoids were also recovered from the neighbouring villages of the released sites. Moreover, the parasitoids are not allowing the mealybugs to cause economic damage as they keep the pest population under check. After the introduction of parasitoids, spectacular success was achieved in the control of papaya mealybug in Tamil Nadu on papaya, tapioca, mulberry, cotton, teak, jatropa and many other host crops. Due to release of the parasitoid, besides saving a loss of Rs 435 crores on papaya, mulberry and tapioca, an amount of Rs 244.5 crores was benefited annually by not recommending chemical pesticides. Hence, it is concluded that the release of *A.papayae* can be employed as a successful candidate for the management of papaya mealy bug.

2) Release *Trichogramma pretiosum* for the management of tomato fruit borer is included in the crop production guide 2013.
3) Similarly the use of other biocontrol agents based on AICRP field trials and large scale field demonstrations were also included in the crop production guide.

**YSPUHF- Solan**

**Lectures delivered in various trainings/Workshops:**

**UG/PG courses taught during the Year 2013-2014**:
ENT 507 : Biological control of crop pests and weeds
ENT606 : Recent trends in biological control
ENT602 : Immature stages of insects
ENT 604: Advanced Insect Ecology
ENT 609: Advanced Host Plant Resistance

| S. No | Title of Lecture | Training | Date | Delivered by |
|---|---|---|---|---|
| 1 | Insect pests of flower crops and their management | Referesher training course on IPMand Biocontrol for the Horticulture Extension Officer of HP sponsored by Deptt of Horticulture HP | 6/11/2013 | Dr Usha Chauhan |
| 2. | Biocontrol Agents and their use | Training for the extension officers of HP on " IPM and Bio- control" organized at SAMETIw.e.f.16$^{th}$-18$^{th}$ April,2013 | 17/04/2013 | Dr Usha Chauhan |
| 3 | Bio-Control and Conservation of useful insects | ---do---- | 17/04/2013 | Dr Usha Chauhan |
| 4. | Application of bio-contriol in Organic Farmingv | Refresher Training Course for Analysts( Agriculture Development Officers and SMS's) from Dept of | 19/06/2013 | Dr Usha Chauhan |

| | | | | |
|---|---|---|---|---|
| | | Agriculture,HP at Sameti ,Mashobra,Shimla, organized by the Regional Centre for Organic Farming,Hisar(Haryana)w.e.f.1 1-20 June,2013. | | |
| 5 | Insect pest management in vegetable crops | Training pragramme for farmers organized by Directorate of Extension education | 6-7-2013 | PL sharma |
| 6 | Insect pest management in vegetable crops | Training pragramme for farmers organized by Directorate of Extension Education | 15-7-2013 | PL sharma |
| 7 | Insect pest management in vegetable crops | Training pragramme for farmers organized by Directorate of Extension education | 16-7-2013 | PL sharma |
| 8 | Insect pest management in vegetable crops | Training pragramme for farmers organized by Directorate of Extension Education | 26-7-2013 | PL sharma |
| 9 | Insect pest management in vegetable crops | Training pragramme for farmers organized by Directorate of Extension Education | 7-8-2013 | PL sharma |
| 10 | Insect pest management in vegetable crops | Training pragramme for farmers organized by Directorate of Extension Education | 23-7-2013 | PL sharma |
| 11 | Insect pests of vegetables and their management | Mahila Gosthi organized by Department of Agriculture, HP | 18-9-2013 | PL Sharma |
| 12 | Insect pest management in vegetable crops | Training pragramme for farmers organized by Directorate of Extension Education | 24-9-2013 | PL sharma |
| 13 | Scope and potential of Biological control | Training pragramme for Horticulture Extension Officers of HP organized by Directorate of Extension Education | 6-11-2013 | PL sharma |

**Demonstration trails laid at different places of three tehsils in District Shimla for the management of apple root borer, *Dorysthenes hugelli Redtenbacher* (Coleoptera: Cerambycidae) during 2013-2014.**

| S.No | Date | Topic of Demonstration | Place of Demonstration | No. of farmers |
|---|---|---|---|---|
| 1 | 18-09-2013 | Management of Apple root borer by the use of Bio-pesticides in field | Village: Chaithla<br>Tehsil : Kotkhai<br>Distt. : Shimla | 5 |
| 2 | 18-09-2013 | ---do------ | Village: Magawta<br>Tehsil : Jubbal<br>Distt. : Shimla | 8 |
| 3 | 19-09-2013 | ----do----- | Village: Manghara<br>Tehsil : Jubbal | 13 |

| | | | | |
|---|---|---|---|---|
| | | | Distt. : Shimla | |
| 4 | 19-09-2013 | ----do----- | Village: Jubbal and Shirthi<br>Tehsil : Jubbal<br>Distt. : Shimla | 12+5=17 |
| 5 | 20-09-213 | ----do----- | Village: Kedi(Piontra)<br>Tehsil : Chopal<br>Distt. : Shimla | 130 farmers and students of Xth ,X1th and X11th class |
| 6 | 28-12-2013 | ----do----- | Village: Tikkri(Nerwa)<br>Tehsil : Chopal<br>Distt. : Shimla | 8 |
| 7 | 13-01-214 | ----do----- | Village: Khaneti<br>Tehsil: Kotkhai<br>Distt. Shimla | 3 |
| | | | Total | 184 |

**TV Talk**: 18-12-2013. Delivered talk on the management of Apple root borer in Live in Programme broadcasted in Parsar Bharti, Doordarshan Kendra Shimla. By Dr JP Sharma (Dean College of Horticulture ) and Dr Usha Chauhan.

**iii. Participation of Scientists in conference, meetings, seminars, workshops, symposia, training extension etc. In India and abroad**

**ANGRAU-Hyderabad**

1. Dr. S.J.Rahman, Principal Scientist & Head participated in International Trade Fair and Directional Programme on Agriculture at HYTEX, Madhapur from 25-28, April, 2013
2. Dr. S.J.Rahman, Principal Scientist & Head participated in REAC Meeting as Special Invitee at Dr. YSR Horticultural University, Venkatramannagudem on 20th December, 2013
3. Dr. S.J.Rahman, Principal Scientist & Head participated in AP Tech 2013 at RARS, Warangal on 6th September, 2013
4. Dr. S.J.Rahman, Principal Scientist & Head participated in Maize Workers Annual Group Meeting and Co – Chaired Entomology Session at Hyderabad on 6th April, 2013.
5. Dr. S.J.Rahman, Principal Scientist & Head participated in GM Awareness Programme and delivered invited lecture at ICRISAT, Hyderabad on 23rd , November, 2013

**CPCRI-Kayangulam**

Dr. Chandrika Mohan attended the following programmes**:**

1. Attended Expert Committee review meeting on coconut root (wilt) disease at CPCRI, Kayamkulam during May 8-10,2013
2. Attended XXII AICRP Biocontrol workers Group Meeting at NBAII, Bangalore 24-25 May 2013
3. Participated in the awareness campaign cum Farmer- Scientist interface programme on health management of coconut with emphasis on drought mitigation was held at Jajur, Arsikere on 10/10/2013 under the leadership of Dr. George V.Thomas, Director, CPCRI.
4. Attended the 13th workshop of the IOBC Global Working Group on mass rearing and quality assurance held at Movenpick Hotel and Spa, Bangalore hosted by NBAII, Bangalore during November 6-8, 2013.

5. Participated as resource person in the Face to Face" programme on "Advances in coconut farming" organized by Prasar Bharati, Doordarshan Kendra, Thiruvananthapuram at CPCRI, Regional Station on 22-01-2014

**IIHR-Bangalore**

Dr. Ganga visalakshy. P N

1. International Conference on Plant Biochemistry, Biotechnology on Food and Nutritional Security and XII Convention of Indian Society of Agriculture Biochemists (Dec 11-14, 2013). Sri Venkateswara University, Tirupati
2. 13$^{th}$ IOBC- MRQA International workshop on Mass Production and Quality Assurance of Invertebrates, Bangalore, India.
3. 10$^{th.}$ Nat. sym. On Soil biology and ecology, GKVK, Bangalore, from 19$^{th}$-21$^{st}$, Dec.,2013
4. Emerging Trends in Eco-friendly Pest Management, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore – 641 003, held from Jan.22-24, 2014.

**KAU-Thrissur**

1. Dr. K. R. Lyla, Professor and Smt. Vidya C.V., Asst. Professor attended XXII Biocontrol Workers Group Meeting held on 24th and 25$^{th}$ May, 2013 at NBAII, Bangalore.
2. Smt. C.V. Vidya, Asst. Professor attended National symposium on Emerging Trends in Eco-friendly Insect Pest Management held on 22$^{nd}$ to 24$^{th}$ January, 2014 at Tamil Nadu Agricultural University, Coimbatore.

**MPKV-Pune**

1. Dr. R. V. Nakat, Entomologist attended the training on Entrepreneurship development programme on microbial bio pesticides organized by Division of Entomology, and Zonal
   Technology Mission, IARI, New Delhi during 19 to 22 March, 2013
2. Dr. D. S. Pokharkar, Entomologist of the project and Shri. A. S. Dhane, JRA attended the Research Review Committee meeting in Plant Protection- Agril. Entomology held at MPKV, Rahuri on 15$^{th}$ April 2013 and presented the research report of the project.
3. Dr. D. S. Pokharkar attended the "XXII Biocontrol Workers Group Meeting of AICRP on Biological Control of Crop Pests and Weeds" at NBAII, Bangalore on May 24-25, 2013 and presented the report. The technical programme for the year 2013-14 and 2014-15 is finalized in the meeting.
4. Dr. R.V. Nakat, Entomologist, and Dr. S. M. Galande, Asstt .Entomologist attended the Indo-Mexican Workshop "Biotechnology Beyond Borders" at CSIR-National Chemical Laboratory, Pune-411008 during October 7$^{th}$ to 9$^{th}$ October, 2013.
5. Dr. R. V. Nakat, Entomologist of the project attended "13$^{th}$ Workshop of IOBC Global Working Group on Mass Rearing and Quality Assurance" during 6-8$^{th}$ November 2013 and presented one research paper and one poster.
6. Dr. R.V. Nakat and Shri. A. S. Dhane conducted the survey of bioagents in 10 districts of Maharashtra from 30/ 11/2013 to 04/12/2013.
7. Dr. R.V. Nakat, Dr. S.M. Galande and Shri. A. S. Dhane attended the Pre-RRC meeting organized by Associate Director of Research, NARP Plain Zone, Ganeshkhind, Pune and presented the Research Review Committee Report of this centre on 18/12/2013.

8. Dr. R.V. Nakat attended the meeting regarding review of all ICAR Programmes, vacant position and utilization of funds at MPKV, Rahuri on 21/12/2013.
9. Shri. A. S. Dhane attended the meeting on Product Testing Trials on 26/12/2013 at MPKV, Rahuri and presented the report.
10. Dr. R.V. Nakat, Dr. S.M. Galande and Shri. A. S. Dhane attended the RRC meeting organized by Director of Research, MPKV, Rahuri and presented the Research Review Committee Report of this centre on 17/01/2014.
11. Dr. R.V. Nakat and Dr. S.M. Galande attended the Research Programme Planning Meeting organized by Director of Research, MPKV, Rahuri and presented the Research Programme Planning Report of this centre on 11/02/2014 and 12/02/2014.
12. Dr. R.V. Nakat attended the meeting on Precautions to be taken regarding pesticide poisoning in Maharashtra State organized by Director of Agriculture Inputs and Quality- Control, Commissionerate of Agriculture on 28/02/2014.

**PAU-Ludhiana**

1. Dr Naveen Aggarwal and Dr Neelam Joshi participated in XXII Biocontrol Workshop group meeting held on 24.5.2012 & 25.5.2012 at NBAII, Bangalore.
2. Dr Rabinder Kaur awarded NFP fellowship to attend short course on "Integrated pest Management and Food Safety" from 3 June - 21 June, 2013 at Centre for Development Innovation, Wageningen UR, The Netherlands.
3. Dr Naveen Aggarwal, Dr. Neelam Joshi & Dr Rabinder Kaur participated in Research and Extension Specialists Workshop for *Rabi* crops August 23-24, 2013 at PAU, Ludhiana.
4. Dr Naveen Aggarwal Dr Neelam Joshi and Dr Rabinder Kaur participated in *Kisan Mela* at PAU, Ludhiana on September 13-14, 2013.
5. Dr Jaspal Singh Virk participated in Research & Extension Specialists' Workshop for fruits, mushroom, agro forestry along with post harvest management, farm power & machinery, food technology and agri. economics and flower crops held on December 19-20, 2013 at PAU, Ludhiana.
6. Dr Naveen Aggarwal awarded Commonwealth fellowship to attend three months training at UK.
7. Dr Neelam Joshi participated and delivered oral presentation of research findings entitled "Paeciliomyces *fumosoroseus* entomopathogenic fungi against *Plutella xylostella*. Linn" in "International Conference in Entomology" at Punjabi University, Patiala from 21-23$^{rd}$ Feburary 2014.

**TNAU-Coimbatore**

1. Dr P.Karuppuchamy and Dr M.Kalyanasundaram attended ***National Symposium on Emerging Trends in Eco-friendly IPM,*** TNAU, Coimbatore, from January 22 to 24, 2014.

**YSPUHF- Solan**

1. Attended XXII Biocontrol workers' group meeting held by NBAII, Bangalore on May24-25, 2013 at NBAII, Bangaluru. by Dr Usha Chauhan and Dr PL Sharma.
2. Attended Workshop on e-learning under NAIP project entitled "development of e-courses for Bsc (hort.) degree programme" held on October 25, 2013 at Dr YS parmar University of Horticulture and forestry, Nauni, solan (HP) by Dr PL Sharma
3. Attended Asia Pacific Regional Symposium on "Entrepreneurship and Innovation in Organic farming," at Bangkok,Thailand w.e.f.2$^{nd}$ to 4$^{th}$ December,2013 by Dr Usha Chauhan

## iv. List of publications

### 1. Research Papers

### NBAII

1. Ankita Gupta& Sunil Joshi. 2013. Additions to the fauna of parasitic wasps (Hymenoptera: Chalcidoidea) and coccoids (Hemiptera: Coccoidea) from the Andaman and Nicobar Islands, India, with illustrations and diagnosis. *Journal of threatened taxa*. 5(11): 4542–4555.
2. Ankita Gupta, Blaise Pereira and Paresh V. Churi. 2013. A new species of *Parapanteles*Ashmead (Hymenoptera: Braconidae) from India reared from *Abisaraecheria* Stoll (Lepidoptera: Riodinidae) with key to the Indian *Parapanteles* species. *Zootaxa*3709 (4): 363–370. http://dx.doi.org/10.11646/zootaxa.3709.4.4
3. Ankita Gupta, G. K. Sujayanand and N. Bakthavatsalam 2013. Record of three larval parasitoids (Hymenoptera: Ichneumonoidea) of *Marucavitrata*(Fabricius) (Lepidoptera: Crambidae) from southern India. *Journal of Biological Control*, 27 (1): 53–55.
4. Ankita Gupta, Swapnil A. Lokhande&Abhay Soman.2013. Parasitoids of Hesperiidae from peninsular India with description of a new species of *Dolichogenidea*(Hymenoptera: Braconidae) parasitic on caterpillar of *Borbocinnara* (Wallace) (Lepidoptera: Hesperiidae) *Zootaxa* 3701 (2): 277–290. http://dx.doi.org/10.11646/zootaxa.3701.2.8
5. Ankita Gupta. &S. Manickavasagam 2013. Taxonomic notes on a collection of Indian Eucharitidae (a family of ant parasitoids) with description of female of *Schizaspidiaandamanensis* (Mani) from Andaman islands, India. *Journal of Biological Contro*l 27(2): 73-80.
6. Ankita Gupta. 2013. Three new species of reared parasitic wasps (Hymenoptera: Braconidae: Microgastrinae) from India.*Zootaxa* 3701 (3): 365–380. http://dx.doi.org/10.11646/zootaxa.3701.3.6
7. Arvind Kumar Yadav, Mahesh S. Yandigeri, Shachi Vardhan, Sivakumar G., Rangeshwaran, R. and C. P. M. Tripathi (2013) *Streptomyces* sp. S160: a potential antagonist against chickpea charcoal root rot caused by *Macrophomina phaseolina* (Tassi) Goid, Annals of Microbiology, DOI 10.1007/s13213-013-0750-6.
8. Bakthavatsalam, N. , Ravindra, K. V., Shylesha, A. N., Ramakrishna, P. and Raghavendra, A. Infochemical mediated responses of *Xylotrechus quadripes* Chev. (Coleoptera: Cerambycidae) to the volatiles of stem and leaf of *Coffea arabica. Environmental Entomology.* (Under Review).
9. Bakthavatsalam, N. Vinutha, J., Ramakrishna, P. Ravindra, K. V. and Deepa Bhagat. 2013. Biology of *Helicoverpa armigera* (Hubner) reared on pigeon pea grown under elevated levels of carbon dioxide. *Journal of Insect Science (India)* 26(special issue) December 2013. 135-141.
10. Bakthavatsalam, N., Vinutha. J., Ramakrishna, P., Ravindra, K. V. & Bhagat, Deepa., &. 2013 Biology of Helicoverpa armigera (Hubner) reared on pigeonpea grown under elevated level of carbon dioxide *Journal of Insect science*, 135-141.
11. Bhagat D., Bakthavatsalam N. and Vinutha J. 2013. Effrect of volatiles of rice varieties on foraging behaviour of *Trichogramma* (HymenopteraL Trichogrammatidae). *Journal of Insect science* (India) 26 (special issue) :168-172.
12. Bhagat, Deepa., Bakthavatsalam, N. & Vinutha, J. 2013 Effect of leaf volatiles of rice varieties on foraging behaviour of *Trichogramma* (Hymenoptera: Trichogrammatidae) *Journal of Insect science*, 168-172.
13. Dhanya K P, Madhusmita Panda, Jalali S K, Krishnakumar k, Gandhi Gracy R, Venkatesan T and Nagesh M. 2013. *In silico* docking studies on cytochrome P450

enzymes of *Helicoverpa armigera* (Hubner) and *Trichograma cacoeciae* marchal and implication for insecticide detoxification. .*Journal of Biological Control,* 27 : 01-09.

14. Geetha, G.T., Nesil, L.B., Venkatesan, T. Abraham Verghese. 2013. Analysis of Opportunities and Challenges in Patenting of management of sucking pests like aphids, hoppers, whiteflies and thrips in agriculture and horticulture fields. *International Journal of Current Microbiology and Applied Sciences,* 2 (9): 164-173
15. Gupta, A., Sujayanand G. K., and Bakthavatsalam, N. 2013. record of three larval parasitoids (Hymenoptera: Ichneumonidae) of Maruca vitrata (Fab.) (Lepidoptera: Crambiade) from southern India. *J. Biol Control* 27(1):53-55.
16. Guruprasad, N. M., Jalali, S. K. and Puttaraju, H.P. 2013. Wolbachia – a foe for mosquitoes? *Journal of Entomological Research*, 37: 351-358.
17. Guruprasad, N. M., Jalali, S. K. and Puttaraju, H.P. 2013. Wolbachia infection frequency and phylogenetic affiliation of wolbachia cell division protein gene (ftsZ) in uzi fly *Exorista sorbillans* (Diptera: Tachinidae) of Karnataka (India). *Journal of Entomology and Zoology Studies,* 1: 129-133.
18. Hayat, M., Zeya, S.B. and Veenakumari, K. 2013. On some brachypterous Encyrtidae (Hymenoptera: Chalcidoidea) from India, with description of four new species. *Zootaxa*, 3716 (2): 259-276.
19. Hayat, M., and Veenakumari, K. 2013. Encyrtidae (Hymenoptera: Chalcidoidea) from Andaman & Nicobar Islands, with description of a new genus and two new species. *Prommalia* I, 98-113.
20. Hemalatha, B.N., T. Venkatesan, S.K. Jalali, S. Sriram and B. Reetha. 2014. Molecular identification of yeast like microorganisms associated with field populations of aphid predator, *Chrysoperla zastrowi sillemi (Esben-Petersen) (Neuroptera: Chrysopidae)* and their role in fecundity. *Journal of Biological Control, 27(3): 176–183, 2013.*
21. Jency Jose, Jalali, S. K., Shivalingaswamy, T. M., Krishna Kumar, N. K., Bhatnagar, R. and Bandyopadhyay, A. 2013. Molecular characterization of nucleopolyhedrovirus of three lepidopteran pests using late expression factor-8 gene. *Indian Journal of Virology*, 24: 59-65.
22. Joshi, S. and Ballal, C. R. (2013) Syrphid predators for biological control of aphids. *Journal of Biological Control* 27(3): 151-170.
23. Kamala Jayanthi, P. D., Vivek Kempraj, Ravindra M. A., Ravindra, K. V. , Bakthavatsalam, N., Abraham Verghese, and Toby T. A. B. 2014. Ovipoisition selection by *Bactrocera dorsalis* is mediated through an innate recognition templated tuned to γ-octalactone.*PLOS one* 9(1):1-6 e85764.
24. Kamala Jayanthi, P. D., Vivek Kempraj, Ravindra M. A., Ravindra, K. V. , Bakthavatsalam, N., Abraham Verghese, and Toby T. A. B. 2014. Specific volatile compounds from nago elcit oviposition in gravid *Bactrocera dorsalis*. *J. Chem. Ecol. 2014*. doi 10.1007/S 10886-014-0403-7.
25. Krishna Kant, Y.K. Sharma, B. Ramanujam, S.K. Tyagi, J.K. Ranjan, B.K. Mishra, S.S. Meena, M.K. Vishal and S.R. Meena. 2013. Biorational approaches for management of aphid (*Hyadaphis coriandri* Das) on fennel. *Indian Journal of Horticulture* 70 (2):300-303.
26. Lalitha, Y., Nagesh, M. and Jalali S. K. 2013. Intraguild Predation and Biosafety of Entomopathogenic Nematode, *Heterorhabditis bacteriophora* Poinar et Al., and its Bacterial Symbiont, *Photorhabdus luminescens,* to Parasitoid, *Trichogramma chilonis* Ishii and Predator *Chrysoperla zastrowi sillemi* (Esben). *Journal of Biological Control,* 26: 27-35.

27. Mani, M., Krishnamoorthy, C. Shvaraju, A.N. Shylesha and D.S. Pokharkar 2013. Recovery of the exotic parasitoid, *Pseudleptomastix Mexicana* Noyes and Schauff (Hymenoptera: Encyrtidae) on the invasive papaya mealybug, *Paracoccus marginatus* ( Williums and Granara de Willink In India. Jl. Boil. Contrl. 27(1): 46-47.
28. Maria Pratheepa, Syshil Kumar Jalali, Robinson Silvester Arokiaraj, Thiruvengadam Venkatesan, Mandadi Nagesh, Madhusmita Panda & Sharath Pattar. 2014. Insect Barcode Information System. *BIOINFORMATION*. 10: 98-100.
29. Mukesh,P.,Sameen S.Fathima,Vasumathi,D., Pratheepa,M. and Kalaisekar. Development of Decision Tree Induction Model Using Sorghum Multi Location Data For Classification and Prediction. International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 11, November – 2013, pp: 3963 – 3970. (Impact factor 1.76)
30. Nagesh M, Saleem Javeed, Ramunajam B, Rangeshwaran R. 2013. Suitability of soil types for Paecilomyces lilacinus and Pochonia chlamydosporia and their performance against root-knot nematode, Meloidogyne incognita on Lycopersicon esculentum in glasshouse. *Indian journal of agricultural sciences,* Vol 83, No 8.825-830.
31. Pashte V. V and A. N. Shylesha. 2013. Pollinators diversity and their abundance on sesamum. Indian Journal of Entomology, 75(3):260-262
32. Pashte V. V., Shylesha A. N. 2013. Effectiveness of attractants and scents in enticement of apis dorsata, *Apis florea* and non-apis bees on sesamum (*Sesamum indicum*). BIOINFOLET - A Quarterly Journal of Life Sciences. 10(4c): 1593-1596
Pashte V. V., Shylesha A. N. 2013. Effect of number of honey bee visits on yield of sesamum. BIOINFOLET - A Quarterly Journal of Life Sciences. 10(4c): 1591-1592.
Pashte V. V and A. N. Shylesha. 2013. Pollen and nectar foraging activity of honey bees in sesamum. Indian journal of entomology, 75(2): 124-126.
33. Prashanth Mohanraj and Veenakumari, K. 2013. Preimaginal stages and natural history of two endemic subspecies of Polyura Billberg (Lepidoptera: Nymphalidae: Chraxinae) from the Andaman Islands. *Proceedings of the National Academy of Sciences, India. Section B: Biological Sciences.* 2250-1746 (online).
34. Pratheepa M, S.K.Jalali, A.Robinson Silvester,T.Venkatesan, M.Nagesh, P. Madhusmita and P. Sharath. 2014. Insect Barcode Information System. Bioinformation 10(2):098-100.
35. Pratheepa, M., Meena, K., Subramaniam, K.R. and Bheemanna, H. 2013. Decision tree induction model for the population dynamics of mirid bug, *Creontiodes biseratense* (Distant) (Hemiptera: Miridae) and its natural enemies. Journal of Biological Control 27(2):88-94.
36. Rajashekar Rao Korada, Naskar, S.K., Bakthavatsalam N., Prasad, A. R. Kushbo Sinha, and Jayaprakash C. A. 2013. Plant volatile organic compounds as chemical martkers to identify resistance in seet potato weevil *Cylas formicarius. Curr Sci.* 105 (9): 10 Nov 2013: 1247-1253.
37. Rajashekar, Y., Vijay Kumar H, Ravindra K. V. and Bakthavatsalam, N. 2013. Isolation and characterization of biofumigant from leaves of *Lantana camara* for control of stored grain insect pests. *Industrial Crops and Products* 51:224-228.
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|---|---|---|---|---|
| **A.** | **Research Papers:** | | | |
| 1. | Mohd Abas Shah and A. A. Khan. Qualitative and quantitative prey requirements of two aphidophagous coccinellids | 2014 | *Journal of Insect Science* | **7.5** |
| 2. | Mohd Abas Shah and A. A. Khan. Imaging techniques for the detection of stored product pests. | 2014 | Applied Entomology and Zoology | **6.9** |
| 3. | Mohd Abas Shah and A. A. Khan. Use of Diatomaceous Earth for the Management of Stored Product Pests | 2014 | International Journal of Pest Management | **7.4** |
| 4. | Mohd Abas Shah and A. A. Khan. Functional response- a function of predator and prey species | 2013 | *The Bioscan* | **5.1** |
| 5. | A. A. Khan. Evaluation of the biological control efficiency of spiders using functional response experiments | 2013 | *The Bioscan* | **5.1** |
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**NBAII**

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2. Ashwitha, K., Rangeshwaran, R., Lalitha, Y. and Ballal, C. R. (2013) Microflora associated with *Corcyra cephalonica* (Stainton) (Lepidoptera, Pyralidae) and their role in affecting its mass production. p. 49, In Abstracts of the IOBC *MRQA 13$^{th}$ workshop on "Emerging Opportunities for the Mass Production and Quality Assurance of Invertebrates"*, Bangalore, India, 94 pp.
3. Bakthavatsalam, N. 2014. Chemical ecology of entomophagous insects. lead lecture presented at National Symposium on emerging trends in Ecofriendly insect pest management. edited by Srinivasan, M.R., N. Ganapathy, M. Suganthy, K. Bhuvaneswari, R. Vishnupriya, S. Kuttlam, and K. Ramaraju. pp30-31. TNAU Coimbatore. p 447.

4. Bakthavatsalam, N., Vinutha. J., Ramakrishna, P, Ravindra, K.V and Bhagat. Deepa., 2013 Biology of *Helicoverpa armigera* (Hubner) reared on pigeon pea grown under elevated level of carbon dioxide p 81 In: the abstracts of papers International conference on Insect Science 14th - 17th February 2013.
5. Ballal, C. R. and Abraham Verghese (2013) *Biological control of major crop pests.* Lead presentatiuon during the KVK National conference at UAS, GKVK, Bangalore, 23rd October, 2013.
6. Ballal, C. R. Joshi, S., Bhaskaran, T. V. and Lakshmi, L. (2013) Production protocols for indigenous ichneumonid parasitoids *Campoletis chlorideae* Uchida and *Eriborus argenteopilosus* (Cameron). p. 33. In Abstracts of the IOBC *MRQA 13th workshop on "Emerging Opportunities for the Mass Production and Quality Assurance of Invertebrates"*, Bangalore, India, 94 pp.
7. Ballal, C. R., Manjunath, T. M., Sithanantham, S. and Verghese, A. (2013) Quality control parameters for mass-reared insects with *Trichogramma* (Hymenoptera, Trichogrammatidae) as a case study. p. 77, In Abstracts of the IOBC *MRQA 13th workshop on "Emerging Opportunities for the Mass Production and Quality Assurance of Invertebrates"*, Bangalore, India, 94 pp.
8. Bhagat. Deepa., Bakthavatsalam, N., Vinutha. J 2013 Effect of volatiles of leaves of rice varieties on foraging behaviour of Trichogramma (Hymenoptera: Trichogrammatidae) p 95 In: the abstracts of papers International conference on Insect Science 14th - 17th February, 2013.
9. Gupta, A., Lalitha, Y. and Ballal, C. R. (2013) Production protocol for *Anastatus (Anastatus) acherontiae* Narayanan, Subba Rao & Ramachandra Rao (Hymenoptera: Euplemidae), a potential egg parasitoid of litchi stink bug, *Tessaratoma javanica* (Thunberg) (Hemiptera: Tessaratomidae). p. 65, In Abstracts of the IOBC *MRQA 13th workshop on "Emerging Opportunities for the Mass Production and Quality Assurance of Invertebrates"*, Bangalore, India, 94 pp.
10. Gupta, T. and Ballal, C. R. (2013) A mass rearing protocol for the anthocorid predator, *Blaptostethus pallescens* Poppius. p. 32. In Abstracts of the IOBC *MRQA 13th workshop on "Emerging Opportunities for the Mass Production and Quality Assurance of Invertebrates"*, Bangalore, India, 94 pp.
11. Hema Bisht & Deepa Bhagat, "Metabolic profiling of different developmental stages of *Solanum lycopersicum* L. using NMR Spectroscopy" published at National Conference on Frontiers in Applied Spectroscopy (NCOFIAS-2014), 13th-14th, Febraury 2014, Department of Chemistry Maharani's Science College for Women, Bangalore, India.
12. Hema Bisht, David K.J, Jayanthi Mala. B.R & Deepa Bhagat, "Chemical profiling of *Bactrocera dorsalis* and *Bactrocera caryeae* species using Proton NMR Spectroscopy"published at National Conference on Frontiers in Applied Spectroscopy (NCOFIAS-2014), 13th-14th, Febraury 2014, Department of Chemistry Maharani's Science College for Women, Bangalore, India.
13. Hema Bisht, Deepa Bhagat, Srujana. S & M. K. Bhatanagar, "Metabolic profiling of different developmental stages of *Solanum lycopersicum* L. using GC-MS Spectrometry" published at Second National conference on Physics and Chemistry of Solids, 29th-30th, March 2014, 4. SR & BGNR Govt. Arts & Science College, Khammam, Andhra Pradesh, India.
14. Hemalatha, B.N, T. Venkatesan, S.K. Jalali, B. Reetha and Abraham Verghese; Endosymbiotic yeast, a dietary source for improved production of *Chrysoperla zastrowi sillemi* (Neuroptera: Chrysopidae) . 35-36 pp. 2013. 13th Workshop of the IOBC Global Working Group on Mass Rearing and Quality Assurance, Mövenpick Hotel & Spa, Bangalore, India November 6–8, 2013.

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21. Nagesh, M. oral presentation on *Nematode management in protected cultivation,* at *National Business Meet on Protected Cultivation, 7.3.14.* Organized by IIHR and Society for Horticulture Advancement.
22. Nagesh, M. Shylesha A.N., Jagadish Patil., Nikita Pai and Saleem Javeed. 2013. Improvised *in vivo* production and formulations of entomopathogenic nematodes, and current status of commercialization in India, *Emerging Opportunities for the Mass Production & Quality Assurance of Invertebrates.* 13th IOBC-MRQA Workshop, NBAII, Bangalore, November 6-8, 2013.
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26. Preetha, B., S. Mohankumar, T. Ramasubramanian and B. Ramanujam. 2014. Exploitation of endophytic *Beauveria bassiana* (Balsamo) Vuillemin - A novel approach to manage fruit and shoot borer, *Leucinodes orbonalis* L.of Brinjal. Paper presented at National Symposium on "Emerging Trends in Eco-friendly Insect Pest Management" held at Dept. Entomology, TNAU, Coimbatore during January 22-24, 2014. Abstract. p 443-444.

27. Presented a invited talk on Biocontrol methods of management of diseases in protected cultivation at National Business Meet on Plant Protection in Protected Cultivation of Vegetables and Flowers organized by IIHR, Bangalore on 6-7, March, 2014 and.

28. Ramya, S.L., Venkatesan, T., Jalali, S.K. Srinivasa Murthy, K. 2014. Biochemical mechanism of insecticide resistance in field populations of diamondback moth, *Plutella xylostella*. In 2$^{nd}$ International Conference on Agricultural and Horticultural Sciences, at Hyderabad during 03-05 Nov. 2014

29. Renuka. S, Ramanujam. B, Honnur Basha and K.R. Yatish. 2014. Effect of solid substrates on conidial production and virulence of *Beauveria bassiana* against maize stem borer, *Chilo partellus*. Paper presented at National Symposium on "Emerging Trends in Eco-friendly Insect Pest Management" held at Dept. Entomology, TNAU, Coimbatore during January 22-24, 2014. Abstract. p136.

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**v. Biocontrol Agents Maintained**

**AAU- Jorhat**

**Bioagent maintained in Biocontrol Laboratory,**

i. *Trichogramma japonicum*
ii. *T. chilonis*
iii. *T. mwanzai*
iv. *T. pieridis*
v. *Xylocoris flavipes*
vi. *Blaptostethus pallescens*
vii. *Trichogramma sp(*unidentified)recovered from castor
viii. *Trichogramma sp*(unidentified)recovered from tea
ix. *Neochetina eichhorniae and N. bruchi*

The biocontrol agents (parasitoids and predators) produced and maintained in the laboratory are being utilized for teaching and training of farmers, extension workers, entrepreneurs and also students of P.G. Research. Cultures of parasitoids (*Trichogramma japonicum, T. chilonis, T. pieridis)*and water hyacinth beetle *Neochetina eichhorniae and N. bruchi* have been supplied to different regional research stations of AAU, KVKs and Agricultural officers, Govt. of Assam for their field demonstration.

**MPKV-Pune**

**1. Maintenance of cultures of natural enemies and their mass production**

Following cultures of bioagents and host insects were maintained in the Biocontrol laboratory and used for experimental purposes as well as supplied to other Biocontrol laboratories in the State. Besides, *Trichogramma* spp., *Cryptolaemus montrouzieri, Ha*NPV, *Sl*NPV, *Metarhizium anisopliae* and *Nomuraea rileyi* were mass cultured and used for action research demonstrations on research farms of University, research stations and farmers' fields. These were also distributed to needy farmers.

**Parasitoids:** *Trichogramma chilonis* Ishii
*Trichogramma chilonis* TTS
*Trichogramma chilonis* SAS
*Trichogramma japonicum* Ashmead
*Trichogramma pretiosum* Riley
*Trichogramma pretiosum* arrhenotokous strain
*Trichogramma pretiosum* thelytokous strain
*Trichogrammatoidea bactrae* Nagaraja
*Trichogramma brassicae* Mot.
*Chelonus blackburni* Blanchard
*Acerophagus papayae* Noyes & Schauff

**Predators:** *Cryptolaemus montrouzieri* Mulsant
*Scymnus coccivora* Ayyar
*Chrysoperla zastrowi sillemi* (Esben-Petersen)
*Blaptostethus pallescens* Poppius
*Xylocoris flavipes* (Reuter)

**Microbial agents:** *Nomuraea rileyi*
*Metarhizium anisopliae*
*Beauveria bassiana*
*Verticillium lecanii*

**Laboratory hosts:** *Phthorimaea operculella* Zeller
*Corcyra cephalonica* Stainton
*Maconellicoccus hirsutus* Green
*Paracoccus marginatus* Williams and Granara de Willink

**Mass production and sale of bioagents:**

| Name of bioagents | Quantity produced | Quantity sold | Receipt realized (Rs.) |
|---|---|---|---|
| 1. *Trichogramma* sp. (Trichocards) | 800 | 51 | 2,550 |
| 2. *Chelonus blackburni* | 4,000 | - | - |
| 3. *Cryptolaemus montrouzieri* | 12,000 | - | Demonstration |
| 4. *Metarhizium anisopliae* | 1,260 kg | 60 kg | 9000 kg Demonstration (740 kg) |
| 5. *Nomuraea rileyi* | 210 kg | - | Demonstration (85 kg) |

**PAU, Ludhiana**

**Materials developed:**

| Name of Centre | Name of Biocontrol agents produced during 2013-14 | Monthly production capacity in brief | Total annual production (2013-14) in brief |
|---|---|---|---|
| PAU, Ludhiana | i) *Trichogramma chilonis* | 700 cards | 9,000 cards |
| | ii) *T. japonicum* | 600 cards | 8000 cards |
| | iii) *Chrysoperla carnea* | 4500 grubs/adults | 45,000 grubs/adults |

## vi. Technology Assessed and Transferred

### AAU-Jorhat

**1.** Three releases of *Trichogramma chilonis* @50,000/ha /week against *Earis sp*. at bud initiation stage along with spray of Bt (commercial formulation) @1kg/ha, use of yellow sticky trap (10-15 no./ha) and mechanical control of infested fruit/shoot could effectively manage the sucking pests and fruit borer of okra. The technology has been assessed and validated during 2011-2013. The multilocational trial has been proposed by Directorate of Extension AAU, Jorhat in different KVKs under OFT and FLD.

**2.** Seedling root dip treatment with 2% suspension of *P. fluorescence,* Spray of *Beauveria bassiana* (commercial formulation)against sucking pest, six releases of *Trichogramma japonicum*@ 1,00,000/ha from 30 days after transplanting against stem borer and leaf folder, spray of *Pseudomonas fluorescence* @2% against foliar diseases, application of botanicals (Neem oil/pestoneem @ 3ml/lit) and erection of Bird perches @ 15/ha could effectively reduce the dead heart and WEH caused by *Scirpophaga sp*s and leaves damage by *Cpnaphalocrosis* sp. and contributing higher yield in BIPM package. The technology has been assessed and validated during 2011-2013. The multilocational trial has been proposed by Directorate of Extension AAU, Jorhat in different KVKs under OFT and FLD.

### ANGRAU-Hyderabad

1. Sequential application of bio agents, Bt-Ha NPV-endo-Bt in pigeon pea against *Helicoverpa.*
2. Bio intensive management of pod borer complex through *Ha* NPV-NSKE alternation in pigeon pea.
3. Release technology of *T.chilonis* @ 1, 50,000/ha/week through distribution @ 200 strips/ha in cotton.
4. BIPM module consisting of alternate methods for management *Helicoverpa* in cotton ecosystem.
5. Effective *Bt* formulations such Biobit & Dipel for managing DBM in cabbage.
6. Combination of *T.pretiosum* @ 50,000/ha-5 times and NPV @250 LE/ha –3 times to manage *Helicovera* in tomato.
7. Application of NPV @ 250 LE/ha in pigeon pea – 4 rounds for *H.armigera*.
8. Dipel @ 0.5 kg/ha effective against castor semi looper.
9. Standardization of host distance for better parasitization by *T.chilonis*-1 meter (Optimum) 4 meter (Maximum).
10. *Bt* @ 1 kg/ha is very effective against *Adisura atkinsoni* on Dolichos bean recording lesser pod damage and good yield .
11. Pigeonpea bordered with two rows of sorghum and intercropped with sunflower (9:1) gave better yields recording lesser population of pests due to higher biological control activity by natural enemy population compared to the sole crop.
12. The Anthocorid bug *Xylocorisflavipes*performed better than *Blaptostethus pallescens*in controlling the moth *Corcyra cephalonica* in stored rice grain. Lesser moths of Corcyra emerged from the bin where the grain was treated with *Xylocoris flavipes.*

### KAU-Thrissur

1. Recommended *Acerophagus papayae* for the management of papaya mealybug

**MPKV-Pune**

1 **Success story of well establishment of *Encarsia flavoscutellum* for the management of sugarcane woolly aphid in western Maharashtra**.

- The culture of parasitoid *E. flavoscutellum* obtained by PDBC, Bangalore from AAU, Jorhat (Assam) was supplied to this centre in 2006. The leaf-bits with parasitized SWA colonies were stapled on the SWA infested leaves and emerged adults (2,000 adults) were released in SWA infested plot at A. C. Pune and S.R.S., Padegaon in Satara district on 22nd December 2006. The recovery of the parasitoid was recorded at monthly interval by observing adult parasitoids in SWA colonies and also confining leaf-bits in test tubes till adult emergence. The parasitoid *E. flavoscutellum* was recovered to the extent of 12.65% two months after its release. The SWA infestation was disappeared from April to June 2007. Thereafter the parasitoid did not recovered till March 2008.

- The survey conducted during 2011-13 the activity of parasitoid *E. flavoscutellum* restarted and established well in Solapur, Pune, Satara districts and controlling the SWA in farmers field. The enormous population of parasitoid *E. flavoscutellum* (30.6 adults per leaf) was observed at Ursale village near Pandharpur, Dist. Solapur during December 2013 which is a successful example of inoculative release of parasitoid brought from Assam and well established in Maharashtra and controlling the SWA in sugarcane.

**2. Large scale production of the parasitoid, *Acerophagus papayae* N & S on papaya mealy bug, *Paracoccus marginatus* W & G in farmers' Papaya orchards**

The papaya mealy bug (PMB), *Paracoccus marginatus* was first recorded in the papaya orchard (var. Taiwan 786-Red Lady) at the Regional Fruit Research Station, Pune in July, 2010. The pest incidence developed up to 85-95 % with a 4-5 pest intensity-rating in the Pune region, causing almost cent per cent losses to farmers. The native strain of the parasitoid, *Acerophagus papayae* Noyes and Schauff (Hymenoptera, Encyrtidae) was collected first time in India on 23rd August 2010 from the PMB infested papaya orchard of the IARI Regional Station on Virology, Baner (Pune), which might be the fortuitous introduction of the parasitoid occurred along with the pest. *Acerophagus papayae* was mass multiplied on PMB colonies reared at the Biocontrol laboratory in Pune and the first inoculative release of the parasitoid was undertaken in the organic farmers' papaya orchards (80 % infested with PMB) at Loni Kand, in Pune district. The parasitoid was allowed to multiply under natural conditions with large population of all nymphal stages of host insect present on papaya plants in farmer's orchard as a mass production centre. The parasitoid population increased from 4-5 adults per leaf to 50 - 60 adults per leaf when at peak within two months period.

The parasitoids from Lonikand orchard were distributed to farmers for inoculative releases at 1,500 adults per acre in Pune and at 1,000 adults per acre in Jalgaon, Dhule and Thane districts free of cost during the first fortnight of October, 2010. The results indicated that there was 85-92 per cent decline in the mealy bug incidence in the Pune region, 70 per cent reduction in Thane and 38-40 per cent reduction in the Dhule and Jalgaon regions within three months. Enormous population of the parasitoid (>-60 adults/leaf at peak) was observed in severely infested orchards. The papaya mealy bug was under control within six months after inoculative release of the parasitoid during 2010-11. During the year 2012, the PMB incidence was noticed in March and it reached its peak during May, causing 30-35% losses in the first flush of fruiting. The natural enemies, particularly *A. papayae*, developed well during May and June, 2012, and second flush of fruiting noticed in July-August, 2012 was found to be free from the pest incidence. However, the parasitoid population which was very high on infested fruits and leaves (av. 40-50 adults/leaf) during May-June declined to 10-15 adults/leaves during August, 2012, obviously due to drastic reduction in the mealy bug population. At present, the PMB incidence is 2-3 % in the farmer's papaya orchard where the natural enemies are well established. The parasitoids were found to be healthy and very active having good capacity of parasitization compared to laboratory reared population which may be due to the availability of large number of host insects under natural conditions. The parasitoid *A. papayae* is well established and evenly distributed in papaya orchards in Maharashtra providing effective control of the mealy bug

**3. Mass production of entomopathogenic fungi *Metarhizium anisopliae* and its demonstration on farmer's field**

Mass production of *Metarhizium anisopliae* was carried out on solid media (rice + soybean) and demonstrated on farmers field over 55 ha against wheat aphid, 25 ha against onion thrips at Niphad Dist. Nashik and 25 ha against mango hoppers in Pune region. It was found infectious to wheat aphids, onion thrips and mango hoppers showing 60-65% decline in the pests' population. Moreover, *M. anisopliae* was also supplied to the farmers from Kolhapur and Pune districts for effective control of white grubs in sugarcane. These Action Research Demonstrations controls the important pests effectively. Farmers from Western Maharashtra are fully convinced with the effect of Biopesticides and they have started using Biopesticides on their own. They are giving their demand of Biopesticides in advance and collecting the Biopesticides regularly from our Biocontrol Laboratory at Department of Entomology, MPKV, Rahuri. The demand for Biopesticides is increased from 2012 due to the large scale Action Research Demonstrations conducted in 1,200 ha area on farmers field through RKVY Project entitled "Promotion and Large Scale Production of Biopesticides Developed by MPKV Rahuri during the last three years 2011 to 2014.

# 5. ACRONYMS

| | |
|---|---|
| AAU-A | Anand Agricultural University, Anand |
| AAU-J | Assam Agricultural University, Jorhat |
| ANGRAU | Acharya N. G. Ranga Agricultural University |
| CPCRI | Central Plantation Crops Research Institute |
| CTRI | Central Tobacco Research Institute |
| CAU | Cental Agricultural University, Pasighat |
| CISH | Central Institute of Sub-Tropical Horticulture |
| Dir. Soyben Res | Directorate of Soybean Research |
| Dir. Sorghum Res | Directorate of Soybean Research |
| Dir. Seed Res | Directorate of Seed Research |
| Dir. Rice Res | Directorate of Rice Research |
| Dir. Weed Sci. Res | Directorate of Weed Sciences Research |
| GBPUAT | Gobind Ballabh Pant University of Agriculture and Technology |
| IARI | Indian Agricultural Research Institute |
| ICAR | Indian Council of Agricultural Research |
| IIHR | Indian Institute of Horticultural Research |
| IISR | Indian Institute of Sugarcane Research |
| IIVR | Indian Institute of Vegetable Research |
| KAU | Kerala Agricultural University |
| MPKV | Mahatma Phule Krishi Vidyapeeth |
| MPUAT | Maharana Pratap University of Agriculture & Technology |
| NBAII | National Bureau of Agriculturally Important Insects |
| NCIPM | National Centre for Integrated Pests Management |
| OUAT | Orissa University of Agriculture & Technology |
| PAU | Punjab Agricultural University |
| SKUAST | Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar |
| TNAU | Tamil Nadu Agricultural University |
| UAS-R | University of Agricultural Sciences Raichur |
| YSPUHF | Y.S. Parmar University of Horticultural and Forestry |