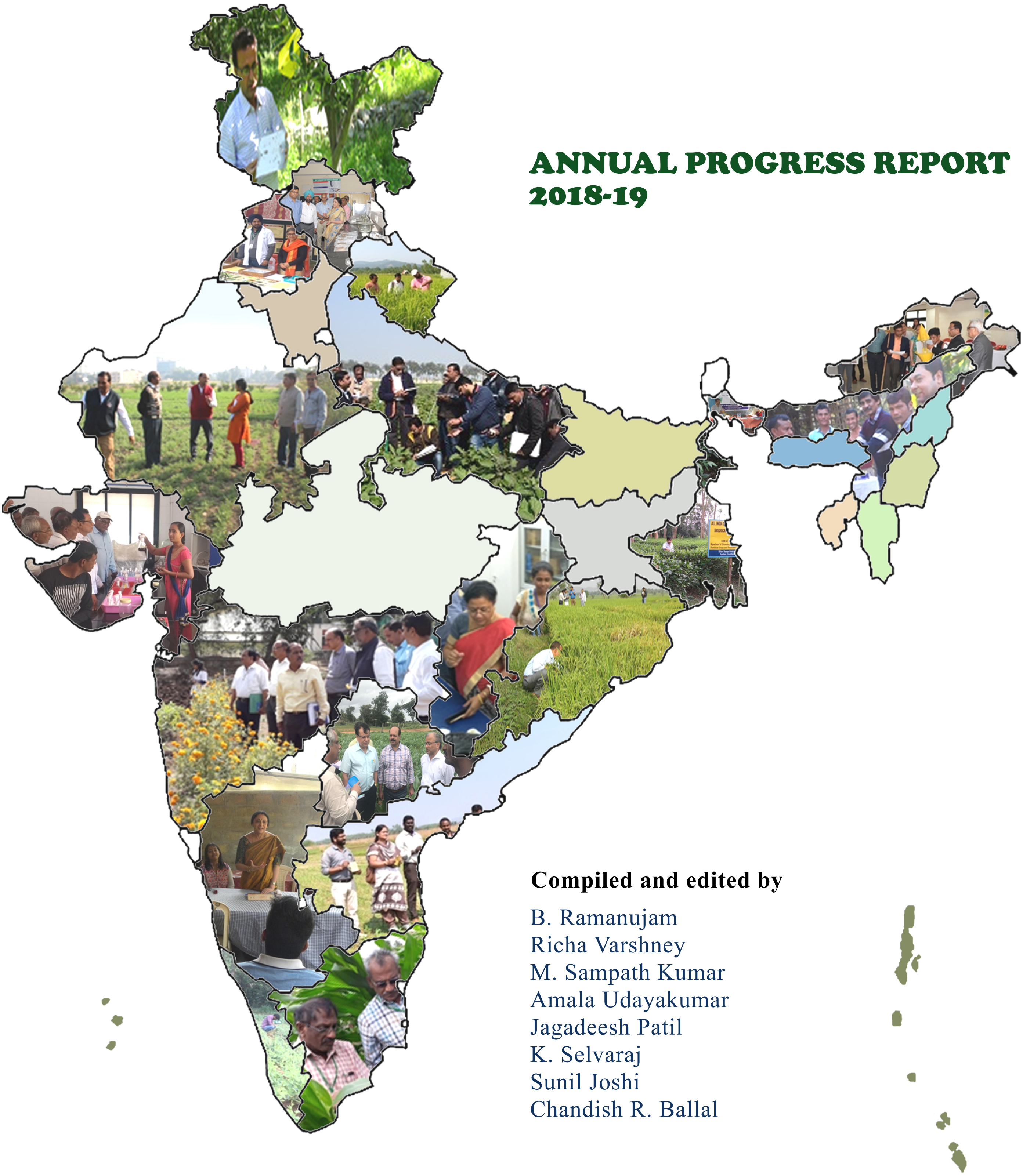
All India Co-ordinated Research Project on Biological Control of Crop Pests



ANNUAL PROGRESS REPORT 2018-19

Compiled and edited by

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ICAR - National Bureau of Agricultural Insect Resources
Bengaluru 560 024

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Cover page: Frontline demonstrations, large scale demonstrations, lab to land programs, extension activities and farmers' meetings at different AICRP – BC centers

Photo credits: All AICRP – BC centers

Cover design: Sunil Joshi

Technical Programme for 2018-19

I. BASIC RESEARCH

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BIOLOGICAL CONTROL OF CROP PESTS

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20.4 Screening of coleopteran specific *Bt* formulation (NBAIR strains) against rhinoceros beetle (*Oryctes rhinoceros*) at CPCRI, Kayangulam

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EXPERIMENTAL RESULT

I. BIODIVERSITY OF BIOCONTROL AGENTS FROM VARIOUS AGRO-ECOLOGICAL ZONES

I.1 ICAR- National Bureau of Agricultural Insect Resources, Bengaluru

I.1.1 Taxonomic and biodiversity studies on parasitic Ichneumonid and chalcid wasps

The natural enemy complex of *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae), commonly known as fall armyworm, was reported for the first time from India. Natural parasitism by egg parasitoids *viz*., *Telenomus* sp. (Hymenoptera: Platygastridae) and *Trichogramma* sp. (Hymenoptera: Trichogrammatidae), gregarious larval parasitoid *Glyptapanteles creatonoti* (Viereck) (Hymenoptera: Braconidae), solitary larval parasitoid *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae), and two braconid larval parasitoids *Phanerotoma* sp. (Hymenoptera: Braconidae) and *Chelonus* sp. (Hymenoptera: Braconidae), a solitary +indeterminate larval-pupal parasitoid (Hymenoptera: Ichneumonidae: Ichneumoninae) and pupal parasitoid *Trichomalopsis* (Hymenoptera: Pteromalidae) were documented. *Spodoptera frugiperda* is the first host record for *G. creatonoti* across the globe. *Glyptapanteles creatonoti*, being a well established parasitoid of various noctuids in India and Malaysia, was capable of parasitizing *S. frugiperda*. Besides these, other commonly found bioagent *viz*., *Forficula* sp. (Dermaptera: Forficulidae) was identified.

The braconid parasitoid group, *Diachasmimorpha longicaudata* species complex was recorded from different species of fruit flies, *viz.*, *Bactrocera dorsalis* (Hendel), *Bactrocera correcta* (Bezzi), *Bactrocera zonata* (Saunders) and *Zeugodacus cucurbitae* (Coquillett) in Dharwad district with 13.52% parasitism.

Klabonosa indica Gupta, Sureshan & Yeshwanth Bouček (Hymenoptera: Pteromalidae) is recorded for the first time from the Oriental regionreared from eggs of the assassin bug *Endochus* sp. (Hemiptera: Reduviidae) on *Artocarpus heterophyllus* Lam. (Moraceae). A new species of *Ooencyrtus* Ashmead (Hymenoptera: Encyrtidae), *O. xenasteiae* Hayat & Gupta, is described and reared from the pupae of a *Xenasteia* sp. (Diptera: Xenasteiidae), a sooty mould scavenger associated with the recent invasive rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) from coastal Karnataka, India.

I.1.2 Spider diversity and biocontrol potential of social spider

Two hundred and fifty spider specimens have been collected from surveys undertaken in five states representing different agri-horti ecosystems like rice, red gram, maize, sunflower, Litchi. One hundred fifty specimens were identified up-to generic level. Rice ecosystem claims more spider diversity and has a great scope for insect pest management, due to their predatory potential. Orb-weaving spiders appear to be of higher significance because of trapping more insects than they consume. Study undertaken to document taxonomic diversity of *Tetragnatha* Latreille, 1804 (family Tetragnathidae, Menge, 1866) probably the most predominant group amongst orb-weavers found in rice fields of IIRR (Rajendranagar), Nelaigudem, Telangana revealed, seven tetragnathid species were recorded from the study area with *T. mandibulata* being the predominant species. The crab spider, *Thomisusspectabilis* has been reported as new distribution record to Gujarat.

Stegodyphus (Eresidae family), commonly called social spiders namely *S. mirandus*, *S. pacificus*, *S. sarasinorum* and *S. tibialis* have been reported from India. Out of these, *S. sarasinorum* is the predominant one can find many numbers depending up on the web size ranging between 100 and 1000 are capable of capturing prey as large as 10 times their size are advantageous from biological control perspective. The social spiders collected from various places in south India were released into NBAIR farm for colonization. The established colonies were deployed in different places of mango fields like, crop boundary and non-crop habits at NBAIR farm. Regular observations were undertaken by recording the pests trapped in the webs of these spiders. Though, observed the presence of non-targets like bees, dragon flies, houseflies but presence of mango pests were outnumbered. Analysis of the prey composition pattern of *S. sarasinorum* present along the non-crop habitats in mango orchard elucidated it can be used as a biocontrol agent in bringing the pest populations.

I.1.3 Molecular Characterization and DNA barcoding of agriculturally important parasitoids, predators and other insects

Different parasitoids, predators and other insects were collected from various crops in Karnataka, Andhra Pradesh, Maharastra, Telangana State, Gujarat and South Andaman and were used for DNA barcoding studies. Molecular characterization and DNA barcodes were generated for 70 agriculturally important insect pests, parasitoids, predators, pollinators including invasive fall armyworm *Spodoptera frugiperda* and other insects based on COI gene. Twenty four populations of fall armyworm, *Spodoptera frugiperda* collected from Gujarat, Karnataka, Telangana State, Andaman, Andhra Pradesh, Maharastra and were identified using COI gene and deposited in NCBI and accession numbers were obtained (Chikaballapur-MH704433; Hassan-MH881533; Belur-MH881532; Shimoga-MH881531; Darwad-MH822830; Anakapalle-MH822831; Chinthapalle-MH822832; Pedabathepalle-MH822833; Nelivada-MH822834; Tirupai-MH899610; Vijayawada-MH899611; Khammam-MH822835; Siddipet-MH881529; Nagarkurnool-MH881528; Rajendranagar-MH881530; Pune-MH899609; Chikaballapur-MK079565; Doddaballapur-MK041922; Gujarat (MK279399; MK303391), Karnataka (MK318531; MK327538) and (MK285364). Whitefly occurring on banana and coconut in Assam was identified as invasive rugose spiraling whitefly *Aleurodicus rugioperculatus* using molecular studies (COI gene). The following Tephrids were characterized *Platensina acrostacta* (MH748566), *Spathulina acroleuca* (Schiner) (MH748567) and *Dacus* (*Didacus*) ciliates (Loew.) (MH733833). The following stored grain pests have been characterized *Corcyra cephalonica* (MK377173), *Sitotroga cerealella* (MK377174). Staphylinid beetle *Paederus fuscipes* (MH916764) was characterized.Different populations of *Bemisia tabaci* were characterized (MH807440, MH823740, MH891617, MK123947, MK568467, MK568468, Asia I (MK497172). Thirty three insect pests attacking medicinal plants were characterized using CO1 gene and the following insects were identified. *Spilarctia oblique* (MK491177), *Pyrausta panopealis* (MK559412), *Apis florea* (MK491178), *Certaina binghami* (MK559415), *Leptocentrus* sp. (MK491176), *Bacchoriso nychinalis* (MK358184), *Olenemendosa* sp. (MK455104), *Catopsilia pyranthe* (MK531549), *Psoroticha ziziphi* (MK416150), *Aleurodicus dispersus* (MK491179), *Spodoptera litura* (MK491175), *Giaura punctata* (MK482339), and *Apocryptophagus* sp. (MK569694) and DNA Barcodes have been generated for the same.

I. 1.4 Diversity of Trichogrammatids

Trichogrammatids were collected from the states *viz*., Kerala, Assam, Karnataka and Gujarat in the agricultural fields, horticultural crops, grassland and from the forest areas. Total 10 genera of trichogrammatids were collected from Karnataka, Kerala, Assam & Gujarat through sweeping net, yellow pan trap and by placing sentinel cards in different ecosystems. The genera include, *Trichogramma*, *Trichogrammatoidea*, *Megaphragma*, *Paracentrobia*, *Chaetogramma* and *Oligosita* were collected from Gujarat, while, *Megaphragma*, *Neocentrobiella*, *Oligosita* and *Trichogrammatoidea* were collected from Assam. The genera *Megaphragma*, *Neocentrobiella***,** *Paracentrobia*, *Tumidiclava* and *Aphelinoidea*were recorded for the first time from Assam and the genera, *Megaphragma* and *Neocentrobiella* collected from the Gujarat. A total of 1587 host eggs belonging to different insect species were collected. In addition, about 670 eggs masses of *Spodoptera frugiperda* from maize were collected at different places in Karnataka. *Trichogramma* sp. was collected from the naturally parasitized eggs of *S. frugiperda* infesting maize. Also,*T. chilonis* and *T. achaeae* were collected from naturally parasitized eggs of *T. absoulta*.

I.1.5 Predatory mirids, geocorids, anthocorids and mites

Biology of of predatory mirid, *Dortus primarius*

Dortus primarius Distant (Miridae: Deraeocorinae) is a predatory mirid and it was observed to feed on thrips and other soft bodied insects in the field. Biology, morphology and feeding potential of this species were studied for the first time in the laboratory (at 26±2^{O} C and 65±2% RH) on UV irradiated *Corcyra cephalonica* (Stainton) eggs. A total of five instars were observed, with nymphal duration of 17.2 days. Mean fecundity was 127.6 eggs per female. Female longevity was higher than male and one nymph could consume a total of 363 *C. cephalonica* eggs in its life span. Adult male and female fed on a total of 713 and 1014.75 eggs, respectively. Cost of producing 100 *D. primarius* nymphs and adults was INR 10.34/- and INR 200/- , respectively. This species could be reared on UV irradiated *C. cephalonica* eggs and bean pieces successfully.

Feeding efficiency of predatory mirid, *Termatophylum orientale* against *Frankliniella schultzei*

Laboratory evaluation of *Termatophylum orientale* was doneagainst *Frankliniella schultzei* and it was observed that 4th and 5th instars consumed more number of thrips at 1:30 density while adult consumed more number of thrips at 1:40.

Predatory efficiency of *Geocoris ochropterus* against red spider mites

Efficiency of *G. ochropterus* was evaluated against red spider mites on tomato plant. When *G. ochropterus* was released @ 10 nymphs /plant, it reduced infestation by 76.21 %. There was no significant difference in reduction in mite population when *G. ochropterus* nymphs were released @ 20 nymphs/plant and 30 nymphs /plant **(Table 1).**

Table 1. Effect of *Geocoris ochropterus* against red spider mites on tomato

Treatment	Mite population / leaf			
	Before release	1st release	2nd release	3rd release
G.ochropterus @10 nymphs (3rd instar) per plant	76.01	50.52[b]	31.74[b]	28.09[b]
G.ochropterus @20 nymphs (3rd instar) per plant	72.56	35.23[c]	19.04[c]	15.3[c]
G.ochropterus @30 nymphs (3rd instar) per plant	71.98	33.64[c]	18.48[c]	13.4[c]
Control	70.63	97.82[a]	110.06[a]	121.53[a]
P value	NS	<0.001	<0.001	<0.001

I.1.6 Studies on maize fall armyworm, *Spodoptera frugiperda*

Incidence of FAW in Karnataka (NBAIR)

Based on the surveys conducted from July to August 2018 by ICAR-NBAIR team in several districts of Karnataka (Chikkaballapur, Hassan, Shivamogga, Davanagere, Chitradurga, Raichur and Dharward), *S. frugiperda* infestation in maize has been reported in many locations in these districts and the incidence ranged from 9.0 to 62.5% at various locations. Maximum incidence was recorded in Hassan district followed by Chikkaballapur, Davanagere, Shivamogga and Chitradurga districts. The larvae were found to be infected with entomopathogenic fungus *Nomuraea rileyi* (Farl.) Samson.

Parasitoid complex:

Several parasitoids were obtained from Fall armyworm from Karnataka which included, *Trichogramma* sp. *Trichogramma pretiosum*, *Telenomus remus*, egg larval parasitoid *Chelonus* sp. and larval parasitoids like *Glyptapanteles creatonoti* (Viereck) (Hymenoptrea: Braconidae),*Apanteles creatonoti* Vier, *Campoletis chlorideae* and several predators like earwig *Forficula sp,* predatory bugs like *Andrallus spinidens*, *Eocanthecona furcellata* were recorded to be highly beneficial for the management of Fall armyworm. In addition, one dipteran parasitoid *Pseudgourax sp* was also recorded on the egg mass of FAW. The maggots were found feeding on the eggs thereby showing a potential for management of FAW.

Effect of NBAIR-*Bt* isolate against, *Spodoptera frugiperda*

In vitro studies with *Bacillus thuringiensis* strain NBAIR-*BT*25 showed an LC_{50} of 44.7 µg/ml **(Table 2)**against 2nd instar larvae of *S. frugiperda*.

Table 2. *In vitro* bioassay of NBAIR *Bacillus thuringiensis* isolates against *Spodoptera frugiperda*

SL. No.	Treatments	Time (hrs)	LC_{50} (ug/ml)	Fiducial Limit		Slope ± SE	Chi Square	P
				Lower	Upper			
1.	NBAIR-*Bt*25	96	44.718	34.691	56.915	2.618 ± 0.389	4.294	0.001
2.	NBAIR-*Bt*1	96	57.299	43.341	76.933	2.146 ± 0.342	0.366	0.001
3.	NBAIR-*Bt*4	96	94.955	69.956	143.322	1.926 ± 0.345	0.443	0.001
4.	NBAIR-*Bt*5	96	211.571	140.262	501.689	1.889 ± 0.436	0.782	0.001
5.	NBAIR-*Bt*6	96	114.209	77.459	216.169	1.496 ± 0.316	0.060	0.001

Liquid formulation of NBAIR-*BT*25 was developed for management of *S. frugiperda*. A field trial was carried out in farmer's field of maize in Doddaballapur. Observations showed that there was 69.4% reduction of pest damage after two sprays of NBAIR-*BT*25. At NBAIR Farm in Yalahanka, NBAIR-*Bt*25 incited 81% reduction of pest based on larval mortality. In Hindupur area of Andhra Pradesh, NBAIR-*Bt*25 showed 70% reduction in pest damage in farmers fields. NBAIR-*Bt*25 formulations were supplied to 9 KVK and 3 AICRP centers for limited evaluation.

Studies on the effect of entomopathogenic fungi fall armyworm*Spodoptera frugiperda*in maize

Ten entomofungal strains were evaluated against 2nd instar larvae of *S. frugiperda* in the Laboratory bioassay. Among the ten EPF isolates tested, *M. anisopliae* NBAIR- Ma-35 caused 67.8% mortality followed by *B. bassiana* NBAIR- Bb-45 with 64.3% and Bb-11 with 57.1% mortality. Rest of the isolates showed 10.7- 28.6% mortality.

Field trials with EPF against *S. frugiperda*.**on maize at NBAIR Yelahanka Attur Farm, Farmers fields at Thondebavi & Gowribidanur**

Field evaluation with *B. bassiana* (ICAR-NBAIR Bb-45) and *M. anisopliae* (ICAR-NBAIR Ma-35) were carried out against *S. frugiperda* in maizeduring *rabi* and late *rabi* season. Three foliar sprays @ 5g/litre (rice grain formulation containing 1x10^8 spores/g) at 15, 30 & 45 days of the crop stage were given. ICAR-NBAIR-Bb-45 and Ma-35 showed 56-80% of pest reduction.

WP formulation of EPN, *Heterorhabditis indica* on Fall armyworm, *Spodoptera frugiperda*

Demonstrated delivery of EPN to whorls using WP formulations of EPN. EPN reduced FAW, *Spodoptera frugiperda*, populations to the tune of 60-72% in maize and sustained plant growth, yield and harvest index compared to emamectin benzoate and chlorpyrifos sprays, both in *kharif* and *rabi* (2018-19).

Studies on virus infecting fall armyworm, *Spodoptera frugiperda*

Surveys were made at maize and sugarcane fields of Chikkaballapura in Karnataka, Pugalur, Coimbatore and Jolarpettai in Tamil Nadu and collected diseased larvae of maize which were showing characteristic viral infection symptoms **(Fig 1).** Observation of discharged body fluid of the diseased larvae under a phase-contrast microscope revealed numerous spherical particles resembling occlusion bodies (OBs) of baculovirus especially nucleopolyhedrovirus. TEM of the OBs revealed the tetrahedral shape with size of polyhedra 1.64 µm**(Fig 2).** Bioassay studies revealed larval mortality with an LC_{50} of 1 × 10^6 OBs/ml against second instar larvae of *S. frugiperda*. The LC_{50} values observed for second instar larvae were 2.17 POBs/mm^2 for SfNPV. Field evaluation of *S. frugiperda* NPV is progressing

Fig 1

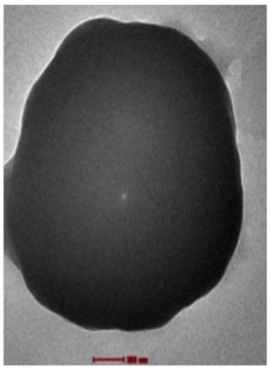


Fig.2

Fig.1. Diseased larvae of S*podoptera frugiperda* showing characteristic viral infection symptoms

Fig. 2. Transmission (electron micrographs of tetrahedral occlusion bodies of *S. frugiperda*

I.1.7 Studies on coconut rugose spiralling whitefly *Aleurodicus rugioperculatus*

***In vitro* evaluation of entomopathogenic fungus, *Isaria fumosorosea* against rugose spiralling whitefly on coconut (RSW)**

Two isolates of *I.fumosorosea* (ICAR-NBAIR Pfu-1 and Pfu-5) were tested against the pest. Spore suspensions of these isolates at the dose of $1×10^8$ spores/ml were used in the laboratory bioassay. Eggs and nymphs of RSW were dipped in a freshly prepared spore suspension for ten seconds and placed on Petri plate (12 ×12 cm). Mortality /mycosis was recorded at 24 hours interval up to seven days. Significantly higher suppression of egg hatching (64-79%), mortality of early nymphal instars (57-78%) and late nymphal instars (56-74%) was observed in both the isolates of Pfu-1 and Pfu-5. The growth and sporulation of the *I. fumosorosea* was noticed on the eggs and nymphs of RSW after 3 days of treatment.

Field evaluation of *Isaria fumosorosea* against rugose spiralling whitefly on coconut and oil palm

Field evaluation was carried out with ICAR-NBAIR Pfu-5 strain at Nelamangala (Bengaluru Rural district, Karnataka) in coconut and at Kalavalapalli, Pullerukuttu & Madhavaraya palyam in West and East Godavari districts of Andhra Pradesh in coconut & oil palm by spraying at the dose of $1x10^8$ spores/ml on ten randomly selected infested palms in each location using power operated high volume sprayer on all fronds of the palm. Two sprays were given at 15 days interval. Results revealed that *I. fumosorosea* (Pfu-5), reduced 51.60-78.58% of egg hatching, causing 47.25-68.30% mortality of early nymphal instars and 42.70-63.41% mortality of late nymphal instars across the locations. Besides, adult's malformation also observed from population emerging from the sprayed palms **(Fig 3).** The study revealed the potential of *I. fumosorosea* as a biocontrol agent for the suppression of *A. rugioperculatus* in coconut and oil palm.

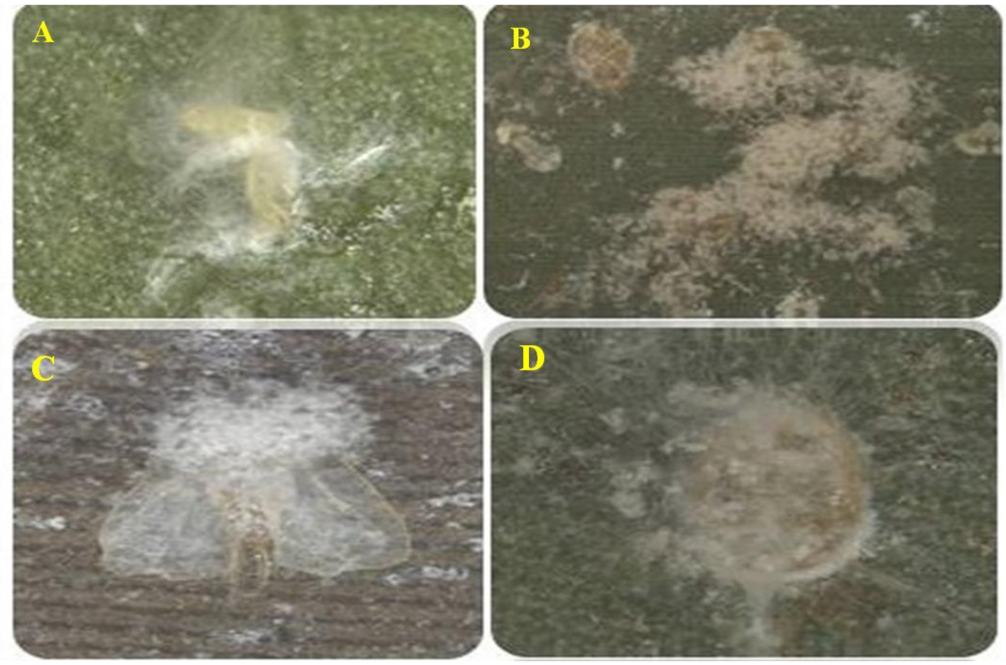


Fig. 3. A. Infection of *Isaria* on eggs; B & D Infection of *Isaria* on nymphs; C Infection of *Isaria* on adult.

Mass production and formulation of *Isaria fumosorosea*

Different liquid culture media like, potato dextrose broth (PDB), molasses yeast extract broth (MYB), jaggery yeast extract broth (JYB) and Sabourauds dextrose yeast extract broth (SDYB) in shaker cultures and a solid substrate, rice have been evaluated for growth and sporulation of *I. fumosorosea*. Highest colony forming units (CFU) were observed on rice grains (2×10^{13} CFU/g), followed by SDYB (2×10^{10} CFU/ml), JYB (8.5×10^{8} CFU/ml), PDB (8×10^{8} CFU/ml) and MYB (4×10^{8} CFU/ml). Talc formulation prepared from SDYB showed CFU of 5×10^{10}/g. The study indicated that rice grain or talc formulation of *I. fumosorosea* can be used for management of CRSW.

I.1.8 Endophytic establishment of *Beauveria bassiana* and *Metarhizium anisopliae* in cabbage for management of diamondback moth (*Plutella xylostella* (L.)

A glasshouse experiment was conducted to examine the endophytic ability of two isolates each of *B. bassiana* (Bb-5a & Bb-45) and *M. anisopliae* (Ma-4 & Ma-35) in cabbage root, stem and leaf tissues by seed treatment, root inoculation and foliar application. Confirmation of endophytic establishment in cabbage root, stem and leaves through plating technique and PCR methods after 15, 30, 45 and 60 days after treatment (DAT). In seed treatment, all four isolates showed maximum colonization in leaf, stem and root parts upto 30DAT, however, Ma-35 isolate showed colonization and persistence in leaf bits upto 60DAT. In root inoculation method, all isolates except Bb-5a showed colonization in leaf and stem upto 15DAT. Ma-35 isolate showed colonization and persistence in root, stem and leaf bits upto 60DAT. In foliar application technique, all four isolates showed colonization and persistence in stem and leaf tissues upto 15DAT. Bb-45, Ma-4 and Ma-35 isolates showed colonization and persistence upto 60DAT in leaf tissues Ma-4 isolate showed colonization only in stem and persisted upto 60DAT.SEM studies showed conidial germination and penetration of germ tube into the leaf tissues after five days of treatment with the four isolates tested. TEM studies showed the presence of conidia inside the parenchymatous and mesophyll cells of the treated leaves after 15 days.

I.1.9 Field evaluation of *Spilosoma obliqua*Nucleopolyhedrovirus (SpobNPV) in jute

Field evaluation on *Spilosoma obliqua* nucleopolyhedrovirus (SpobNPV) in jute revealed that 68.92%, 78.59% and 93.16% reduction in larval population of jute hairy caterpillar *S. obliqua* respectively at 3, 4, 7 days after spray of SpobNPVstrain NBAIR1 (1.5×10^{12} POBs/ha @ 2ml/L).

I.1.10. Field evaluation of *Spodoptera mauritia* NPV (SpmaNPV) against rice armyworm

Field evaluation of *Spodoptera mauritia* NPV (SpmaNPV) against rice armyworm *Spodoptera mauritia* was carried at Moncompu, Kerala. All the three concentrations of NPV (1×10^7 POBs/ml, 1×10^6 POBs/ml, 1×10^5POBs/ml) were found effective in reducing the larval population of armyworm. The number of larvae recorded for all the concentrations ranged from 1.33 to 3.75 where as it was 0.75 in the insecticide chlorpyrifos **(Table 3).** The concentration 1×10^7 POBs/ml was found most effective in reducing the larval numbers from 36.45 to 1.33 followed by concentration 1×10^6 POBs/ml which reduced from 40.25 to 3.15 and the concentration 1×10^5 POBs/ml reduced from 38 to3.75. The insecticide Chlorpyrifos reduced the larval numbers from 38 to 0.75.

Table 3. Field evaluation of biofficacy of *Spodoptera mauritia* NPV (SpmaNPV) against Rice armyworm (Moncompu, Kerala)

Treatments (Concentrations of NPV)	No of larvae/ 25 Hills			
		Days after treatment		
	Pretreatment	3	4	7
1×10^7 POBs/ml	36.45	20.83 [a]	10.50 [a]	1.33
1×10^6 POBs/ml	40.25	19.10 [a]	12.75 [a]	3.15
1×10^5 POBs/ml	36.50	20.50 [a]	11.25 [a]	3.75
Chlorpyrifos20EC@2ml/L	38.00	9.50 [b]	4.55 [b]	0.75
CD (P= 0.05)		6.68	4.12	NS

I.1.11 Taxonomy and biocontrol potential of entomopathogenic nematode in Deccan Plateau of India

A total of 22 soil samples were collected randomly from sugarcane and turmeric growing regions of Hosur, Belgaum and Karnataka. *Oscheius rugaoensis* NBAIRO27 isolated form Hosur, Belgaum, Karnataka. A soil sample drawn from sugarcane rhizosphere of Hosur, Belgaum, Karnataka and a positive sample was anticipated with *Oscheius* sp. nematode. Based on morphological and morphometrical studies, the EPN, *Oscheius*sp. was identified and designated as *O. rugaoensis* NBAIRO27. Further identity was confirmed with molecular characterization using the ITS-rDNA region. To our knowledge, this is the first report of *S. cholashanense* from India and this nematode can be used for the management of white grubs occurring in sugarcane fields.

Demonstration of *Heterorhabditis indica* NBAIRH38 and *Steinernema abbasi* NBAIISa01 WP formulation for management of sugarcane white grubs in Vijayapura and/or Bagalakot districts of Karnataka.

During 2018-19, two field demonstrations were carried out at Vijayapura district of Karnataka to evaluate the efficacy of two species of entomopathogenic nematodes (EPN), *Steinernema abbasi* and *Heterorhabditis indica*, along with a commonly used insecticide (chlorpyrifos) against *Holotrichia serrata*. Field trial data showed that the percentage reduction in *H. serrata* grub population was significantly higher using *H. indica* at a dose of 2.5×10^9 IJ ha^{-1} than *S. abbasi* and chlorpyrifos 20 EC application. Chlorpyrifos application was more efficient in reducing the grub population than both nematode species at the lower application rate (1.25×10^9 IJ ha^{-1}) **(Fig. 4)** and overall, these experiments suggest *H. indica* to be a promising biocontrol agent.

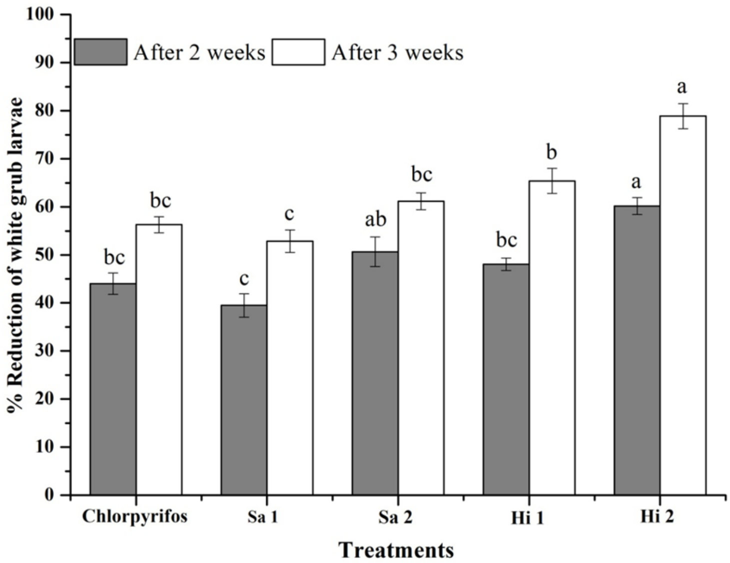


Fig.4

Fig. 4. Percentage reduction of secondinstar grubs of *Holotrichia serrata,* at 2 and 3 weeks after different treatments in in farmer's field at Vijayapura, Karnataka, India. Different letters on the top of error indicate statistically different values for different nematode concentrations at ($P < 0.05$) using Tukey's test. Bars = standard error. Sa, *Steinernema abbasi*; Hi, *Heterorhabditis indica*; 1 = 1.25×10^9 IJ ha^{-1}, 2 = 2.5×10^9 IJ ha^{-1}. Chlorpyrifos was used at the rate of 4,500 ml ha^{-1} as drench application.

Integrated management of root-knot nematodes in polyhouses using *Pochonia chlamydosporia*& growth promoting bacterium in capsicum and English cucumber and capsicum

Location 1: Kanakapura, Bengaluru Capsicum polyhouses

An experiment on integrated management of root-knot nematode infection in capsicum grown under polyhouse conditions using *Pochonia chlamydopsoria* and growth promoting *Bacillus* sp., in a farmer's polyhouse was carried out. Results indicated that root-knot nematode infection was significantly low (less than 1.0 RKI) in *P. chlamydosporia* and *Bacillus* sp. treatments and yield increase of capsicum of 18-24% was recorded.

Location 2: Dr YSR HU, Venkataramanagudem

An experiment was carried outin nematode infested-polyhouse at centre of excellence for protectedcultivation, Dr YSR HU, Venkataramanagudem, during January-May 2019 with applications of nematode-antagonistic fungus, *Pochonia chlamydosporia* NBAIR Vc56, PGP bacterium, *Bacillus* species NBAIRBfn1 and their combinations against root-knot nematode, *Meloidogyne incognita* in English cucumber. A standard check with carbofuran was kept for comparison. The experiment will be terminated during 3rd week of May 2019, and the data shall be presented at the AICRP BC Workers Group Meeting, June 6-8, 2019 at Anand.

I.2 REPORT FROM DIFFERENT AICRP-BC CENTRES

I.2.1 AAU-Anand

Location and agro climatic sub region: MiddleGujarat

Trichogramma

During 2018-19, sentinel cards with eggs of *C. cephalonica* were placed in cotton, groundnut, okra, maize, rice and tomato fields for parasitism by *Trichogramma* species in different geographical areas. Observed the emergence of *Trichogramma* spp., and *Trichogramma chilonis*. *Trichogrammatoidea bactrae* was observed in the cotton crop.

Chrysoperla

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

Coccinellids

Diversity of coccinellids from different crop ecosystems of the region was studied.*Cheilomenes sexmaculatus* Fabricius was found to be the predominant species. Majority of the species belonged to sub family Coccinellinae representing 40% of the total species collected, followed by Chilocorinae and Epilachinae.

Spiders

Spiders were belonging to three families namely Araneidae, Tetragnathidae and Thomisidae.

Isolation of antagonists/bioagents

In the year 2018-19, seventy soil samples collected from different locations of Gujarat were analyzed for the presence of EPN by using *Corcyra cephalonica* larvae (2nd and 3rd instar). Eight soil samples found positive for EPN. Out of 8 isolates, 7 turned to be *Steinernema pakistanense* (GenBank accession No. MK491792, MK491793, MK491794, MK491795, MK491796, MK491797, MK491798).

Anthocorids

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

Surveillance for alien invasive pests in vulnerable areas

a. *Brontispa longissima*
b. Aleurodicus dugesii
c. Phenacoccus manihoti
d. Phenacoccus madeirensis
e. Alien invasive pests of fruits and vegetables in the market yards.
f. Tuta absoluta
g. Paracoccus marginatus

Periodic surveys were carried out but none of the invasive pest listed above was recorded except *Paracoccus marginatus.*

I.2.2 AAU-Jorhat

Extensive surveys were conducted in ICR farm, AAU, Jorhat as well as in farmers' fields located at Rajabahar, Teok, Dangdhora, Allengmara, Neulgaon and Titabar during 2018-19 to record the population of natural enemy complex of rice and vegetables (brinjal, tomato, okra, cole crops cucurbits, papaya, bhut jolokia) of Jorhat districts.

In case of vegetables, coccinellid predators were recorded by visual counts per plant basis. Moreover, collection of egg masses and larvae of lepidopteran pests were made and reared in the laboratory for emergence of parasitoids. In rice and vegetables, sentinel cards containing 100 numbers of *Corcyra* eggs were placed for parasitization by Trichogrammatids. The spiders collected from different rice and vegetable fields were preserved in 70% alcohol. Highest number of spider population (1.0 to 3.0 spider/ m^2) was recorded in rice fields. One hundred and twelve numbers of spiders from 7 different families (Tetragnathidae, Lycosidae, Oxyopidae, Araneidae, Salticidae, and Linyphidae) were collected from different rice fields. The predominant spider was *Pardosa pseudoannulata* (32) and *Oxyopes javanus* (27). Both the spiders were active throughout the cropping season **(Table 4).**

Table 4. Natural enemies (Class: Arachnida) of the rice ecosystem

Arthropod groups	Common name	Scientific name	Relative abundance
Tetragnathidae	Long-jawed orb weaver	*Tetragnatha javana*	++
		Tetragnatha bengalensis	++
		Tetragnatha maxillosa	+
Lycosidae	Wolf spider	*Pardosa pseudoannulata*	+++
	wolf spiders	*Pardosa sumatrana*	+
Oxyopidae	Lynx spider	*Oxyopes shweata*	++
		Oxyopes javanus	+++
Araneidae	Orb spiders	*Cyclosa insulana*	+
	Orb spiders	*Argiope pulchella*	+
	Orb spiders	*Argiope catenulata*	++
	orb-weaving spider	*Araneus* sp.	+
	orb spider	*Neoscona bengalensis*	+
Salticidae	Jumping spider	*Phidippus indicus*	+
	Jumping spider	*Plexippus* sp	+
Linyphidae	Dwarf spiders	*Callitrichia formosana*	+

+++ = high; ++ = moderate; + = low

Moreover, in vegetative and reproductive growth stage of rice crop, more number of odonates (12 species), where 7 numbers of dragonfly and 5 numbers of damselfly were recorded. The most dominant damselfly and dragonfly species were *Agrionemisfemina* and *Brachythemis contaminate* in all rice growing areas. Among coccinellids, *Micrapsis crocea* was the most predominant in rice ecosystem **(Table 5).**

Table 5. Natural enemies (Class: Insecta) of the Rice ecosystem

Arthropod groups	Common name	Scientific name	Relative abundance
Order:Orthoptera			
Coenagrionidae	Damselfly	*Agrionemis femina*	+++
	Damselfly	*Agriocnemis pygmaea*	++
	Damselfly	*Ischnura aurora aurora*	++
	Damselfly	*Ischnura senegalensis*	+
	Damselfly	*Ceriagrion cerinorubellum*	+
Libellulidae	Dragonfly	*Brachythemis contaminate*	+++
	Dragonfly	*Crocothemis servilia servilia*	+
	Dragonfly	*Diplacodes nebulosa*	+
	Dragonfly	*Diplacodes trivialis*	+
	Dragonfly	*Neurothemis fulvia*	+
	Dragonfly	*Orthetrum sabina Sabina*	+
	Dragonfly	*Pantala flavescens*	+
Order: Coleoptera			
Anthicidae	Lady beetle	*Micrapsis crocea*	+++
	Lady beetle	*Harmonia eucharis*	++
	Lady beetle	*Menochilus sexmaculatus*	+
Cicindellidae	Tiger Beetle	*Cicindela undulate*	+++
	Tiger Beetle	*Cicindela melancholia*	+++
Trichogrammatidae	Trichogrammatid	*Trichogramma japonicum*	+++
	Trichogrammatid	*Trichogramma chilonis*	++

+++ = high; ++ = moderate; + = low

During survey period, 52 numbers of egg masses of stem borer was collected and per cent parasitasation by parasitoids was 9.2. The eggs are mostly parasitized by *Trichogramma* sp. and *Telenomus* sp. The per cent parasitisation by *Cotesia* sp. (Leaf folder larvae) was 15.8.

From vegetable ecosystem, maximum number of spiders was collected from tomato (24) and brinjal (11) and okra (12). Moreover, 283 numbers of predators like *Spalgius epius (*20*)*, Chysopids (28), *Coccinella septempunctata* (45), *C. transversalis* (50), *Serangium parcesetosum* (10*)*, *Harmonia dimidiata* (33), *Cheilomenes sexmaculata* (48) and *Brumoidessuturalis* (49) was recorded from different *rabi* and *kharif* vegetablesduring 2018-19 **(Table 6).**

Table 6: Natural enemies recorded from different crop ecosystem

Crop	Name of Insect	Natural enemies			
		Parasitoids	**Parasitisation (%)**	**Predator**	**Relative abundance**
Papaya	Mealy bug , *Paracoccus marginatus*			*Spalgius epius*, Chysopids	++ ++
Cabbage	Cabbage caterpillar, *Pieris brassicae*	*Cotesia vestalis*	15.3	*Coccinella septempunctata* *C. transversalis* *Serangium parcesetosum* *Harmonia dimidiata*	+++ +++ + ++
Bhut jalakia	*Aphis gossypi*			*Harmonia dimidiata* *Micraspis discolor* *Cheilomenes sexmaculata* *Brumoides suturalis* *Cocinella septempunctata*	+ +++ +++ ++ +++
Brinjal	*Aphis gossypi*			*C. transversalis*	+++
Okra				*Coccinella septempunctata* *C. transversalis*	+++ +++
Potato	Potato aphid, *Myzus persicae*			*Micraspis* spp.	+++

+++ = high; ++ = moderate; + = low.

I.2.3 MPKV, Pune

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

The natural enemies inclusive of coccinellids like *Coccinella septempunctata* L. *Menochilus sexmaculata* F., *Scymnus* sp., *Dipha aphidivora* Meyrick, *Micromus igorotus* Bank. and syrphid, *Eupeodes confrater* and the parasitoid *Encarsia flavoscuttellum* were recordedon sugar wooly aphid (SWA) in sugarcane, *Coccinella transversalis* F., *M. sexmaculata, Brumoides suturalis* F., *Scymnus coccivora*, *Triomata coccidivora* Ayyar and *B. suturalis* in mealybug colonies on custard apple, *Acerophagus papayae* N. & S., *Mallada boninensis* Okam. and *Spalgis epius* Westwood on papaya mealybug.

The sentinel egg-cards of *Corcyra* were deployed in the crops like cotton, maize, soybean, pigeon pea, sugarcane, tomato and brinjal to record parasitism of *Trichogramma* in Pune region, but the parasitoid was not recorded. The chrysopid, *Chrysoperla zastrowi* *sillemi* Esben. was observed in cotton, maize, bean, sorghum, okra and brinjal, while, *Mallada boninensis* Okam. on cotton, beans, mango, papaya and ornamental plants. The *Cryptolaemus* adults were recovered from the custard apple and papaya orchards, cotton and ornamental hibiscus. 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, cabbage, pigeonpea and tomato crops in farmer fields.

I.2.3.2 Monitoring the sugarcane woolly aphid incidence and impact assessment of natural enemies on its bio-suppression (MPKV, Pune)

The Pune and Solapur districts recorded slightly increase in SWA incidence (3.33 %) compared with Sangli, Satara and Kolhapur districts. The average SWA per cent incidence was 2.38 % and pest intensity rating was 2.00 **(Table 7).** The natural enemies recorded in the SWA infested fields were mainly the predators like *D. aphidivora* (1.00 to 2.50 larvae/leaf), *M. igorotus* (1.00-4.50grubs/leaf), syrphid, *Eupoderes confractor* (0.60-1.00 larvae/leaf) and spider (0.60-1.25 /leaf) during August to February, 2019. The parasitoid *Encarsia flavoscutellum* introduced from Assam (1.00-3.50 /leaf) found distributed and well established in almost all sugarcane fields and suppressed the SWA incidence in Western Maharashtra.

Table 7. Effect of natural enemies on incidence of sugarcane woolly aphids in Western Maharashtra

Districts surveyed	**SWA incidence (%)**	**Pest intensity rating (1-6)**	**Natural enemies/leaf**				**Spiders**
			D. aphidivora	***M. igorotus***	***E. flavoscu-tellum***	***E. confractor***	
Pune	3.33	2.00	2.50	4.50	3.50	1.00	1.00
Satara	2.00	2.00	2.00	1.00	2.00	0.60	0.66
Sangli	2.00	2.00	1.00	1.50	2.00	0.62	0.62
Kolhapur	1.66	2.00	1.21	1.50	1.00	1.00	0.60
Ahmednagar	2.00	2.00	1.00	1.00	2.00	0.62	1.25
Solapur	3.33	2.00	2.50	4.00	3.50	1.00	1.00
Average	**2.38**	**2.00**	**1.70**	**2.25**	**2.33**	**0.80**	**0.86**
Range	**0.20-3.40**	**2.00**	**1.00-2.50**	**1.00-4.50**	**1.00-3.50**	**0.60-1.00**	**0.60-1.25**

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

I.2.3.3 Survey and record of incidence of pinworm, *Tuta absoluta* on tomato

The survey and surveillance of natural enemies of pinworm, *Tuta absoluta* on tomato was conducted during April to March, 2019. There was no infestation of *T. absoluta* on tomato in Pune, Satara, Sangli, Solapur, Kolhapur, Ahmednagar, Nashik, Dhule, Nadurbar and Jalgaon districts of Maharashtra state.

I.2.3.4Monitoring the incidence of papaya mealybugs and its natural enemies on papaya and other alternate hosts (MPKV, Pune)

The papaya mealybugs were noticed to the extent of 1.0 to 3.00% in all districts of Western Maharashtra. It was relatively very low with 1.0 pest intensity rating during this year. The PMB incidence is noticed maximum (3.00%) in Shahada (Nandurbar) followed by Shirpur (Dhule) and Chopada teshil of Jalgaon district (1.00%) with state average of PMB incidence is 1.2%. The encyrtid parasitoid, *Acerophagus papayae* found parasitizing the mealybugs in almost all the papaya orchards surveyed and it was ranged from 0 to 2.5 adults/leaf.

Natural enemies recorded in papaya mealybug colonies are Encyrtid parasitoid, *Acerophagus papayae* N. & S, *Spalgius epius* (Westwood)**,** *Coccinella septempunctata* Linn.*Scymnus* sp., *Menochilus sexmaculatus* (Fab.), Anthocorids, *Mallada* sp., *Brumoides* sp. and Spiders. During survey, the papaya mealybug was observed on following plants/weeds namely *Parthenium* (*Parthenium hysterophorus* L.) Safed chafa (*Plumeria alba*) Mulberry (*Morus alba*) as alternate hosts in the vicinity of papaya orchards.

I.2.3.5 Monitoring the biodiversity and outbreaks of sap sucking pests, mirids and their natural enemies in *Bt* cotton ecosystem (MPKV, Pune)

The *Bt* cotton *var*. SWCH-4749 BG-II registered the incidence of aphids and jassids during 2nd week of July, 2017 (28th MW), while thrips and white flies were observed in the subsequent week. All these sucking pests were prevalent during the period from July to November 2018. The incidence of aphids (16.33-54.33), jassids (3.66-9.93), thrips (7.00-10.13) and whiteflies (2.33-5.93) per three leaves per plant found relatively high from 1st week of August to 3rd week of October, 2018. The peak incidence of aphid (54.33) and whitefly (5.93) were recorded during 3rd of October (42nd MW), while in case of jassid (9.93) it was recorded during 2nd October (41st MW). The highest population of thrips (4.66) was observed in 3rd week of September (38th MW). Mealybug *P. solanopsis* was not observed throughout the season in the experimental field (**Table 8**).

The natural enemies *viz.,* coccinellids, *Menochilus sexmaculata* Fab. and *Coccinella septempunctata* Linn. were recorded from 2ndweek of July to 3rd week of November 20187 (28th - 46th MW). The highest population of coccinellids (1.93 grubs and/or beetles/plant) was observed in 3rd week of October, 2018 (42nd MW). The chrysopid, *Chrysoperla zastrowi sillemi* Esben observed from 1st week of July, 2018 (28th MW) and peak population (1.8 grubs/plant) was recorded in 3rd week of October 2018. The spiders were noticed throughout the crop growth period and it was highest in 2nd week of August 2018 (33rd MW). The infestation of pink bollworm and red cotton bug was observed on *Bt* II cotton in western Maharashtra (**Table 8**).

Table 8. Incidence of sucking pests and their natural enemies in *Bt* cotton

Date of record		Av. population / 3 leaves / plant						
	Aphids	**Jassids**	**Thrips**	**White flies**	**Mealy bug**	**Chrysopid**	**Coccinellids**	**Spiders**
09.07.2018	4.06	4.20	0.00	2.00	0.00	0.33	1.13	0.00
16.7.2018	4.66	3.93	5.33	2.20	0.00	0.33	1.40	0.40
23.07.2018	1.66	1.20	2.66	1.66	0.00	0.26	0.66	0.53
30.07.2018	8.66	4.66	6.06	2.20	0.00	0.33	0.87	1.00
06.08.2018	16.33	3.66	7.00	2.33	0.00	0.07	2.20	1.13
13.08.2018	20.20	6.60	8.06	3.86	0.00	0.00	1.53	1.33
20.08.2018	22.20	7.33	10.66	2.13	0.00	0.00	2.80	1.26
27.08.2018	15.33	3.66	5.36	1.20	0.00	0.00	1.86	0.93
03.09.2018	26.80	5.33	6.13	1.53	0.00	0.40	2.06	1.00
10.09.2018	32.66	6.06	5.86	1.93	0.00	0.53	2.13	0.86
17.092018	36.73	7.13	8.93	3.20	0.00	0.00	1.46	0.67
24.09.2018	40.06	8.33	10.13	3.66	0.00	0.66	1.60	0.53
01.10.2018	44.66	9.33	7.86	4.06	0.00	1.33	1.33	0.67
08.10.2018	41.06	9.93	4.33	4.66	0.00	1.53	1.53	0.80
15.10.2018	54.33	6.33	1.4	5.93	0.00	1.80	1.93	1.13
22.10.2018	52.33	3.80	0.66	3.80	0.00	0.46	1.46	0.67
29.10.2018	40.26	3.13	0.00	2.80	0.00	0.00	0.93	0.33
07.11.2018	27.36	2.20	0.00	1.66	0.00	0.00	0.67	0.20
14.11.2018	13.33	1.33	0.00	0.93	0.00	0.00	0.47	0.00
Range	**1.66 - 54.33**	**1.20-9.93**	**0.66-10.66**	**0.93-5.93**	**0.00**	**0.07 - 1.80**	**0.47 – 2.80**	**0.20-1.33**

I.2.4 PAU, Ludhiana

Isolation of microbials from various agro-ecological zones of Punjab

Forty two samples of soil/insect cadavers collected from different crops from different zones of Punjab were processed for the isolation of entomopathogenic fungi. Three entomopathogenic fungi have been isolated from these samples and slants of these will be sent to NBAIR, Bengaluru for confirmation, identification and repository deposit.

Diversity of insect pests and natural enemies on vegetables under polyhouse conditions

The diversity of insect pests was recorded on cucumber crop grown under net house conditions during 2018. Four species of insect pests namely red spider mite, *Tetranychus urticae* whitefly, *Bemisia tabaci*, leafminer, *Liriomyza* sp. and aphid, *Myzus persicae* were recorded. Amongst these, red spider mite and whitefly were pre-dominant species during spring and rainy season crops, respectively **(Table 9).**

Table 9: Insect pests recorded on cucumber crop under net house conditions during 2018

Season	Insect pests	Pre-dominant species	Peak incidence
Spring season crop	Red spider mite, *Tetranychus urticae* Leafminer, *Liriomyza* sp. Whitefly, *Bemisia tabaci* Aphid, *Myzus persicae*	Red spider mite (2.4 - 90.3 / leaf)	4th week of May
Rainy season crop	Whitefly, *Bemisia tabaci* Leafminer, *Liriomyza* sp. Red spider mite, *Tetranychus urticae*	Whitefly (0.2 – 10.0 adults/ leaf)	1st week of October

I.2.5 SKUAST, Srinagar

I.2.5.1 Biodiversity of natural enemies of pests of apple, apricot, plum, pear, peach, cherry walnut and almonds.

A total of thirty one natural enemies including parasitoids and predators belonging to the orders Coleoptera, Diptera, Neuroptera, Hymenoptera and Mesostigmata were collected from fruit orchards in different districts of Kashmir and Laddakh during 2018-19. Apple indicated a healthy fauna of natural enemies comprising of 20 species associated with apple aphids (*Aphis pomi*), San Jose scale (*Quadraspidiotus perniciosus*), Wooly aphid (*Eriosoma lanigerum*), European red mite (*Panonychus ulmi*) and Two spotted spider mite (*Tetranychus urticae*). Majority of natural enemy on apple were associated with apple aphid (9 spp.), followed by San Jose scale (6 spp.), Wooly apple aphid (3 spp.) and European red mite and two spotted spider mite (2 spp.). Out of 20 natural enemies on apple, 16 predator spp. and 4 parasitoid spp. were collected. Per cent parasitism by *Aphelinus mali* on woolly apple aphid was found highest (34.0-80.0%) in unmanaged orchards. Parasitism by *Encarsia perniciosi* and *Aphytis proclia* ranged 14.0-29.0%) in similar orchards. However, parasitism by above mentioned parasitoids was minimal in managed orchards. Hyper parasitoids such as *Marietta* sp. and *Azotus kashmiriensis* were found associated normally with *E. perniciosi* and *A. proclia*. Number of natural enemies recorded on walnut, plum, pear and pomegranate were 1, 3, 4 and 3, respectively. *Chilocorus infernalis* was found actively associated with San Jose scale on apple and *Parthenolecanium corni* on plum. Among the reported natural enemies, predators constituted 81.0% with 80.0% share of coccinellids, and 19.0% parasitoids.

I.2.5.2 Monitoring of apple codling moth from various agro-ecological zones of Kashmir to see its spread

Different villages between Chanigund and Drass sector of Kargil district were visited for ascertaining the spread of codling moth. The villages Thasgum, Bimbat, Chokiyal, Jasgund, did not show the presence of the pest. Sporadic occurrence was however reported from the following villages Kaksar, Dandalthung and Khebair. Other districts such as Anantnag, Budgam, Baramullah, Pulwama, Kupwara, Bandipora, Ganderbal and Srinagar did not indicate occurrence of Codling moth. Although lepidopteran pests like *Archips pomivora*, Fireworm, Hairy caterpillar etc. were found at many places, but no Codling moth was reported in these districts. Incidence of fire worm was observed in some areas of Bandipore.

I.2.6. TNAU, Coimbatore

1.2.6.1 Survey, surveillance and monitoring of rugose whitefly and their natural enemies on coconut

Rugose whitefly and their natural enemies on coconut were monitored during 2018-19. The pest population escalated from July to November, 2018 and declined from Dec. 2018 to March 2019. The occurrence of RSW was recorded in various Districts in Tamil Nadu *viz.,* Coimbatore, Tirupur Theni, Thanjavur, Cuddalore, Kanyakumari, Tiruvarur, Tirunelveli Dindigul and Erode.The infestation index ranged between 1.00 and 3.00 in various Districts in Tamil Nadu. The parasitisation by *Encarsia guadeloupae*ranged between 10.00 and 100.00% on coconut gardens. A diverse array of predators *viz.,* *Chilocorus nigrita*, *Coccinella transversalis, Mallada desjardinsi, Cheilomenes sexmaculatus, Propylea dissecta, Scymnus nubilis, Scymnus saciformis, Chrysoperla zastrowi sillemi* are present in association with RSW colonies.

1.2.6.2 Survey and surveillance of natural enemiespinworm, *Tuta absoluta* on tomato

The occurrence of tomato pinworm, *Tuta absoluta* was monitored using water pan trap in tomato growing areas of Coimbatore district *viz.,* Rottigoundanur, Thondamuthur and Thudiyalur. The moth population ranged between 3.00 and 15.00 per plant from first fortnight to second fortnight of December. In Thondamuthur block, the leaf and fruit damage was recorded as 10.0 and 4.0%, respectively. The occurrence of pinworm was also recorded from other districts of Tamil Nadu *viz.,* Dharmapuri, Krishnagiri and Erode. It was not observed in any other alternate host crops like potato, brinjal, chilli and tobacco.

1.2.6.3 Monitoring and record of incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts

The infestation of *Paracoccus marginatus* was noted in crops like papaya, tapioca, mulberry, guava, brinjal and cotton. The incidence of papaya mealybug was recorded in Coimbatore, Erode, Tiruppur, Salem, Karur, Villupuram, Karur, Cuddalore and Namakkal districts of Tamil Nadu. The occurrence of this pest was observed from August to December, 2018 and it was more in Erode, Tirupur, Coimbatore and Karur districts **(Table 10).** It was also observed that the papaya mealybug parasitoid, *Acerophagus papayae,* has widely spread and established in papaya and cassava crops inTamil Nadu. Natural predators like *Cryptolaemus montrouzieri*, *Spalgiusepius* and *Malladaigorotus* were also noted.

1.2.6.4 Survey, surveillance and collection of natural enemies including spiders in different agro-ecological zones and on different crops

The natural enemies *viz*., *Trichogramma* sp., *Cryptolaemusmontrouzieri*, *Chrysoperla zastrowi sillemi*and parasitoids of papaya mealybug, scales were collected. The parasitoid of rugose whitefly in coconut was identified as *Encarsia guadeloupe*. The activity of egg parasitoid, *Trichogramma* sp. parasitizing fruit borer of tomato, bhendi and shoot and fruit borer of brinjal, bud borer of jasmine and DBM in cabbage was observed. The predators *viz.,C. montrouzieri*, *Chrysoperla zastrowi sillemi and Mallada* sp was seen on mealybug, scales, whiteflies, psyllids infesting the crops namely tapioca, papaya, brinjal, bhendi, curry leaf and coconut while *Dipha aphidivora* and *Micromus igorotus* were observed on sugarcane woolly aphid. Spiders *viz., Telamonia dimidiata, Peucetia viridana* were collected from brinjal field.

1.2.6.5 Monitoring of sugarcane woolly aphid incidence and impact assessment of natural enemies on its bio suppression

The incidence of sugarcane woolly aphid was only recorded at Ravathur area of Coimbatore District during August 2018 at high intensity with 11.5 SWA/6.25 cm^2leaf. The natural enemies associated with woolly aphid observed were *Dipha aphidivora, Micromusigorotus* and *Encarsia* sp.

Table 10. Incidence of papaya mealybug and its natural enemies

Places surveyed	Period	*P. marginatus* incidence (%)	Natural Enemy/5 leaves			
			A. papayae	*Cryptolaemus*	*Mallada*	*Spalgis epius*
Coimbatore	July 18	--	--	--	--	--
	Aug 18	3.5	2.0	1.0	--	1.0
	Sep 18	6.4	3.0	2.0	--	1.0
	Oct 18	8.2	3.0	4.0	--	--
	Nov18	--	--	--	--	--
	Dec 18	--	--	--	--	--
	Jan 19	--	--	--	--	--
	Feb19	--	--	--	--	--
	Mar 19	--	--	--	--	--
Erode	July 18	--	--	--	--	--
	Aug 18	7.0	2	1	--	2
	Sep 18	11.5	4	2	--	2
	Oct 18	10.0	2	2	1	1
	Nov18	10.5	5	2	--	1
	Dec 18	6.0	2	--	--	1
	Jan 19	--	--	--	--	--
	Feb19	5.4	2	1	--	1
	Mar 19	11.2	4	1	--	1
Karur	July 18	--	--	--	--	--
	Aug 18	5.5	2	1	--	
	Sep 18	6.0	2	--	--	1
	Oct 18	8.5	3	1	--	2
	Nov18	5.0	3	2	--	--
	Dec 18	4.5	2	1	--	--
	Jan 19	--	--	--	--	--
	Feb19	--	--	--	--	--
	Mar 19	--	--	--	--	--
Tirupur	July 18	--	--	--	--	--
	Aug 18	8.0	3	1	--	1
	Sep 18	6.5	2	--	--	1
	Oct 18	--	--	--	--	--
	Nov18	4.0	1	2	--	--
	Dec 18	--	--	--	--	--
	Jan 19	4.5	1	2	--	--
	Feb19	--	--	--	--	--

	Mar 19	--	--	--	--	--
Trichy	July 18	--	--	--	--	--
	Aug 18	5.2	2	1	--	--
	Sep 18	--	--	--	--	--
	Oct 18	--	--	--	--	--
	Nov18	--	--	--	--	--
	Dec 18	6.0	3	1	--	--
	Jan 19	--	--	--	--	--
	Feb19	--	--	--	--	--
	Mar 19	--	--	--	--	--
Namakkal	July 18	--	--	--	--	--
	Aug 18	--	--	--	--	--
	Sep 18	5.7	4	2	--	2
	Oct 18	--	--	--	--	--
	Nov18	7.4	3	2	1	--
	Dec 18	--	--	--	--	--
	Jan 19	6.5	3	1	--	--
	Feb19	--	--	--	--	--
	Mar 19	--	--	--	--	--

I.2.7 YSPUHF, Solan

The survey carried during April to September 2018 at Bilaspur, Mandi, Kullu, Solan, Sirmaur, Shimla, Kangra, Kinnaur and Lahaul & Spiti districts against the temperate crops (apple, apricot, peach, plum, almond) and vegetable crops (tomato, cucumber, brinjal, okra, cole crops, capsicum) recorded an array of coccinellids like *Coccinella septempunctata, Hippodamia varigieta, Adalia tetraspilota, Cheilomenes sexmaculata, Propylea lutiopustulata, Chilocorus infernalis, Priscibrumus uropygialis, Platynaspis saundersii, Harmonia eucharis, Oenopea sauzetii, Oenopia kirbyi, Oenopia sexareata, Scymnus nubilus, Scymnus posticalis, Coelophora bissellata, Harmonia dimidiata*, *Scymnus* sp and the chrysopids, *Chrysoperla zastrowi sillemi.* The flowering plants surveyed in theNauni, Solan, Nainatikkar, Sarahan, Rekongpeo, Kalpa, Kullu, Kelong locations during April to September 2018 recorded the syrphid flies, *Episyrphus balteatus, Eupeodes frequens, Melanostoma univitatum, Betasyrphus serarius, Sphaerophoria indiana, Ischiodon scutellaris. Dinocalpus coccinellae* has been recorded as theparasitoid of coccinellids, *Coccinella septempunctata* atNauni region. *Diadegma semiclausum* and *Diadromus collaris* was recorded as parasitoids of DBM. Peach aphid was predated by the anthocorid bugs *Orius* sp. and *Anthocoris* sp are recorded at Rekongpeo during April-July, 2018. The tomato grown at Nauni, Nainatikkar, Sarahan, Nahan, Mandi locations during June to September 2018 were affected by *Tuta absoluta,* greenhouse whitefly, serpentine leafminer and phytophagous mites. The predator feeding the tomato pests are *Nesidiocoris tenuis, Neochrysocharis formosa.*

Besides above mentioned natural enemies, *Cotesia glomerata* parasitizing *Pieris brassicae* in cauliflower and *Campoletis chlorideae* parasitizing *Helicoverpa armigera* in tomato, *Diplazon* sp. parasitizing syrphid flies, *Trathla* sp. parasitizing brinjal shoot and fruit borer were also collected from Nauni.

I.2.8 CAU, Pasighat

Biodiversity of Bio-control agents from Arunachal Pradesh

Eighteen species of spider has been collected from different crops and they are preserved in 95% ethyl alcohol.

Biodiversity of entomopathogenic nematode from Arunachal Pradesh

Random survey was conducted during June to November 2019 for isolation and identification of EPN from Arunachal Pradesh. A total of 30 soil samples were collected from Arunachal reserve forest at Ruksin block. Insect baiting technique was used to determine the presence of EPN, *Steinernema* spp.

I.2.9 MPUAT, Udaipur

Biodiversity of natural enemies of pests of chickpea, tomato and maize

The surveys conducted from July to September, 2018 in sole maize crop and November, 2018 to February, 2019 in chickpea and tomato crops at Udaipur, Chittorgarh and Bhilwara districts of Rajasthan recorded the predators, *Coccinella septempuctata* Lin., *Cheilomenes sexmaculata* Fab., *Illeis cincta* (Fabricius), *Brumoides suturalis* (Fabricius), *Chrysoperlazastrwoi sillemi* (Stephen). The parasitoids reported are *Cotesiaflavipes* (Cameron) and *Campoletus chloridae.*

I.2.10 OUAT, Bhubaneswar

Survey, surveillance and monitoring of rugose whitefly and their natural enemies on coconut

Surveys conducted in the coconut plantations of Khurda, Cuttack, Jajpur and Puri districts reported no incidence of RSW.

Seasonal abundance of spiders in rice ecosystem by general collection, pitfall traps and sweep net method

The spiders were collected from paddy fields grown in the entomological research fields of OUAT, Bhubaneswar during *kharif* season of 2018. The spiders belonging to four genera and two families namely *Araneus ellipticus, Argiope* sp. *Neoscona* sp., *Tetragnatha mandibulata* and *Tetragnatha maxillosa* were recorded.

I.2.11 UAS, Raichur

Monitoring of sucking pest complex, Pink bollworm and their natural enemies in cotton

In Non *Bt* Hybrid BGDS-1063, peak activity of 8.62 thrips/leaf, 11.32 leafhoppers/leaf and 8.72 aphids/leaf were noticed during first week of October, November and last week of December respectively. Whiteflies were negligible throughout the cropping period. Predator's likespiders, syrphids and coccinellids activity was coincided with the peak activity of the pest population. A maximum of 1.98 mirid bugs per 25 squares was noticed during second week of November. The peak activity of mealybug was noticed during last week of January (22.56/2.5 apical shoot length/plant. The primary parasitoid (9.86/ 2.5 cm apical shoot length/plant) was noticed during third week of February and eliminated the pest completely at final picking of the crop.

The activity of PBW moth started from third week of September and continued till harvest of the crop. Maximum moth catches were recorded on last week of November (117 moths/trap/week) and highest number of larvae (14.86/10 bolls) were recorded during second week of January with 65% locule damage at the time of final picking.

I.2.12 CISH, Lucknow

Biodiversity of bio-control agents from mango ecosystem

Peak hopper and thrips infestation were recorded during 15th SMW with 15.5 hoppers/sweep and 68.75 thrips/tap respectively. Among the natural enemies, spider and coccienellids population was high during 21and 20 SMW with number being 2.3/tree and 4.2 adults/tree, respectively **(Table 11).***Coccinella septempunctata, Cheilomenes sexmaculata,, Chilocorus rubidus, Scymnus* sp. were observed feeding on mango hoppers, most abundant was *Coccinella septempunctata.* Peak population of hoverflies and chrysopids was recorded during 18th and 16th SMW with 4.2 and 1.3 adults /tree respectively. *Glyptapanteles* sp. (Braconidae) and *Tetrastichus* sp. (Eulophidae) has been found parasitizing on mango hairy caterpillar.

Table 11. **Predator population dynamics in relation to the pest population in mango ecosystem during 2018**

SMW	Hopper (No./panicle/sweep)	Thrips (No./tap)	Spider (No./tree)	Coccinellids (No./tree)	Hoverflies (No./tree)	Chrysopids (No./tree)
10	11.8	0	0.00		0.08	0
11	5.45	1.7	0.00	0	0.21	0
12	5.45	3.15	0.00	0	0.12	0
13	10.8	1.65	0.80	0	0.37	0
14	10.6	0.55	0.80	0	0.14	0
15	18.55	68.75	1.50	0.15	0.02	1.2
16	12.65	35.2	0.45	0.2	4.20	1.3
17	12.85	26.9	0.45	2.6	3.25	0
18	13.85	9.7	0.45	2.5	4.58	0
19	8.7	6.2	0.30	3.8	3.60	0
20	11.9	3.8	2.30	4.2	2.10	0
21	15.95	3.55	2.60	2.3	0.25	0
22	9.25	15.55	2.55	1.2	0.22	0
23	8.7	1.65	0.90	0.28	0.10	0
24	3.8	2.3	0.15	0.1	0.00	0
25	1.5	0	0.35	0	0.00	0

I.2.13 CPCRI, Kayamkulam

I.2.13.1 Survey, surveillance and monitoring of rugose whitefly and their natural enemies on coconut

The rugose spiralling whitefly has reached all coconut growing regions of South to North-East India (Assam). A new distribution record of RSWwas confirmed from Nalbari and Kamrup districts of Assam infesting coconut, arecanut, ornamental yellow palm, banana and crotons in August 2018. Natural parasitism of 82.1% by *Encarsia guadeloupae* on RSW was observed at Nalbari and Kamrup districts. The green lacewing, *Pseudomallada astur* resulted in low RSW, was observed in Madhapur, Nalbari districts. RSW population was reduced immediately after monsoon in Andhra Pradesh and Tamil Nadu but soared in few coconut gardens during winter months.

Two species of new invasive nesting whiteflies were reported infesting coconut leaves at Kerala. The neotropical invasive Bondar's nesting whitefly, *Paraleyrodes bondari* Peracchi and the exotic nesting whitefly, *Paraleyrodes minei* Iaccarino. *Paraleyrodes bondari* constructs unique woolly wax nests on abaxial palm leaflets and possesses "X"-shaped oblique greyish bands on wings. Nesting whiteflies are quite small (1.00 - 1.20 mm) and the immature stages *viz*., nymphs and pseudo-pupae have been flat. Distinct cephalic and abdominal pores on pupae and the male genitalia aid in taxonomy with *P. bondari* possessing apicolataeral processes whereas *P. minei* had the cock-head like aedeagus. Concurrent co-existence of *P. bondari* and *P.minei* on coconut palms along with *Aleurodicus rugioperculatus* was observed in Kayamkulam, Kerala. Quantum of honey dew excreted by nesting whiteflies are low than RSW **(Fig. 5) (Fig. 6).**

Bondar's Nesting Whitefly (BNW), *Paraleyrodes bondari* Peracchi-adults, colony, eggs and crawlers and *P.minei* devoid of markings on wings. Fig. 5

P. bondari Male genitalia *P. minei* Male genitalia

Fig6

The voucher specimens of *Paraleyrodes bondari* Peracchi and *Paraleyrodes minei* Iaccarino after confirmation are further deposited in ICAR-NBAIR repository as NBAIR/Hem-1/2019 and NBAIR/Hem-W8/2019, respectively. At Kasaragod and Kayamkulam, *P. minei was* also found on guava and the ornamental plant, *Heliconia* sp. Alternate hosts recorded during survey are rudraksha tree (*Elaeocarpus* sp.), red sanders (*Pterocarpus* sp.) and cinnamon tree (*Cinnamomum* sp.). In Kasaragod and Karnataka, *P.*

minei predominates whereas *P. bondari* is found predominant in other districts of Kerala such as Kozhikode, Thrissur, Ernakulam. Polyphagous nature, short life cycle and invasive potential of the pest call upon strict policy frameworks in exchange of planting materials to prevent its spread to other areas in future.

Pesticide holiday approach and conservation biological control of RSW

Pesticide holiday approach, jet propulsion spray of water on palm leaflets and conservation biological control of RSW using the aphelind parasitoid, *Encarsia guadeloupae* was found successful. The RSW population reduced in Kerala and Tamil Nadu aided by the natural parasitism of *E. guadeloupae* accomplished in a period of 8-10 months. Approximating 300 million coconut palms in the country having sprayed with chemicals averaging Rs 15/- per palm, a total of 4.5 billion Indian rupees was saved for the country and chemicals harming ecosystem is entirely dispensed with saving several more billion rupees as well. Thus, a classical success story of conservatory biological control that ensured safety to mankind and the naturale was augured for the first time in the perennial palm system in Kerala.

I.2.13.2 Natural re-emergence of sooty mould feeding beetle, *Leiochrinus nilgirianus*

First occurrence of sooty mould feeding Leiochrinid beetle, *Leiochrinus nilgirianus* Kaszab (Tenebrionidae: Coleoptera) was reported from Kayamkulam on RSW infested coconut palm during June-July, 2017. The scavenger beetle, *L. nilgirianus* could not be observed beyond November 2017 till May 2018 after withdrawal of monsoon. With the onset of South-West monsoon showers in June 2018 at Kayamkulam, *L. nilgirianus* re-emerged with the active presence of immature stages, feeding on the sooty mould deposits and cleansing the palm leaflets. Dissection of field collected *L. nilgirianus* revealed sooty mould laden food bolus further confirming its feeding on sooty moulds in moist environment.

Introductory Biological Scavenging programme launched by ICAR-CPCRI in Andhra Pradesh, Tamil Nadu and Assam on palms infested by rugose spiralling whitefly

The launching ceremony of the introductory biological scavenging programme by importing the sooty mould feeding *L. nilgirianus*, first of its kind, was held during the inauguration of the KRUSHIVALA Coconut Farmers Producers Company held at Amalapuram, Andhra Pradesh on August 2018. Field release of the beetle was also undertaken at West Godavari district of AP and other states (Tamil Nadu and Assam).

I.2.14 IIMR, Hyderabad

Studies on abundance of natural enemies of borers in Millets, IIMR, Hyderabad (2018-19)

During *kharif* 2018, *Chilo partellus* was predominant (10-15%) as compared to *Sesamia inferens* (5-7%) in Sorghum. About 25% parasitisation by *Cotesia flavipes* was observed. Shoot fly incidence ranged from 30–75% while in *rabi* incidence ranged from 25.0-70%. In Barnyard, Proso, Little, Kodo millets the incidence of shoot flies was recorded at seedling, panicle stages causing deadhearts (10-40% DH) and white ears (10– 30%), respectively. Egg parasitoid *Trichogrammatoidea simmonds*i (18%); larval parasitoid, *Neotrichoporoides nyemitawus* (21%) and pupal parasitoid, *Spalangia endius* (13%) were found parasitizing shoot flies across species and millets.

Surveys for incidence of *Spodoptera frugiperda* was carried out during *kharif* season in Mahboobnagar (Telangana), Parbhani, Rahuri, Akola (Maharastra) where incidence of pest was observed at low levels (< 5.0%) on Sorghum. Incidence was not observed at Hisar, Udaipur, Ludhiana, Indore and Surat. During *rabi* at medium to severe damage (10.0 - 60.0%) was observed across the millets. On an average 1-2 larvae were found in each whorl of Sorghum, Pearl millet **(Fig. 7).**

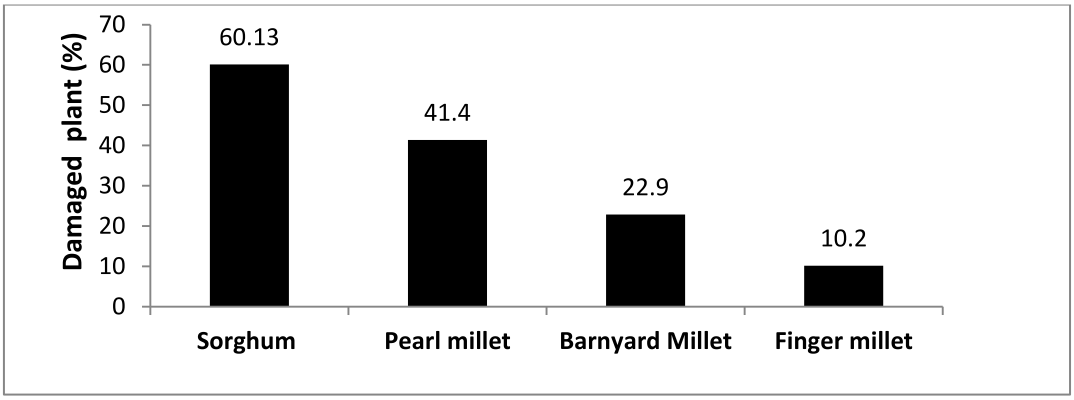


Fig.7. Incidence of Fall armyworm in Millets (*rabi*, 2018, IIMR, Hyderabad)

I.2.15 IIRR, Hyderabad

Seasonal abundance of spiders in rice ecosystem by general collection, pitfall traps and sweep net method

Survey and collection of spiders was done at the Indian Institute of Rice Research, Hyderabad and Nalgonda Telangana, in farmer's fields. Samples were collected from sweep net, yellow pan trap and pitfall traps. The species collected and their abundance are listed in (**Table 12).**

Table 12. Spider fauna observed in rice fields

Family	Genus	Stage Observed	Average no/ 5 sweeps
Araneidae	*Neoscona inusta*	Active tillering to harvest	2.5
	Neoscona sp		6
	Argiope bruennichii Scopoli		0.5
	Argiope catenulata (Doleschall)		2.2
Tetragnathidae	*Tetragnatha maxillosa*	Active tillering to harvest	5.8
	Tetragnatha javana		2.4
	Tetragnatha nitens		6.3
	Leucage decorata	Reproductive stage	1.2
Salticidae	*Bianor* sp.	Nursery to flowering	4.8
	Oxyopes javanus	Active tillering to harvest	2.1
	Oxyopes salticus		3.1
	Myrmarachne sp	Flowering	0.5
	Plexippus sp.	Active tillering	1.3
Lycosidae	*Pardosa pseudoannulata*	Nursery to harvest	4.4 (Pit fall)
	Pirata sp.		1.2
	Hippasa sp.		1.0
Sparassidae	*Olios* sp.	Reproductive stage	1.0
Cheiracanthiidae	*Cheiracanthium* sp.	Reproductive stage	1.8
Clubionidae	*Clubiona* sp.	Active tillering to harvest	3.9
Linyphiidae	*Atypena* sp.	Reproductive stage	2.1
Theridiidae	*Chrysso* sp.	Active tillering	1.0
Thomisidae	*Thomisus* sp.	Reproductive stage	4.3

The most abundant group were the Tetragnathids, followed by the Lycosid and *Pardosa*.

I.2.16 IIVR, Varanasi

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

The pin worm damage was observed during second week of December (50^{th} SMW) onwards and continued till last week of March, 2019 (14^{th} SMW). The maximum fruit damage was recorded during the 10^{th} SMW (5% fruit damage). The polyphagous predator namely *Nesidiocoris tenuis* was observed in abundance (maximum 4.3 bugs / apical twigs) feeding on early instar larvae and other soft-bodied insects in tomato field.

I.2.17 UBKV, Pundibari

Survey, surveillance and collection of natural enemies of major pests infesting tea, mustard and mungbean

The survey carried at tea garden in Pundibari during July-September, 2018 recorded the following pests, tea mosquito bug (*Helopeltis* sp.), tea looper (*Hyposidra talaca*), tea jassid (*Empoasca flavescens*), tea aphid (*Toxoptera aurantii*) and red spider mite (*Oligonychus coffeae*). Natural enemies observed in the same tea garden were dragon fly, *Forficula* (Earwig) and *Calosoma* (Ground beetle), *Trichogramma* sp. and *Cotesia* sp.The mungbean and mustard crop grown at Pundibari during October-December, 2018 recorded the following natural enemies *Trichogramma* sp., *Tetrastichus* sp., *Chelonus* sp., *Bracon* sp.and *Ichneumon* sp.

I.2.18 PJTSAU, Hyderabad

Biodiversity monitoring of sucking pest complex, Pink Boll Worm and their natural enemies in cotton belt of Telangana state

Incidence of sucking pests and their natural enemies in *Bt* cotton in Telangana

The *Bt* cotton growing areas of Telangana *viz*., Adilabad, Warangal, Rangareddy, Nalgonda and Khammam districts were surveyed for infestation and intensity of sucking pest incidence. Four species of Mealybugs, *viz*., *Paracoccus marginatus, Maconellicoccus hirsutus, Phenacoccus solenopsis*, and *Ferrisia virgata* were recorded. *P. solenopsis* was the predominant species recorded on cotton. Jassid attack was found to be more in Warangal and Nalgonda. PBW was recorded around ETL in Adilabad and Warangal. The natural enemies, *viz*., *Acerophagus papayae*, *Cryptolaemus montrouzieri*, *Coccinella septumpunctata* and *Chrysoperla* were recorded on different species of mealybugs.

Incidence of Pink Boll Worm in *Bt* cotton in Telangana

After heavy infestation during August, PBW infestations in the cotton belt of Telangana started coming down as evidenced by trap catches and also damage levels by PBW. Owing to early rains and intermittent dry spells the sowing operations started as early as from last week of May 2018 and continued till first week of August 2018. This unusual wide sowing window resulted in to staggered sowing of the crop across the state is seen as one reason for spread of PBW in addition to carry over population of PBW due to crop stubbles and damaged plant parts of earlier season left over in the field. As a result of staggered sowing, the crop is in different stages now. Early sown crop (50-60%) sown between May to June 15th is in flowering, boll formation & boll development stages while the late sown crop is in vegetative to square formation stage. It has been observed that in many cotton growing areas of Telangana, the incidence of PBW was reaching above ETL even though initially in the first & middle stages of the crop the PBW incidence was below ETL. Though the incidence of PBW is sporadic & moderate in early sown/early flowered crop till July-August, it has spread & intensified further during late August, in view of the availability of crop in varying stages and also because of availability of the pest inoculum due to early incidence. Later stages of the crop hosted high infestation levels even by witnessing 3-4 larvae in a single square/flower. Several mandals across the cotton growing districts of the state were found to be affected by PBW in Telangana irrespective of type of hybrids grown. The sporadic & moderate incidence of PBW was noticed in Adilabad, Warangal and Nagarkurnool districts. Some packets of Jogulamba Gadwal district also recorded considerable incidence, in view of presence of early sown seed cotton crop.

II. SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS

II.1 Surveillance

II.1.1 AAU- Anand

Wheat

During February 2019, incidence (6-10%) of green aphid was recorded at Tarapur village in Sojitra taluk of Anand district. Coccinellid beetles were observed.

Maize

Surveys undertaken during the month of August 2018 recorded moderate incidence of stem borer in maize at Bedhiya in Kalol taluk of Panch Mahal district. Natural parasitization by parasitoid, *Cotesia*sp was observed. In Karena in Amod taluk of Bharuch district, moderate level of infestation of sucking insects was observed in Okra. During October 2018 to January 2019, moderate to severe incidence of fall armyworm, *Spodoptera frugiperda* was recorded in sweet corn in Chikodra, Vaghasi,Surkuva, Shihole, Sandesar, Sarole, Borsad, Sardarpura, AAU Campus, Sojitraand Morai villages of Anand district. Natural enemies like *Chrysoperla zastrowi sillemi* and NPV and fungus infected larvae were observed. Sorghum crop grown at AAU campus at Anand recorded 3-4% incidence of fall armyworm during January 2019.

At Jitodiya, Karamsad, Sandesar, Sihol, Bhawanipura, Davalpura, Hadgood, Jhangirpura villages in Anand taluk, Dantali in Petlad taluk, Bamanva, Piploi in Khambhat taluk of Anand district and Dhava in Talala taluk of Somanath district recorded moderate to severe incidence of fall armyworm during March and April 2019. Parasitoid, *Chelonus* spp. and NPV infected larvae were observed.

Cotton

Cotton crop grown at Karena in Amod taluk of Bharuch district was infested with low infestation of jassids, whitefly and mealybug and leaf spot disease (10%) during August 2018. Moderate incidence of pink bollworm (6-8%), aphid (8-10%), mealybug (8-10%) was recorded during the month of November 2018 at Vadodara. Natural enemies like spiders, lady bird beetle, *Chrysoperla* and *Aenasius arizonensis* was recorded in the cotton fields. Wilt (8%) and Powdery mildew (6-8%) disease incidence was recorded.

Sugarcane

Sugarcane grown at Vanoti Village in Thasra taluk in Kheda district was infested with shoot borer (10-13%). Low incidence of red rot disease was observed.

Banana

Low incidence of banana aphid, pseudostem borerand red rot disease was observed at Koshindra Village in Anand taluk in Anand district during December 2018.

Chickpea

At AAU campus, Anand incidence of *Fusarium* wilt disease (5-8%) was observed. Incidence of pod borer (10-12%) and *Fusarium* wilt (8-10%) was recorded at AAU campus in Anand during February 2019.

Tomato

During February 2019, incidence of fruit borer, *Helicoverpa armigera* (6-8%) was recorded Runaj in Sojitra taluk of Anand district.

Cabbage & Mustard

Moderate incidence of aphids (12-15%) and diamondback moth (2-4%) was recorded in the Jogan village in Petlad taluk of Anand district during January 2019. Severe incidence of aphid (30%) was recorded at AAU campus in Anand during February 2019.

Bhendi

Moderate level of sucking pests and lower incidence of fruit borer was observed at Karena in Amod taluk of Bharuch district during August 2018. Incidence of Yellow vein mosaic virus (10-12%) was observed.

Mango

Hopper incidence (10-12%) was recorded at Tarapur in Sojitra taluk of Anand district during February 2019.

Survey and surveillance of natural enemies of pinworm *Tuta absoluta* on tomato (AAU- Anand):

Results: No incidence of *Tuta absoluta* was recorded during the survey period.

II.1.3 ANGRAU, Anakapalle

Techniques adopted: Visit, survey and surveillance of pests and diseases in major crops and interaction with state/line department officials and local farmers.

Periodicity: Once in a month.

Executive Summary:

Conducted 31 field visits in Visakhapatnam, Vizianagaram and Srikakulam districts of Andhra Pradesh during 2018-19 in paddy, sugarcane, maize and coconut. Monitored severe outbreak of BPH, WBPH and sheath blight in paddy; early shoot borer, white grub and YLD in sugarcane. As per the pest alert message on new invasive pest, fall armyworm in maize received from NBAIR, Bengaluru about the first report of new Invasive Pest, FAW in India and also in Asia by University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India on 27.7.2018 and NBAIR, Bengaluru alert in website on 30.7.18, Director of Research, ANGRAU alerted all Scientists of ANGRAU for monitoring Fall armyworm in maize; Department of Agriculture and maize farmers through press coverage.Based on the surveys conducted from 9-18th august, 2018, severe outbreak of new invasive pest, fall armyworm in maize noticed in all maize growing areas during *kharif*, 2018.

First report of fall armyworm, *Spodoptera frugiperda* in maize on 10.8.19 at RARS, Anakapalle and in farmers fields at Pedabathivalasa, Vizianagaram district on 11.8.19 alerted maize farmers of Andhra Pradesh for identification and management of fall armyworm through mass media. Incidence of Fall armyworm noticed at severe level (30-50%) in maize crop at 40-60 days age during August, 2018. FAW larvae collected from four locations i.e., Anakapalle, Chinthapalli, Vizianagaram and Srikakulam submitted to NBAIR, Bengaluru during August, 2018. Molecular identification by NBAIR, Bengaluru confirmed 100% match with other countries (America) through morphological characters and DNA barcoding and sequences with accession numbers were submitted to NCBI.Monitored severe incidence of new invasive pest, rugose whitefly in coconut in Srikakulam, Vizianagaram, Visakhapatnam districts of Andhra Pradesh during February, 2019. Spread of fall armyworm to ragi, bajra, sorghum during *kharif* and *rabi*, 18 and on sugarcane during February, 2019; severe outbreak of coconut rugose whitefly noticed in February, 2019 and advised management practices to farmers **(Table 13).**

Table 13. Crop pest outbreak during 2018-19

S. No	Month	Date	Locations	Crop	Problems noticed & Level of incidence
1.	May,18	9.5.18 30.5.18	Lakkavaram, Visakhapatnam Dist.	Sugarcane	Early shoot borer - Moderate to severe Smut-Moderate to severe YLD-Moderate to severe
2.	June, 18	7.6.18 14.6.18	Lakkavaram, Pydipala, Visakhapatnam Dist.	Sugarcane	Early shoot borer -Moderate to severe Smut-Moderate to severe YLD-Moderate to severe
3.	July, 18	4.7.18 11.7.18 25.7.18 31.7.18	Ps Peta, Lakkavaram,Visakhapatnam Dist. Peddapuram, Chebrolu, East Godavari dist	Sugarcane	Early shoot borer-Moderate to severe Yellow mosaic & YLD- Severe White grub in few areas
4.	August, 18	11.8.18 13.8.19 17.8.18 20.8.19 23.8.19	Pedabathivalasa, Vizianagaram dist; Neliwada, Srikakulam dist; Kondalaxmipuram, Vedulavalasa, Klpuram, Vizianagaram dist:Kumaram, Kapusambham , Vizinagaramdist:Thotakotrapalem, Visakhapatnamdist; Venkataraopeta, Srikkulamdist;Pasupam, Vizianagaram dist	Maize	New invasive pest Fall armyworm noticed - Severe
5.	September,18	6.9.18 12.9.18 15.9.18 22.9.18 24.9.18	Gurla, Goshada, Kondagandredu, Jami, Kothavalasa, Kondalaxmipuram, Cheepurupalli, Garividi, Kapusambham, Denkada, Vizianagaram dist	Paddy Maize	Blast – Low to moderate;Leaf folder, Stem borer, thrips, caseworm – Low; *Sesamiainferens*, FAW – low to moderate
			Lakkavaram, Jithasda,Visakhapatnam Dist.	Paddy Sugarcane	Stem borer, Leaf folder, Blast – Moderate to severe;

					Sheath blight - Severe;Red rot, Yellow mosaic - severe
6.	October, 18	12.10.18	Munagapaka, Makavarapalem, Visakhapatnam dist	Paddy	WBPH, BPH - Severe
		15.10.18	Meliaputtimandal, Srikakulam dist	Paddy	Lodging due to cyclonic wind
		30.10.18	Gurla, Cheepurupalli, Garividi, Vallapuram, Kella, Vizianagaram dist	Paddy Maize	WBPH, BPH – Severe FAW - moderate
		31.10.18	Lakkavaram, Visakhapatnam Dist.	Paddy	WBPH, BPH – Severe
7.	November,18	1.11.18 9.11.18	Tumpala, Visakhapatnam distAnakapalle, Visakhapatnam dist	Paddy	Plant hoppers (WBPH, BPH) - Moderate to severe Panicle mite – moderate to severe; Blast- low to moderate
8.	December,18	22.12.18	Vedulavalasa, Cheepurupalli, Vizianagaram dist	Maize	FAW – low
9.	January,19	9.1.19 19.1.19	Pidisila, Gajapathinagaram Vizianagaram dist	Maize	Stem borer- low FAW- low
10	February,19	2.2.19	Patharlapalli, Pathiwadapalem, Srikakulam dist	Maize Coconut Banana Maize	FAW – low to moderate Stem borer – low rugose whitefly- severe in coconut rugose whitefly noticed in banana, maize
		4.2.19	Chollangipeta, Denkada, Vizianagarmdist	Maize Coconut BananaMaize Papaya	Maize FAW – low to moderate; Maize Stem borer – low rugose whitefly- severe in coconut rugose whitefly noticed in papaya, banana, maize

		18.2.19	Patharlapalli, Pathiwadapalem, Srikakulam dist	Maize Coconut	FAW – low to moderate rugose whitefly- severe
		20.2.19	Pidisila, Gajapathinagaram; Chollangipeta, Pidisila, Vizianagarmdist	Maize Coconut	Maize FAW – low to moderateMaize Stem borer – low rugose whitefly- severe
11	March, 2019	23.3.19	Pusapatirega, Chollangipeta, Vizianagaram district and Patharlapalli, Pathiwadapalem, Srikakulam dist	Maize Coconut	Maize FAW – low Maize Stem borer – low rugose whitefly- severe

II.1.4 KAU, Thrissur

II.1. Outbreaks of the following insects were reported:

1. *Spodoptera litura* in banana and vegetables in Alwaye, Chalakudyetc
2. *Spodoptera mauritia* in Thrissur,Kole and Palghat
3. Flower thripsin mangoat Muthalamada in Palghat
4. Thrips incidence in little gourd in Vaniampara, Palghat
5. Alien invasive species reported:
6. *Paraleurodes bondari* from coconut in Thrissur
7. *Euplatypus parallelus* in rubber in Irutty, Kannur
8. *Spodoptera frugiperda* from Malappuram and Thrissur on maize

II.1.5 MPKV, Pune

The fields, horticultural crops and ornamental plants were observed during survey in Western Maharashtra covering five agro-ecological zones. The fields and orchards in and around Pune and Ahmednagar region as well as fruits and vegetables market areas around Pune were visited for record of pests species *viz.*, coconut leaf beetle *Brontispa longissima*, spiralling whitefly *Aleurodicus dugessi*, mealybug species *Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis, Pseudococcus jackbeardsleyi,* American pinworm *Tuta absoluta* on tomato and other alien invasive pests. The pests infested fruits and vegetables samples were collected from the market yards and nearby village markets and observed for alien invasive pest species and natural enemies.

Nymphs and females of mealybug species *P. jackbeardsleyi* and *P. marginatus* were recorded on custard apple and papaya respectively, in Pune Ahmednagar, Dhule, Jalgoan and Nandurbar district. The encyrtid parasitoid, *Acerophagus papayae* N and S, predatory larvae of *Spalgisepius*, coccinellids, anthocorids, chrysopids, syrphids and spiders were recorded in Pune and Dhule, Jalgoan and Nandurbar district. Amongst the target pests, *Tutaabsoluta*was not recorded in surveyed area of Western Maharashtra during April to March, 2019 on tomato crop.

New alien pest, Fall armyworm (FAW), *Spodoptera frugiperda* (Smith) was reported in July, 2018 in Kolhapur district on maize crop and detail infested area of FAW is presented in **Table 14** after that it is spread in Solapur, Sangli, Satara, Jalgaon, Jalana, Budhana and Usmanbad district. The pest extended its host range it is also reported sorghum in Satara, Pune, Solapur, Jalgaon districts and reported on sugarcane in Palustahasil of Sangli district and Kagaltahasil of Kolhapur district, respectively. Hence this pest will be become serious concern to these crops. Hence monitoring of*Spodoptera frugiperda* (Smith) on top priority basis is very essential and itsdamage ranges between 10 to 40 % in maize crop.

Infestation of FAW is observed in seedling stage upto 30 days. However, afterwards the incidence showed declined trend and there is not much more effect on yield due to compensatory mechanism is observed. Cob infested is observed in Babulga on village of Indapur Tahasil of Pune district.

Table 14. FallArmyworm, *Spodoptera frugiperda* (Smith) infested area in Maharashtra (10th November, 2018)

S. No.	District	Infested area (Ha)
1	Solapur	1130
2	Sangli	410
3	Satara	180
4	Kolhapur	450
5	Jalgaon	170
6	Jalana	2610
7	Buldhana	147
8	Usmanabad	47
Total area		5144

II.1.6 TNAU, Coimbatore

Survey was conducted in different districts of Tamil Nadu for the occurrence of the alien invasive insect pests.

Papaya mealybug

During the investigation period the incidence of papaya mealybug *Paracoccus marginatus* was observed in crops like papaya, tapioca, guava, cotton and mulberry.

Rugose spiraling whitefly

The occurrence of rugose spiraling whitefly *Aleurodicus rugioperculatus* was recorded in various Districts in Tamil Nadu *viz.*, Coimbatore, Tirupur Theni, Tanjore, Cuddalore, Kanyakumari, Tiruvarur, Tirunelveli Dindigul and Erode. The infestation index ranged between 1.00 and 3.00 in various Districts in Tamil Nadu **(Table 15).** The parasitisation by *Encarsia spp.* ranged between 10.00 and 100.00% on coconut gardens. A diverse array of predators *viz.*, *Chilocorus nigrita*, *Coccinella transversalis*, *Mallada desjardinsi*, *Cheilomenes sexmaculatus*, *Propylea dissecta*, *Scymnus nubilis*, *Scymnus saciformis; Chrysoperla zastrowisillemi* are present in the coconut gardens.

Fall armyworm

The incidence of an invasive pest fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Noctuidae: Lepidoptera), a native of America was observed in maize hybrids COH (M) 6 and fodder maize sown during June and July at Eastern block and new area of TNAU, Coimbatore campus. The occurrence of this pest has also been reported from all maize growing areas in Tamil Nadu. The damage symptoms in leaves *viz.*, scrapping of leaves, pin holes, small to medium elongated holes, parallel shot holes and irregular shaped holes on leaves, loss of top portion of leaves, presence of chewed up frass material and fecal pellets in the leaf whorl, drooping of leaf portion above the feeding area, feeding on tassel, terminal and stalk portion of cob were observed in 2.00 to 90.00% of the maize plants in different locations **(Table 16).** In Chinnavalavadi village in Tirupur District, 90.00% of the terminal portion of the cob had different instars of FAW during November 2018. The yield of maize ranged between 5.50 and 6.25 t/ha in well irrigated fields while it was 3.00 to 4.5 t/ha in fields where there was water shortage **(Table 17).**

Table 15. Status of rugose spiralling whitefly (RSW) in Tamil Nadu

District	RSW - Infestation index	*Encarsia sp.*
Coimbatore	2.0 -3.0	30.0 - 100.0%
Erode	1.0 - 2.0	25.0 – 60.0%
Tirupur	1.0 - 2.0	30.0 -40.0%
Namkkal	--	--
Virudhunagar	--	--
Cuddalore	2.0 -3.0	---
Tanjore	1.0 – 2.3	10.0%
Thiruvarur	1.6 – 2.3	10.0%
Tirunelveli	1.0 -2.0	20.0 – 66.7%
Thoothukudi	--	--
Dindigul	1.0	--
Kanyakumari	1.0 - 2.0	25.0 – 60.0%

Table 16. Status of fall armyworm in Tamil Nadu

Location	Date	Varity/Hybrid	Age of the crop	Plants with damge symptoms in leaf (%)
Coimbatore District				
Administrative block, TNAU	20.07.18	CoH M 6	30days	45%
Eastern block, TNAU	13.08.18	CoH M 6	53days	85%
Ravathur	22.08.18	Syngenta 6204	40days	80%
Ravathur	23.09.18	Syngenta 6204	70days	80%
Kantharipalayam	17.09.18	Fodder maize	50days	2%
Rottigoundanur	23.09.18	CP808	53days	10%
Tirupur district				

Andiagoundanoor	12.10.18	Syngenta 6668	15days	20%
Malayandipattinam	12.10.18	Syngenta 6668	15days	24%
Malayandipattinam	12.10.18	Syngenta 6668	75days	28%
Modakkupatti	12.10.18	Loacal	80days	13%
ChinnaValavadi	19.11.18	NK6688	75days	2% (larvae in 90% of the cobs)
Peryavalavadi	19.11.18	Proline	52days	50%
Salem District - Selliyampalayam	20.10.18	NK6204	35days	33 – 50%
Erode District				
Mulianoor	30.11.18	Cauvery	65days	80%
Poomanur,KarumkiraduAlam arathupatti	30.11.18	Pioneer	45days	90%
Bejaletti	21.03.19	Cauvery K 2515	70days	2%
Theni district- Krishnapuram	30.10.18	--	45days	40%
Cuddalore District - Korakkavadi	29.10.18	--	40days	40%
Ariyalur District - Silluppanoor	18.09.18	Mahyco	43days	35%
Tanjore Dt.- Nainankulam	10.09.18	CP333	40days	80%
Krishnagiri Dt. - Elachur	10.08.18	--	35days	30%

Table 17. Yield of maize (2018-19) (Plants with FAW damge symptoms in leaves – 30.00-70.00%)

Sl.No.	Name of farmer/Name of the village	Maize variety/hybrid	Yield t/ha	No. of sprays given	Remarks
1	Mr.R.Ganesh Ragulbhavi	NK999	3.00	Coragen – 2Sprays Phorate – Whorl application	Water shortage
2	Mr.M.Muthuswamy Ragulbhavi	NK999	3.75	Phorate – 3 times Whorl application	Water shortage
3	Mr.Thangaraj Sundakkampalayam	NK6088	3.75	Rich – 1Spray	Water shortage
4	Mr.Kannan Sundakkampalayam	NK6088	4.40	Resume – 2sprays	Water shortage
5.	Mr.Padmanaban	NK6088	4.40	Coragen –	Water

	Pulankinar			2Sprays Phorate – 2 Whorl application	shortage
6	Mr. Kanagaraj Ragulbhavi	Proline	3.75	Phorate – 1 Whorl application Karate – 2sprays	Water shortage
7	Mr.Ravikumar Chinnaveerampatti	CP303	6.25	2 sprays (Dupont)	--
8.	Mr.Jaganathan Valavadi	NK6088	5.50	Coragen- 1spray Emamectin benzoate – 1spray	--
9.	Mr.Karunakaran Chinnaveerampatti	CP303	5.50	2 sprays (Dupont)	--
10.	Mr.Senthilkumar Bodipatti	Sathya	4.50	Ekalux – 2sprays	Water shortage
11	Mr.Jeyakumar Narasingapuram	Pioneer	5.50	Indoxicarb-2sprays	--

II.1.7 YSPUHF, Solan

Different vegetable and fruit ecosystems in district Solan,Sirmour, Mandi, Kullu, Bilaspur, Shimla, Kangra, Kinnaur and Lahaul & Spiti were surveyed for the collection of pests like, *Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus*, *Phenacoccus madeirensis* and *Tuta absoluta* but only *T. absoluta* was recorded.

Survey and surveillance of pin worm, *Tuta absoluta* on tomato:

A survey was conducted to record the incidence of the *Tuta absoluta* on tomato, potato and brinjal from May to September, 2018 at 19 locations of districts Solan, Sirmour, Mandi, Kullu, Bilaspur, Shimla, Kangra, Kinnaur and Lahaul&Spiti which are the major tomato and/or potato growing areas of Himachal Pradesh **(Table 18)**. The incidence of *Tutaabsoluta*was also recorded under polyhouse conditions at Nauni and Subathu of district Solan (HP) on tomato, potato and brinjal. Under open field conditions the pest infested tomato at eight locations namely Nauni, Dharja, Nainatikkar, Subathu, Sarahan, Nahan, Mandi and Kullu. At these locations 38 to 79% of the tomato plants were infested with *T. absoluta* with the number of mines/leaf/infested plant varying from 0-7 and fruit damage varying from 0-5% at different locations.

Under open field conditions no incidence of the pest was recorded on potato or brinjal at any of the locations, however, in one of the polyhouses the pest was found to attack potato and brinjal when they were grown simultaneously with tomato. The severity of the pest was, however, more on tomato than potato or brinjal. Survey reveals that the pest does not infest potato or brinjal when tomato is present in the adjacent fields. Furthermore, in higher hills of district Shimla, Kinnaur and Lahaul & Spiti, which are the major potato growing areas, the pest has not been recorded so far. During the survey a mirid predatory bug, *Nesidiocoris tenuis* was recorded preying on eggs and early instars of the leafminer.

Table 18. Infestation of *Tuta absoluta*on tomato under open field conditions at different locations

SN	Location	District	Plants infested (%)	Number of mines/leaf/infested plant	Fruit damage (%)
1	Nauni	Solan	51 - 62	0-6	1-4
2	Dharja	Solan	47 - 73	1-7	2-3
3	Subathu	Solan	66 - 79	0-4	0-5
4	Nainatikkar	Sirmaur	51 - 67	2-5	1-4
5	Sarahan	Sirmaur	56 - 81	1-7	1-3
6	Nahan	Sirmour	43-59	0-2	0-3
7	Mandi	Mandi	38-74	0-6	1-5
8	Kullu	Kullu	42-69	1-4	0-5
9	Harlog	Bilaspur	Nil	Nil	Nil
10	Duttnagar (Rampur)	Shimla	Nil	Nil	Nil
11	Kufri	Shimla	Nil	Nil	Nil
12	Theog	Shimla	Nil	Nil	Nil
13	Chopal	Shimla	Nil	Nil	Nil
14	Rohru	Shimla	Nil	Nil	Nil
15	Palampur	Kangra	Nil	Nil	Nil
16	Nurpur	Kangra	Nil	Nil	Nil
17	Kalpa	Kinnaur	Nil	Nil	Nil
18	Rekongpeo	Kinnaur	Nil	Nil	Nil
19	Kelong	Lahaul&Spiti	Nil	Nil	Nil

II.1.8 MPUAT, Udaipur

Surveys were conducted to record the incidence of the tomato pin worm, *T. absoluta* from November, 2018 to February, 2019 at 10 locations of districts Udaipur, Chittorgarh and Bhilwara, which are the major tomato growing areas of Rajasthan. The incidence of *T. absoluta* was also recorded under both open and polyhouse conditions at Dabok, Mavli, Pilader and Veerpura villages of Udaipur district (Rajasthan) on tomato. Among all these locations the infestation ranged from 20 to 40%. Whenever no control measures were taken, 70-78% infestation was recorded in tomato crop. Survey reveals that the pest is more severe under polyhouse conditions than in open field conditions and prefers tomato over other host plants **(Table 19).**

Table19. Survey and surveillance of tomato pin worm, *T. absoluta* in tomato crop

Place	Date of Observation	Severity of damage	Crop age (in days)	Per cent Damage (%)
Pilader, Jaisamand & nearby villages	02.12.2018	Low	10-15	10-15
Pilader, Jaisamand & nearby villages	10.12.2018	Low to Moderate	15-20	10-15
Pilader, Jaisamand & nearby villages	11.12.2018	Low to Moderate	15-20	10-15
Pilader, Jaisamand & nearby villages	01.02.2019	Moderate	30-40	30-40
Pilader, Veerpura (Jaisamand) & nearby villages	02.02.2019	Moderate	30-40	30-40
Bhilwara and nearby area	21.02.2019	Moderate	50-60	35-45

Survey and surveillance of Fall armyworm, *Spodoptera frugiperda* on maize

Surveys were conducted to record the incidence of fall armyworm, *S. frugiperda* from July, 2018 to February, 2019. The survey indicated that the incidence of fall armyworm was noticed to be moderate to severe in Udaipur, Chittorgarh, Banswara and Dungarpur districts of Southern Rajasthan with an average incidence range of 10-50% **(Table-20) (Fig.8).**

Fig 8. FAW infested field at RCA, Udaipur

Table 20 Survey and surveillance of fall armyworm, *S. frugiperda* in maize crop

Place	Date of Observation	Severity of damage	Crop age (in days)	Per cent Damage (%)	Advice given
Piladar, (Jaisamand)	19.07.2018	Low	15-20	10-15	Use of Tricho-card
Vishama, Hyala, P.S. - Saira	30.07.2018	Low to Moderate	20-30	10-15	
Mavli, Vallabhnagar and surrounding	10.08.2018	Low to Moderate	40-50	20-25	
Vishama, Hyala, P.S. – Saira	29.08.2018	Low to Moderate	50-60	20-25	
Surrounding Villages of Mavali, Fatehnagar and Vallabhnagar	18.09.2018	Moderate	75-85	40-50	
Vishama, Hyala, P.S. – Saira	18.10.2018	Moderate	80-90	30-40	
Sare, Kailashpuri, Rama, & nearby villages	19.10.2018	Moderate	80-90	40-50	

II.1.9. NBAIR, Bengaluru

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

About 3 trips were made to Dakshina Kannada, Udupi and Uttar Kannada districts and 3 trips in Ramanagara, Mandya, Mysuru districts 4 trips to Bengaluru rural district in Karnataka for survey on incidence and infestation of rugose spiralling whitefly *Aleurodicus rugioperculatus* Martin on coconut and other host plants during 2018-19. Survey route was Mangalore to Bhatkal (*via* Udupi and Brahmavar, Kundapura, Hemmadi, Marvanthe, Byndoor, Shiroor); Bengaluru to Malavalli (via Ramanagara, Channapatna, Madduru, KM Doddi) and Malavalli to Bengaluru (*via*, Lakshmipura, Bannur, Mysuru, Srirangapatna and Mandya). Incidence and infestation of rugose spiralling white on coconut was recorded to the extent of 5-30% in different locations with maximum incidence was observed in younger and dwarf hybrid palms. The incidence noticed on banana, Indian almond, *Callophyllum*, Indian ficus and many other ornamental plants. RSW incidence drastically reduced in the locations where severe infestation noticed in previous year 2017-18. This is due to enhancement in natural enemies population over the period of time and weather factors. The pest population continue to spread newer areas along coastal tracts in Karnataka and incidence was even more serious in Goa. As per the natural parasitism as concern, the predominant natural enemies were *Encarsia guadeloupae* which parasitism was recorded to extent of 24-62%.

Besides, RSW infestation of three invasive whiteflies such as Bondar's nesting whitefly, *Paraleyrodes bondari* and *P. minei* to the extent of 15-28% on coconut was noticed. In few location, it was observed that this nesting whiteflies co-existence with RSW on coconut. Similarly, yet another whitefly was recorded from south India causing extensive infestation and its identification is under progress.

II.1.10. OUAT, Bhubaneswar

Survey was made in every month starting from May 2018 in Odisha for the outbreak of insect pests in different crops. The CPOR reports along with photographs in the specified proforma were communicated to NBAIR, Bengaluru every month through e-mail **(Table 21).**

Table 21. Month wise outbreak of insect pests in Odisha during 2018-19

Month and year	**Crop**	**Pest**	**Level of infestation**	**Site**
	Paddy (*Oryza sativa*)	BPH (*Nilaparvata lugens*)	Moderate	Dumalpadar village of Jujumara block of Sambalpur district.
	Paddy (*Oryza sativa)*	Yellow stem borer (*Scirpophaga incertulas)*	Severe	Bhellagaon village of Kalampur block of Kalahandi district
June 2018	Bamboo (*Bambusa* sp.)	Bamboo seed bug (*Udonga montana*)	Severe	Chandaka area of Khurda district
July 2018	Paddy (*Oryza sativa)*	Swarming caterpillar (*Spodoptera mauritia*)	Severe	Rasamtala village of Karangia block of Mayurbhanja district
August 2018	Baula (*Mimu-msopselengi)*	Leaf webber (*Nephopteryx eugraphella*)	Severe	Bhubaneswar, Khurda
September 2018	Maize (*Zea mays*)	Fall armyworm (*Spodoptera frugiperda*)	Moderate	Chheliguda, Patapani, Kandhadiha villages of R. Udayagiri block of Gajapati District
October 2018	Paddy (*Oryza sativa*)	BPH(*Nilaparvata lugens*)	Moderate to severe	Kudasingha, Sahajbahal villages of BolangirSadar block of Bolangir district
	Paddy (*Oryza sativa*)	Rice hispa (*Dicladispa armigera*)	Severe	Santarapur village of Chilika block of Khurda district
November 2018	Maize(*Zea mays*)	Fallarmyworm (*Spodoptera frugiperda)*	Severe	AICRP on Maize field, OUAT, Bhubaneswar
December 2018	Paddy(*Oryza sativa*)	BPH (*Nilaparvata lugens*)	Severe	Sarua village of Khurda district
January 2019	Groundnut (*Arachis hypogea*)	Spodoptera (*Spodoptera litura)*	Severe	Lohosingha, Pataka, Dahimal&Tantulipadar village of Atthamallik block of

				Anugul district
February 2019	Green gram and Black gram	Stem fly (*Ophiomyia phaseoli*)	Severe	Ballav and Bainsia villages of Gondia block of Dhenkanal district
March 2019	*Delonix regia*	Bag worm (*Pteroma plagiophleps*)	Severe	Avenue plantations of Bhubaneswar

II.1.11. UAS, Raichur

During current year (2018-19) heavy incidence of fall armyworm was noticed on maize as detailed below. District wise incidence of FAW as on August 2018 and November 2018 are presented in Table 4a and 4b.

A roving was conducted during August 2018 in maize crop to monitor the invasive pest, fall armyworm, *S. frugiperda* in six districts of North Eastern Karnataka. The study indicated that there was no incidence of pest in Bidar (964 ha), Kalaburgi (224 ha), Raichur (15 ha) and Yadgir (10 ha) district while in Koppal and Ballari districts the incidence of FAW noticed in Gangavathi taluk of Koppal which had 10 -15 % incidence. In Ballari district the total area under maize was 80024 ha in which around 2070 ha area was severely affected by FAW and its severity ranged from 10 to 40% **(Table 22).**

Roving survey conducted during November 2018 in six districts of North Eastern Karnataka indicated that FAW was noticed on *rabi* Jowar (M 35-1) with a severity of 10-15% across the six districts but yield loss due to FAW was less than 5%. On the contrary, on hybrid Jowar the FAW caused significant grain and fodder yield loss to the tune of 10-15%. On maize the incidence ranged from 10-20 % in Bidar, Kalaburgi and Yadgir district while in Raicuhr, Ballari and Koppal districts it ranged from 50-80 % **(Table 23).**

Table 22. Incidence of fall armyworm, *Spodoptera frugiperda* (J E Smith) in North Eastern Karnataka during August, 2018

District	Taluks	Area	Crop	Stage of the crop	Pest status	FWA infested area	Severity (%)
Bidar	Bidar	225	Maize	Cob Formation stage	No Incidence	-	-
	Bhalki	0	Maize	-	No Incidence	-	-
	Basava Kalyan	195	Maize	Cob Formation stage	No Incidence	-	-
	Humnabad	529	Maize	Cob Formation stage	No Incidence	-	-
	Aurad	15	Maize	Cob Formation stage	No Incidence	-	-
Kalaburgi	Alanda	100	Maize	-	No Incidence	-	-
	Afzalpur	54	Maize	Cob Formation stage	No Incidence	-	-
	Kalaburgi	50	Maize	Cob Formation stage	No Incidence	-	-
	Chittapur	0	Maize	Cob Formation stage	No Incidence	-	-
	Sedam	20	Maize	Cob Formation stage	No Incidence	-	-
Koppal	Koppal	7480	Maize	Cob Formation stage	No Incidence	-	-
	Kushtagi	1329	Maize	Cob Formation stage	No Incidence	-	-
	Yalburga	2753	Maize	Cob Formation stage	No Incidence	-	-
	Gangvati	1325	Maize	30 to 40 days old	Neg. incidence	10 ha	10-15
Ballari	Ballari	100	Maize	60-70 days old crop	No Incidence	-	-
	Sirguppa	0	Maize	-	No Incidence	-	-
	Sandur	9945	Maize	40-50 days old crop	Moderate	650	20-30
	Kudlgi	26147	Maize	40-50 days old crop	Moderate	320	10-15
	Hospet	3454	Maize	40-50 days old crop	Moderate	75	10-15
	Hagaribommanhalli	19110	Maize	40-50 days old crop	Severe	450	25-30
	Hadgali	30268	Maize	40-50 days old crop	Severe	575	30-40

Table 23. Incidence of Fall Armyworm, *Spodoptera frugiperda* (J E Smith) in North Eastern Karnataka during November, 2018

District	Crop	Area (ha)	FAW Damage		Crop Stage	Variety /Hybrid	Remarks
			Foliage (%)	Cob (%)			
Bidar	Jowar *(rabi)*	4469	15-30	-	25-35 days old	M 35-1	First report of FAW
	Sugarcane (K)	24350	Nil	-	6-8 months old	-	-
	Wheat (*rabi)*	603	Nil	-	10-15 days old	-	-
	Maize (K/R)	Nil	Nil	Nil	Nil	-	-
Kalaburgi	Jowar *(rabi)*	81950	20-40	-	20-30 days old		First report of FAW
	Maize (R)	350	30-50	Nil	20-30 days old		First report of FAW
	Wheat *(Rabi)*	11450	Nil	Nil	Nil	-	-
Yadagir	Maize (K/R)	152	Nil	Nil	Nil	-	-
	Jowar *(rabi)*	7675	25-40	Nil	20-30 days old	-	First report of FAW
	Bajara (K/R)	19345	Nil	Nil	Nil	-	-
	Sugarcane (K)	265	Nil	-	6-8 months old	-	-
Raichur	Maize (K/R)	2500	50-70	15-30	Vegetative Stage	-	-
	Jowar (*rabi)*	-	60-80	Nil	20-30 days old	-	-
	Bajara (K/R)	-	10-15	Nil	-	-	-
Ballari	Maize (K/R)	900	60-80	30-50	Vegetative Stage	-	-
	Jowar *(rabi)*	-	50-60	Nil	20-30 days old	-	-
Koppal	Jowar (K)	870	25-35				Harvested with 15 % yield loss
	Jowar (R)	21534	60-75	Nil	20-30 days old	-	-
	Maize (K)	4855	70-80	25-35			
	Maize (R)	4010	100	-	20-30 days old	-	100 % damage
	Bajara (K/R)	9155	10-15	-	-	-	-
	Wheat *(rabi)*	3141	Nil	Nil	Nil	Nil	Nil

II.1.12. IIHR, Bengaluru

Reported *Spodopterafrugiperda* on maize crops planted as barrier crops around horticultural crops. No incidence was observed on the main crops such as tomato, chilli or okra.

II.1.13. UBKV, Pundibari

Rice

Moderate infestation of leaf folder and stem boer was observed in the Huslurdanga in Mainaguri block of JalpaiguriSadarmandal in Jalpaiguri district and Paschim Falakata in Falakata of Alipurduar district during August and September 2018. During October 2018, severe damage of mealybug and moderate infestation of leaf folder was recorded at BhagniDwitiyoKhondo, Balika Bandar, Uttar Bara Sakdal, Kalmati villages in Dinhata block and Hoglabari, Sajherpaar, Dakshin KalarayerKuthi, Dhangdhinguri, Konamalli and MoranodirKuthi, Patlakhaowa, Singimari, Khagribari, Uttar KalarayerKuthi, Shooting Camp and Shakunibala villages in Coochbehar II block during October 2018. Moderate infestation of rice bug, WBPH, grasshopper, coreid bug and leaf folder was observed at Dhangdhinguri village of Coochbehar II dt during November 2018 **(Fig.9)**.

Fig. 9 Severe mealybug damage

Maize

Severe cutworm damage was recorded during January 2019 at Bhangamore, Hazrahat villages in Mathabhanga I Block. Low incidence of fall armyworm was recorded at Notuarpar (Garopara), Satmail and Howargari in Coochbehar I block during February 2019. The survey was intended for locating fall armyworm, but no insect could be traced from different places of Coochbehar district. However, some larvae were collected from maize and has already been sent to NBAIR, Bengaluru for identification**.**

Tea

Moderate infestation of tea looper, tea mosquito bug and severe infestation of red spider mite was observed in the Gandapara, Banarhat in Dhupguri block of Jalpaiguri Sadarmandal in Jalpaiguri district during August 2018. Natural enemies like predatory mites and spiders were observed. During December 2018, moderate infestation of tea mosquito bug was recorded at Nagrakata.

Gerbera

In Pundibari in Cooch Behar II block of Cooch Behar district, severe infestation of leaf beetle was observed during September 2018.

Pointed gourd& Ridge gourd

Surveys undertaken in the Ikorchala, BairagirHaat in Coochbehar Sadarmandal and Barasimulguri, Ghokshadanga GP in Mathabhanga II mandal of Mathabhanga block of Coochbehar district recorded moderate to severe infestation of fruit fly in pointed gourd and ridge gourd during June and July 2018. Moderate infestation of aphid and low infestation of Coreid bug was recorded in cucumber. Natural enemies like spiders, Coccinellids and *Apanteles*sp were recorded. Incidence of vine rot and root rot diseases (7-8%) were recorded

Bottle gourd

In Chatjorepatki, Jorepatki GP in Mathabhanga II mandal of Mathabhanga block in Coochbehar district, severe infestation of fruit fly and root rot disease (12-15%) was recorded during July 2018.

III BASIC WORK ON BIOLOGICAL CONTROL OF PLANT DISEASES USING ANTOGONISTIC ORGANISMS

GBPUAT, Pantnagar

III 1. List of *Trichoderma/ Pseudomonas* isolates used in the present investigation

S.No.	*Trichoderma / Pseudomonas* isolates	Source
1.	TCMS-36 (*T. asperellum*)	Pantnagar
2.	PBAT-3 (*T. asperellum* Th14 + *P. fluorescens* Psf 173)	Pantnagar
3.	Th-14 (*T. asperellum*)	Pantnagar
4.	Th-17 (*T. asperellum*)	Pantnagar
5.	Th-39 (*T. asperellum*)	Pantnagar
6.	Th-19 (*T. asperellum*)	Pantnagar
7.	Psf-173 (*Pseudomonas fluorescens*)	Pantnagar
8.	Psf-2 (*Pseudomonas fluorescens*)	Pantnagar
9.	NBAIR-1 (*T. harzianum*)	NBAIR –Bengaluru
10.	NBAIR-2 (*T. asperellum*)	NBAIR –Bengaluru
11.	*T. viride*	Pvt. Company
12	*T. harzianum*	BARC- Mumbai

III. 2. Molecular signature of promising *Trichoderma asperelleum* TCMS 36, *T. harzianum* (Th14) and *Pseudomonas* (PSF 173) validated under AICRP on Biological Control

Gene sequence of ITS1 and ITS4 region of TCMS-36 and TH-14 (*Trichoderma asperellum)* has been submitted to NCBI and Accession number have been assigned GenBank: MH593785.1(TCMS36) and MK044000.1 (TH-14) and TCMS36 deposited under the Budapest treaty in the National Centre for Microbial Resource (NCMR), Pune, India and assigned the accession number MCC 0154. 16S rDNA *(Pseudomonas*) amplification, identification and characterization are under progress.

III. 3. Isolation and evaluation of temperature tolerant *Trichoderma* isolates for crop health management during coldest/hottest climate

Isolation of potential temperature tolerant isolates of *Trichoderma*from the rhizosphere soils and rhizoplanes of crops during the coldest (from chickpea) and hottest months (Rice). *Trichoderma* was done on selective medium (TSM). 20 isolates of *Trichoderma*, coded as Ta-1 to Ta-20 were obtained. These isolates have been purified, identified and morphologically characterized.

III. 4. *In vitro* evaluation of temperature tolerant *Trichoderma* isolates

To study the effect of various temperature regimes, *Trichoderma* isolates were incubated at different temperatures ranging between 5^{o}C–45^{o}C for 5 and 10 days, respectively in Petri plates and flasks containing basal medium. No growth was recorded at temperature of 5^{o}C and 45^{o}C, and hence has been deleted from the statistical analysis for finding out the best temperature for linear colony diameter and average mycelial fresh weight of *Trichoderma* isolates. The data obtained for average colony diameter (**Table 24)** and mycelial fresh weight **(Table 25)** of *Trichoderma* isolates were recorded at 10^{o}C to 40^{o}C.

Table 24. Colony diameter of different *Trichoderma* isolates at various temperatures on solid medium (PDA)

Isolates	Average colony diameter (cm) of *Trichoderma* isolates after 5 days					
	10°C	20°C	30°C	35°C	40°C	Mean
Ta1	3.73	6.10	9.00	7.30	0.00	5.22
Ta2	3.46	7.60	8.80	4.40	1.80	5.21
Ta3	3.76	9.00	8.80	3.90	0.00	5.09
Ta4	3.63	7.70	8.80	4.20	0.00	4.86
Ta5	3.30	8.10	8.80	8.10	0.00	5.66
Ta6	3.66	8.30	8.80	2.80	2.30	5.17
Ta7	2.83	7.30	8.80	2.40	0.00	4.26
Ta8	3.10	7.50	8.80	3.40	0.00	4.56
Ta9	3.63	7.20	8.80	8.00	0.00	5.52
Ta10	4.13	8.20	8.80	3.00	2.50	5.32
Ta11	3.36	8.80	8.80	6.70	0.00	5.53
Ta12	4.20	8.80	8.80	8.30	1.70	6.36
Ta13	3.80	8.10	8.80	7.60	2.50	6.16
Ta14	4.00	7.90	8.80	8.80	2.00	6.30
Ta15	4.16	8.80	8.80	3.20	2.60	5.51
Ta16	2.96	7.40	8.80	4.50	0.00	4.73
Ta17	4.66	8.80	8.80	3.50	0.00	5.15
Ta18	5.70	9.00	8.80	5.00	0.00	5.70
Ta19	3.63	8.80	8.80	8.00	0.00	5.84
Ta20	2.86	8.00	8.80	7.50	2.10	5.85
Mean B	3.73	8.07	8.81	5.53	0.87	
Effect		**CD (0.05)**				
Factor(A) (Colony diameter)		**0.24**				
Factor(B) (Temperature)		**0.12**				
Factor (A X B)		**0.54**				

*Diameter of Petri plates, 9.0 cm. Each value is an average of three replications.

Table 25Fresh mycelial weight of different *Trichoderma*isolates at various temperature on liquid medium (Potato Broth)

Isolates	Average mycelial fresh weight (mg) of *Trichoderma* isolates after 10 days					
	10°C	20°C	30°C	35°C	40°C	Mean
Ta1	129.83	235.50	272.33	225.83	0.00	201.40
Ta2	125.66	240.50	275.83	225.50	0.00	173.50
Ta3	124.16	225.83	249.83	210.50	0.00	162.06
Ta4	120.83	238.50	251.50	209.83	0.00	164.13
Ta5	124.50	216.16	279.00	230.00	123.83	194.70
Ta6	128.50	219.66	248.83	223.66	0.00	164.13
Ta7	125.50	234.50	274.00	230.16	0.00	172.83
Ta8	124.16	226.00	257.83	207.16	0.00	163.03

Ta9	121.16	227.50	275.00	224.50	124.33	194.50
Ta10	129.16	231.16	268.50	219.16	0.00	169.60
Ta11	126.50	220.83	259.16	213.50	119.00	187.80
Ta12	149.16	228.33	282.50	229.16	127.83	203.40
Ta13	127.50	230.16	255.50	209.83	125.16	189.63
Ta14	126.50	231.50	279.16	228.50	128.50	198.83
Ta15	124.50	227.00	258.33	213.66	143.50	164.70
Ta16	130.00	225.33	267.66	219.83	0.00	168.56
Ta17	153.50	236.00	270.00	218.50	0.00	175.60
Ta18	155.83	234.83	262.00	218.00	0.00	174.13
Ta19	129.00	230.66	278.83	230.16	141.16	201.96
Ta20	126.83	228.50	255.50	224.16	129.16	192.83
Mean B	130.14	229.42	266.06	220.58	58.12	
Effect		**CD (0.05)**				
Factor(A) (Colony diameter)		**0.67**				
Factor(B) (Mycelial Fresh Weight)		**0.34**				
Factor (A X B)		**1.51**				

Significantly maximum average growth (**Table 24**) of all the isolates was recorded at 30^{o}C, followed by 20^{o}C and 35^{o}C. The temperature of 30^{o}C was significantly best for the growth of all the isolates of *Trichoderma*, which recorded 8.81 cm average colony diameter in 5 days. Minimum average colony diameter of 0.87 cm was recorded at 40^{o}C. Simultaneously isolates Ta12 showed maximum average colony diameter of 6.36 cm, which did not differ significantly from Ta14 (6.30 cm) and Ta13 (6.16 cm).

The interaction study revealed that isolate Ta 18 recorded maximum (5.70 cm) colony diameter at 10^{o}C which was significantly different from other isolates. Isolates Ta3 and Ta18 showed maximum (9.00 cm) colony diameter at 20^{o}C which did not differ significantly from other isolates *viz*., Ta11 (8.8 cm), Ta12 (8.8 cm), Ta15 (8.8 cm), Ta17 (8.8 cm) and Ta19 (8.8 cm). Isolates Ta1 recorded maximum (9.00 cm) colony diameter at 30^{o}C which did not differ significantly from other isolates. Isolates Ta14 recorded maximum (8.80 cm) colony diameter at 35^{o}C which did not differ significantly from Ta 13 (8.30 cm). Isoltes Ta15 showed maximum colony diameter (2.60 cm) at 40^{o}C, while most of the other isolates were not able to grow at this temperature.

Significantly maximum (266.06 mg) average mycelial fresh weight of all the isolates (**Table 25)** was recorded at 30^{o}C followed by 20^{o}C (229.42 mg). Irrespective of temperature isolate, Ta 12 recorded maximum (203.40 mg) average fresh weight of mycelium followed by Ta 19 (201.96 mg) and these two differed significantly among themselves. Minimum (162.06 mg) average fresh weight of mycelium was recorded by Ta3.

The interaction of temperatures with the fresh weight of mycelium revealed that maximum (155.83 mg) mycelial fresh weight was recorded by Ta18 at a temperature of 10^{o}C, which was significantly different from other isolates. Isolates Ta2 showed maximum (240.50 mg) fresh weight at 20^{o}C, which was significantly different from other isolates. Significantly maximum mycelial fresh weight (282.50 mg) was recorded at 30^{o}C by isolate Ta12. Isolate Ta 7 and Ta 19 showed maximum (230.16 mg) fresh weight at 35^{o}C, followed by Ta 5 (230.00 mg) at the same temperature and these were not differing significantly among themselves. Significantly maximum (143.50 mg) fresh weight was recorded at 40^{o}C by Isolate Ta15.

CEREALS

1. RICE

1.1 Management of rice stem borer and leaf folder using Entomopathogenic nematodes and entomopathogenic fungi (ANGRAU, KAU-Thrissur)

1.1.1 ANGRAU, Anakapalle

Paddy leaf folder damage recorded low in *Steinernema carpocapsae* (1.67 rolled leaves/sq. m) followed by *Bacillus thuringiensis* (2.00 rolled leaves/sq. m), *Heterorhabditis indica* (2.67 rolled leaves/sq. m) and chemical treatment, Flubendiamide recorded (2.33 rolled leaves/sq. m) and high incidence was observed in control (6.33 rolled leaves/sq. m). YSB damage as white ear recorded low in *Bacillus thuringiensis* (24.33 WE/sq. m)followed by chemical treatment, Flubendiamide (25.0 WE/sq. m) and high in control (53.33 WE/ square m)% reduction in leaf folder damage over untreated control was high in *Steinernema carpocapsae* (73.62%) followed by *Bacillus thuringiensis* (68.0 %) and Flubendiamide (63.19 %). Percent reduction in stem borer damage over untreated control was high in Flubendiamide (56.25%) and *Bacillus thuringiensis* (53.12%). Grain yield recorded high in chemical treatment flubendiamide 40SC @ 0. 1 ml/lt (3.57 t/ha) followed by *Bacillus thuringiensis* (NBAIR strain) (3.27 t/ha) and *Metarhizium anisopliae* (3.13 t/ha) and low in control (2.73 t/ha) (**Table 26**).

Table 26. Management of rice stem borer and leaf folder using Entomopathogenic nematodes and entomopathogenic fungi

Treatment	Number of rolled leaves / square metre					Number of deadhearts or white ear/square metre			Grain yield (t/ha)	Percent increase in yield over control
	Before 1st spray	After 1st spray	After 2nd spray	% reduction after 1st spray	% reduction over control	After 2nd spray	At harvest	% reduction over control		
T1: *Steinernema carpocapsae*	4.33	4.67	1.67	85.65	73.62	1.33	32.33	39.38	3.1	13.55
T2: *Heterorhabditis indica*	5.33	5.67	2.67	49.91	57.82	1.0	39.33	26.25	2.97	8.79
T3: *Bt* (NBAIRstrain)	4.0	4.0	2.0	50.0	68.40	1.0	23.33	53.12	3.27	19.78
T4: *Beauveria bassiana*	5.0	5.0	4.67	6.6	26.22	1.33	39.33	26.25	2.73	16.12
T5: *Metarhizium anisopliae*	5.0	5.0	5.0	0.0	21.01	2.67	26.67	50.0	3.13	14.65
T6: Flubendiamide 40 SC @ 0.1 ml/lt	5.0	5.0	2.33	53.4	63.19	1.67	23.33	56.25	3.57	30.77
Untreated control	5.67	5.33	6.33	10.43 (increase)		2.67	53.33		2.73	
CD(0.05)	NS	NS	NS			1.6	NS		NS	
CV%	26.26	32.03	31.76			19.01	16.9		16.09	

1.1.2 KAU, Thrissur

The first trial conducted in farmer's field at Vadekkenchery during October, 2018 to January, 2019 were inconclusive due to low levels of infestation by both stem borer and leaf folder**(Table 27).** Hence the experiment was repeated at Regional Agricultural Research Station, Pattambi from November, 2018 to February, 2019.

Table 27. Effect of entomopathogens on incidence of dead hearts in rice at Pattambi.

	Mean number of dead hearts/m^2										
Treatments	**Pre count**	**7 DAS1**	**14 DAS1**	**7 DAS2**	**14 DAS2**	**21 DAS2**	**7 DAS3**	**14 DAS3**	**21 DAS3**	**28 DAS3**	**Yield**
T1:*S.carpocapsae*	0	1.66	2.66	4.00	3.66	6.00	5.33	6.33	3.66	3.33	526.67
T2: *H. indica*	0	1.00	0.66	3.33	2.66	6.66	6.00	5.33	7.33	3.66	496.00
T3: *Bt*	0	2.00	0.33	1.33	2.66	4.33	4.00	2.66	3.66	2.66	590.00
T4: *B.bassiana*	0	0.33	1.00	2.00	3.33	5.00	5.00	2.66	3.66	3.00	485.00
T5: *M.anisopliae*	0	1.00	1.00	2.67	3.33	5.33	5.33	4.66	8.00	5.33	466.67
T6:Flubendiamide	0	0.66	0.66	1.00	1.33	4.33	4.33	1.33	3.66	2.66	585.00
T7: Control	0	1.66	1.33	7.33	5.00	10.33	10.66	6.33	7.66	10.33	362.67
CD @ 5%		NS	NS	2.44	1.98	2.92	2.47	3.34	NS	3.49	NS

Seven days after the second spray, all the treatments were significantly superior to the untreated control. Flubendiamide @ 25 g a.i ha^{-1} recorded the lowest mean value of one dead heart/m^2. The same, however, was at par with the treatments involving bioagents except *S. carpocapsae* @ 1.2x 10^9 IJs ha^{-1} which registered a mean value of 4.0 deadhearts/m^2.

Fourteen days after second spray, flubendiamide, *H. indica* and *Bt*, with 1.33, 2.66 and 2.66 mean deadhearts/ m^2 were on par with each other and significantly superior to the untreated control. They were followed by the two entomopathogenic fungi, namely, *B. bassiana* and *M. anisopliae* with mean values of 3.33 deadhearts/m^2. All the plots treated with entomopathogenic microbes were significantly superior to the untreated control and on par with each other 21 days after second spray. There was no significant difference in yield between the treatments was observed.

Effect of entomopathogens on incidence of rolled leaves in rice at Pattambi suggested Flubendiamidetreatment is the best, with lowest mean value (0.66/m^2) followed by *B. bassiana* and *Bt*. Overview of the results suggested that the bioagents evaluated, *B. bassiana* and the *B. thuringiensis* could be viable alternatives to insecticides for the management of leaf folder and stem borer in rice.

1.2 Evaluation of *Beauveria bassiana* and *Lecanicillium lecanii*against brown plant hopper *Nilaparvata lugens* Stål

The experiment could not be taken up non availability of infested fields.

1.3 Management of planthoppers through BIPM approach in organic *basmati* rice (ANGRAU, PAU)

1.3.1 ANGRAU, Anakapalle

Hopper population was significantly low in farmers practice plot (9.78 hoppers/hill) compared to BIPM plot (13.81 hoppers/hill) and control plot (15.4 hoppers /hill). Reduction in hopper population was high in BIPM plot (99.4%) and farmers practice plot (98.03%) and increase in hopper population recorded in control plot (12.27%). Grain yield recorded was high in BIPM practice i.e., *Beauveria bassiana* (5g/lt), *Metarhizium anisopliae* (5g/lt) (3.56 t/ha) comparedto farmer's practice i.e., monocrotophos (1.6 ml/lt) and acephate (1.5 g/lt) (3.26 t/ha) and untreated control (2.67 t/ha) **(Table 28).**

Table 28.Management of planthoppers through BIPM approach in rice

Treatment	Number of hoppers /hill			% reduction in hopper population		Grain yield (t/ha)	Percent increase in yield over control
	Before first spray	After first spray	After second spraying	After 1st spray	After 2nd spraying		
T1 – BIPM	81.28	13.33	0.48	83.6	99.4	3.56	33.2
T2- Farmers' practice	39.78	9.0	0.78	77.38	98.03	3.26	21.98
T3- Control	43.2	43.9	48.5	1.62	12.27	2.67	
CD(0.05)	NS	4.15	1.74			NS	
CV%	29.47	33.88	20.54			17.66	

1.3.2: PDKV, Akola

The experiment conducted with the variety PKV HMT during July 2018 revealed significant differences among the treatments. The population of GLHwas significantly minimum in T1 (BIPM) recording 1.72 and 1.46 GLH/hill followed by T2 (Farmers' practice), both being at par with each other and significantly superior over control. Similar trend was observed in case of WBPH as well.

The data on brown planthoppers revealed that T1 (BIPM) was significantly most effective in reducing BPH population recording 2.73 and 2.81 BPH/ hill at 92 and 107 DAT, respectively.The data on yield also recorded significant differences among the treatments. Maximum yield of 22.52 q/ha was recorded in T2 (Farmers' practice) followed by T1 (BIPM) recording 21.78 q/ha, both being at par with each other and significantly superior over untreated control (**Table 29**).

Table 29. Effect of different treatments on peak incidence of plant hopper and yield of rice crop (*kharif*2018).

Treatment	Incidence of hoppers (No./Hill)								Yield (q/ha)
	GLH		WBPH			BPH			
	65 DAT	79 DAT	65 DAT	86 DAT	107 DAT	65 DAT	92 DAT	107 DAT	
BIPM	1.72 (1.49)	1.46 (1.40)	1.56 (1.44)	1.19 (1.30)	1.44 (1.39)	2.83 (1.83)	2.73 (1.80)	2.81 (1.82)	21.78
Farmers' practice	1.85 (1.53)	1.50 (1.42)	1.50 (1.42)	1.21 (1.31)	1.51 (1.42)	3.03 (1.88)	3.29 (1.95)	3.36 (1.96)	22.52
Control	2.06 (1.60)	3.61 (2.03)	1.86 (1.54)	2.89 (1.84)	1.77 (1.51)	2.65 (1.78)	7.66 (2.86)	5.49 (2.45)	15.37
'f' test	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**NS**	**Sig**	**Sig**	**Sig**
SE (±M)	0.02	0.04	0.03	0.02	0.02	0.02	0.03	0.03	1.04
CD at 5%	0.07	0.11	0.08	0.07	0.05	-	0.08	0.10	3.21
CV (%)	3.74	6.07	4.92	3.90	3.00	-	3.14	4.03	13.87

*Figures in parentheses are corresponding values of square root (n+0.5) transformation.

1.3.3 PAU, Ludhiana

The population of planthoppers in BIPM and control plots was 2.88 and 4.21/hill resulting in a reduction of 31.7% over control. The population of spider was comparatively higher in BIPM plot. Basmati yield was 31.25 q/ha in BIPM as compared to 29.75 q/ha in untreated control with an increase of 5.04 %.

1.4. Improved formulation of *B.bassiana* against rice leaf folder *Cnaphalocrocis medinalis* (KAU, Vellayani)

To validate the efficacy of chitin enriched formulation of KAU isolate of *Beauveria bassiana* (ITCC 6063), against *C. medinalis* the experiment has been conducted, the mean population per plot ranged from 34.75 to 45.50/10hills/plot prior to treatment, while it was reduced to 0 to 8.5 after treatment. Analysis of data revealed that the population was minimum in plots treated with chitin enriched formulation of KAU *Bb* **(Table 30)** which was nil at the end of the experiment. The effect of NBAIR isolate was on par with that of flubendiamide 18.5 SC.

Table 30. Effect of improved formulations in the management of *C.medinalis* in rice

Treatments	Precount	Population of leaf folders/10 hills/plot						
		First spraying		Second spraying			Third spraying	
		7DAS	14DAS	7 DAS	14 DAS	21 DAS	7 DAS	14 DAS
B.b KAU conidial suspension @ 10^8 spores/ml	45.50 (6.72)	27.50 (5.232)	19.00 (4.36)	11.50 (3.36)	5.00 (2.12)	1.50 (1.40)	1.75 (1.45)	0.75 (1.10)
B.b NBAIR conidial suspension @ 10^8 spores/ml	51.25 (7.04)	29.25 (5.384)	28.93 (5.79)	22.00 (4.68)	15.25 (3.88)	7.25 (2.78)	4.00 (2.12)	2.25 (1.65)
Chitin enriched *Bb* (KAU)	44.25 (6.49)	25.00 (4.938)	17.75 (4.19)	9.00 (3.00)	4.50 (2.11)	0.75 (1.10)	0.25 (0.84)	0.00 (0.71)
Chitin enriched *Bb* (NBAIR)	51.00 (7.09)	39.75 (6.250)	28.75 (5.30)	21.00 (4.55)	15.00 (3.86)	9.50 (3.15)	5.75 (2.48)	2.50 (1.73)
Flubendiamide 18.5 SC @ 0. ml/L	40.00 (6.20)	30.75 (5.402)	22.5 (4.71)	16.5 (4.05)	10.75 (3.26)	5.75 (2.49)	3.25 (1.92)	2.25 (1.65)
Untreated check	34.75 (5.88)	29.25 (5.384)	32.50 (5.67)	26.00 (5.10)	21.00 (4.58)	15.25 (3.96)	11.00 (3.38)	8.50 (3.00)
CD @5%	NS	0.951	0.60	0.58	0.75	0.28	0.41	0.25

Values in paranthesis are after square root transformation

1.5. Comparative efficacy of entomopathogenic fungi against sucking pests of rice, *Leptocorisaacuta* (KAU, Vellayani)

To assess the comparative efficacy of KAU isolate of *Lecanicillium saksenae* (ITCC Ls Vs 1 7714) with NBAIR isolates of *L. lecanii*, *M. anisopliae* and *B. bassiana* in the management of major sucking pest of rice *Leptocorisa acuta* the experiment was undertaken.The plots treated with *L. saksenae @ 10* ^{7}spores /ml was the superior followed by NBAIR isolate Bb5 @10^8 spores/ml, where the mean population per sweep is 5 and 6.75 respectively. Bb5and *M. anisopliae* @10^8 spores/m was on par with each other and also with thiamethoxam. Among the four biocontrol agents *L. saksenae* was most effective for rice bug with mean number population per sweep was 1.75 followed by *B. bassiana* 2.75 **(Table 31).** Natural enemy population recorded throughout the experimental period did not show much variation.

Table 31. Effect of entomopathogenic fungi on population of rice bug

Treatments	Precount/ 5 sweeps	Post count (5 sweeps per plot)					
		First spraying			Second spraying		
		3DAS	7DAS	14DAS	3 DAS	7 DAS	14 DAS
L. saksenae@ 10^7 spores mL^{-1}	18.50 (4.28)	10.50 (3.24)	9.00 (3.00)	5.00 (2.34)	4.00 (1.98)	3.25 (1.79)	1.75 (1.29)
L. lecanii @ 10^7 spores mL^{-1}	18.00 (4.24)	18.00 (4.24)	12.75 (3.62	11.00 (3.39)	10.75 (3.28)	11.00 (3.31)	11.00 (3.31)
B.bassiana Bb5 @ 10^8 spores mL^{-1}	15.50 (3.93)	9.25 (3.04)	9.50 (3.08)	6.75 (2.68)	5.75 (2.39)	4.50 (2.11)	2.75 (1.65)
M.anisopliae Ma4@ 10^8 spores mL^{-1}	17.00 (4.10)	11.25 (3.33)	12.25 (3.48)	12.75 (3.62)	12.25 (3.49)	11.50 (3.38)	12.00 (3.46)
Thiamethoxam 0.2 g/L	16.50 (4.05)	11.00 (3.30)	11.25 (3.35)	7.75 (2.85)	6.50 (2.54)	5.50 (2.34)	3.75 (1.93)
Untreated check	16.00 (3.97)	20.75 (4.54)	23.00 (4.79)	20.00 (4.52)	19.25 (4.38)	18.50 (4.30)	17.25 (4.15)
CD @5%	NS	0.41	0.42	0.34	0.43	0.31	0.34

Figures in parentheses are square root transformed values

1.6 Seasonal abundance of spiders in rice ecosystem by general collection, pitfall traps and sweep net method

1.6.1 AAU, Anand

During *kharif* 2018-19 periodical surveys were conducted for the collection of spiders from paddy ecosystem. Tarapur region of Anand district was selected for the survey and sampling. Total 22 spider samples were collected and preserved as per the standard methodology and samples had been sent to ICAR-NBAIR for identification **(Table 33).** The spiders were belonging to four families namely Araneidae, Oxyopidae, Tetragnathidae and Salticidae. Out of 41 specimens, 17 turned to be *Neoscona theisi* **(Table 32).**

Table 32. Diversity of spiders in paddy ecosystem of middle Gujarat (*kharif* 2017-18)

Vial No.	Sex/stage	Family	Genera	Species	Author
1	♀	Araneidae	*Argiope*	*pulchella*	Thorell
2	--	Araneidae	--	-	--
3	♀	Araneidae	*Argiope*	*pulchella*	Thorell
4	♀	Araneidae	*Argiope*	*pulchella*	Thorell
5	Sub adult♀	Araneidae	*Argiope*	*pulchella*	Thorell
6	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
7	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
8	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
9	♀	Araneidae	*Argiope*	sp.	--
10	♂	Oxyopidae	*Oxyopes*	*javanus*	Thorell

11	Spiderling	Tetragnathidae	*Leucauge*	sp.	
12	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
13	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
14	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
15	♂	Oxyopidae	*Oxyopes*	*javanus*	Thorell
16	♀	Oxyopidae	*Oxyopes*	*javanus*	Thorell
17	♂	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
18	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
19	Sub adult♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
20	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
21	Sub adult♀	Tetragnathidae	*Tetragnatha*	sp.	--
22	--	Araneidae	--	--	--
23	♀	Tetragnathidae	*Tetragnatha*	*javana*	Thorell
24	Sub adult♂	Araneidae	*Neoscona*	*?theisi*	(Walckenaer)
25	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
26	♂	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
27	Sub adult♂	Araneidae			
28	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
29	Spider ling	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
30	♀	Araneidae	*Araneus*	*ellipticus*	(Tikader& Bal)
31	♀	Salticidae	*Bianor*	*incitatua*	Thorell
32	--				
33	Sub adult♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
34	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
35	Sub adult ♂	Oxyopidae	*Oxyopes*	*javanus*	Thorell
36	Sub adult♂	Tetragnathidae	*Leucauge*	sp.	NA
37	♂	Tetragnathidae	*Tetragnatha*	sp.	NA
38	Sub adult♂	Tetragnathidae	*Tetragnatha*	sp.	Okuma
39	Spider ling	Araneidae	*Argiope*	sp.	NA
40	♀	Araneidae	*Argiope*	*pulchella*	Thorell
41	Sub adult♀	Tetragnathidae	*Tetragnatha*	sp.	--

. **Table 33. Diversity of spiders in paddy ecosystem of middle Gujarat (*kharif* 2018-19)**

Vial No.	Sex/stage	Family	Genera	Species	Author
1	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
2	Spider ling	Araneidae	*Argiope*	sp.	
3	Spider ling	Araneidae	*Argiope*	sp.	
4	Spider ling	Araneidae	*Argiope*	sp.	
5	Spider ling	Tetragnathidae	*Tertragnatha*	sp.	
6	Spider ling	Araneidae	*Argiope*	sp.	
7	Spider ling	Araneidae	*Argiope*	sp.	
8	♀	Araneidae	*Argiope*	*pulchella*	Thorell
9	Spider ling	Araneidae	*Argiope*	sp.	
10	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
11	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
12	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
13	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
14	♀	Araneidae	*Araneus*	*ellipticus*	(Tikader& Bal)
15	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
16	♀	Araneidae	*Cyclosa*	sp.	Thorell
17		Araneidae	*Argiope*	sp.	
18	♀	Araneidae	*Araneus*	*ellipticus*	(Tikader& Bal)
19	Spider ling	Araneidae	*Argiope*	sp.	
20	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
21	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
22	♀	Thomisidae	*Thomisus*	*spectabilis*	Doleschall

The samples were belonging to three families namely Araneidae, Tetragnathidae and Thomisidae. Out of 22 specimens, 8 turned to be *Agriope* sp.and 8 were *Neoscona theisi.*Five pit fall traps on border (20/field) were installed in each field and collections were made on alternate days. Less numbers of spiders were collected in pit fall trap method as compared to general collection/sweeping net method. Only two spiders were trapped in pit fall during the study. Species richness, species diversity and species evenness will be calculated by analysing the data and making comparison between the seasons.

1.6.2 AAU, Jorhat

The seasonal abundance of spider was recorded, covering an area of 1 hectare at ICR farm, AAU, Jorhat under unsprayed condition **(Table 34).** The entire field was subdivided in to 5 equal blocks and from each block 10 spots were randomly selected measuring 1 sqm. Observations of spider population were recorded from the 1 sqm. by visual count, pitfall traps and sweep net methods at 15 days interval starting from 2nd week of August (35 DAT) to till maturity of crop. For sweep net method, 10 catches per unit was made randomly from each block to collect the spiders from the field. Similarly, 10 numbers of pitfall traps was randomly placed in the rice field in each block at a distance of 100 m and replaced it after 48 hrs. Total numbers of spiders collected by three methods weregeneral collections -visual methods (100 Nos); sweep net methods (38 Nos) and pitfall traps (27 Nos).

Table 34. Seasonal abundance of predatory spiders (Av)

Period of observation	Visual count	*Sweep net	Pitfall traps
2nd wk. of August	2.0	0.8	--------
1st wk. of September	0.8	0.6	---------
2nd wk. of September	2.0	0.7	0.7
1st wk. of October	1.4	0.9	0.2
2nd wk. of October	1.0	0.8	0.2
1st wk. of November	1.0	-------	0.7
2ndwk.of November	0.7	------	0.9
1st wk. of December	0.7	------	-----
2nd wk. of December	0.4	--------	-------

*Sweep net was not used from first week of November, 2017 due to reproductive growth phases of the crop.

1.6.3 PAU, Ludhiana

Regular surveys were conducted to collect spiders from south western region (Fazilka and Abohar) of Punjab. Collected specimens were brought back to the laboratory and were preserved in 70% alcohol. A total of four species were recorded from the rice fields and its relative abundance was determined (**Table 35)**. *Tetragnatha javana was* predominant species (45.64%) followed by *T. maxillosa* (30.20%) and *Neoscona theisi* (18.21%). Species diversity (1.1987) was calculated as per Shannon-Weiner index of diversity. Species evenness (0.8646) and dominance index (0.1354) was worked out as per formulae given by Krebs and Southwood, respectively.

Table 35. Diversity of spiders in rice during 2018

Sr. No.	Species	Family	Relative abundance (%)
1.	*Tetragnatha javana*	Tetragnathidae	45.64
2.	*Tetragnatha maxillosa*	Tetragnathidae	30.20
3.	*Neoscona theisi*	Araneidae	18.12
4.	*Oxyopes kusumae*	Oxyopidae	6.04
H (diversity index) : 1.19865 Species evenness : 0.86464 Dominance index : 0.13536			

1.7. Large scale biointensive pest management on rice (AAU-Anand, ANGRAU, KAU, OUAT, IIRR, GBPUAT, AAU-J, PAU, NBAIR)

1.7.1 AAU, Anand

Large scale demonstration on biointensive pest management in rice crop (cv. Suryamoti) covering 2ha was carried out during *kharif* 2018 at Farmer's field, Runaj, Sojitra taluk, Anand district.Among different insect pests infesting rice, only the incidence of rice leaf folder (5-15%) was recorded during the experimental period. Based on the mean of leaf folder damaged leaves (%) in farmers' practice block at 30, 45 and 65 DAT was 7, 12.37 and 15.37% respectively. In BIPM package block these corresponding figures were 7.75, 10.62 and 12.62% **(Table 36).** It is observed that at 45 and 60 DAT there was significant lower leaf damage in BIPM package as compared to farmers practice block. Similar trend was recorded with regard to grain yield. Significant grain yield (39.10 q/ha) was recorded in BIPM package as compared to farmers practice (36.43 q/ha). It can be concluded that use of BIPM strategies resulted in lower incidence of rice leaf folder and higher grain yield.

Table 36. Large scale demonstration of BIPM package in rice during 2018

Treatments	Leaf folder damaged leaves (%)			Yield (q/ha)
	30 DAT	**45 DAT**	**60 DAT**	
BIPM package	7.75 ±1.035	10.62 ± 1.18	12.62 ± 1.18	39.10±2.13
Farmers' practice	7 ± 1.069	12.37 ± 1.40	15.37 ± 1.59	36.43±2.32
P value	NS	0.004	0.006	0.04

1.7.2 ANGRAU, Anakapalle

Demonstration was conducted in 15 acres at three locations in farmers' fields of Pydipala, Munagapaka, Visakhapatnam district and Denkada, Vizianagaram districts during *kharif*, 2018. Paddy stem borer damage was low in BIPM package (0.97 % DH) compared to farmers practice (3.21 % DH and 5.55% WE). Leaf folder was low (1.51%) in BIPM plot and high in farmers practice (5.35 %). Grain yield recorded was 5.64 t/ha in BIPM plot compared to farmers practice plot (4.63 t/ha). Adoption of BIPM package in three locations resulted in 20.32% increased yields (5.64 t/ha) with high incremental ratio (12.84) over farmers practice (4.63 t/ha) with incremental ratio of 4.56 **(Table 37 & 38).**

Table 37. Demonstration of BIPM in farmer fields in *kharif* 2018

Location	Stem borer damage (%DH & % WE)		Leaf folder damage (%)		Sheath blight (%)		Grain yield t/ha		Benefit cost ratio		Incremental benefit cost ratio	
Denkada, Vizianagaram district (5 acres)												
Area	T1-BIPM	T2-FP	T1-BIPM	T2-FP	T1-BIPM	T2-FP	T1-BIPM	T2-FP	T1-BIPM	T2-FP	T1-BIPM	T2-FP
5 acres	1.68 DH	3.32 DH 5.71 WE	0.16	6.44	-	-	5.25	4.31	10.74	3.03	2.62	1.29
Pydipala, Visakhapatnam district (6 acres)												
6 acres	-	0.81 WE	0.22	1.93	-	-	6.56	5.44	17.75	7.67	2.02	1.63
Munagapaka, Visakhapatnam district (4 acres)												
4 acres	1.13DH	6.32 DH 10.13 WE	4.16	7.67	0.97	3.22	5.12	4.15	10.04	2.98	1.58	1.25
Average	0.97 DH	3.21 DH 5.55 WE	1.51	5.35	0.32	1.07	5.64	4.63	12.84	4.56	2.07	1.39

DH – Dead Heart WE- White Ear

Table 38. Comparision of bio-intensive pest management with farmers practice in rice

Location	% reduction in stem borer damage in BIPM over farmers practice	Reduction in leaf folder damage in BIPM over farmers practice (%)	Reduction in sheath blight incidence in BIPM over farmers practice (%)	Increase in grain yield BIPM over farmers practice (%)
Denkada, Vizianagaram district				
	81.4	97.52		21.81
Pydipala, Visakhapatnam district				
	81.0	88.6		20.59
Munagapaka, Visakhapatnam district				
	93.13	45.76	69.88	18.55
Average	**85.18**	**77.29**	**69.88**	**20.32**

1.7.3 KAU, Thrissur

Large scale validation of BIPM in rice was carried out over an area of 150 ha in AlathurGrama Panchayat of Palghat district from September 2018 to February 2019. The results of the validation in terms of pest infestation, natural enemy population and yield are as follows,

The sporadic outbreak of rice armyworm during the late nursery stage was managed by flooding the fields. Adoption of BIPM practices led to substantial reduction in infestation by major pests. The mean stem borer population in BIPM plots was 70% lower as compared to non BIPM plots. Similarly, the dead heart as well as whiteear head symptoms recorded 40 and 66% reduction in BIPM plots as compared to non BIPM plots.

The population of natural enemies also recorded higher in BIPM plots. The mean spider population in BIPM plots was 12.5/m^2, the same for non BIPM plots was only 8.5/m^2. Greater parasitoid activity was observed in BIPM plots.

The yield obtained from BIPM plots, at 8000 kg/ha was approximately 14.5% more than the non BIPM plots (7000 kg/ha). The increased yield as well as reduced cost resulted in an increase in profit by Rs. 46,210/ha. The cost benefit ratio worked out to be 2.24 for BIPM plots similarly it was 1.90 for non BIPM fields **(Table 39).**

Table 39. Comparison between BIPM and non BIPM plots at Alathur Panchayat

Sl. No.	Particulars	BIPM plot (Mean no/m^2)	Non BIPM plot (mean no/m^2)
1.	Armyworm in nursery	25	26
2.	Thrips damage	37	48
3.	Bacterial leaf blight attack	10	35
4.	Dead hearts	4	6.5
5.	White ear heads	6	18
6.	Stem borer moths	2.5	8.5
7.	Leaf folder damage	3	14
8.	Rice bug	4	12
9.	Spiders	12.5	8.5
10.	*Ophionea* sp	20.2	9.3
11.	Water striders	17.8	12.4
12.	Dragon fly	20.7	10.5
13.	Parasitoids	18.0	9.5
14.	Yield (kg/ha)	8750 kg	7000 kg
15	Returns per ha (@Rs. 23.5/kg)	Rs. 2, 05,625/-	Rs. 1,64,500
16.	Cost of cultivation (Rs/ha)	Rs. 63,415/-	Rs. 68,500/-
17.	Net return per ha	Rs. 1,42,210/-	Rs. 96,000/-
18.	Cost benefit ratio	2.24	1.40

1.7.4 OUAT, Bhubaneswar

The experiment was conducted in 5ha area atGadapadanapur Panchayat, Nimapada block, Puri during*kharif* 2018. The silver shoot(SS), dead heart (DH), white ear head (WEH) and leaf folder (LF), incidence in BIPM demonstrated plots were 2.80,4.71,3.55 and 4.61%, respectively as compared to 3.70, 4.09, 2.90 and 4.50% infestation in their respective farmers practice (FP) with use of chemical pesticides. Significantly, higher SS (6.86%), DH (11.33%), WEH (12.35%) and LF (13.65%) infestation was noticed in untreated control.

Highest yield (80.68q/ha) was recorded in FP. Lowest yield (61.45 q/ha) was recorded in untreated control. The benefit cost ratio in BIPM treated plots was found highest (1.63) against 1.35 and 1.28 in FP and untreated control, respectively **(Table 40)**.

Table 40. BIPM demonstration in paddy (5ha) at Gadapadanapur Gram Panchayat of Puri district.

Treatments	SS (%)	DH (%)	WEH (%)	LF (%)	Yield (q/ha)	B:C ratio
BIPM package	2.80 (1.82)	4.71 (2.28)	3.55 (2.01)	4.61 (2.26)	79.46	1.63
Farmers' Practice	3.70 (2.05)	4.09 (2.14)	2.90 (1.84)	4.50 (2.23)	80.68	1.35
Untreated Control	6.86 (2.71)	11.33 (3.44)	12.35 (3.58)	13.65 (3.76)	61.45	1.28

Parenthesis are $\sqrt{(x+0.5)}$ transformed values

1.7.5 IIRR, Hyderabad

Demonstration trials were undertaken in 3 acres of farmer's fields in Neelayagudem village. The BIPM interventions were application of phosphorous solubilising bacteria, alleyways, organic manuring in addition to synthetic fertilizers (dose adjusted), owl perches for rodent management and marigold grown on bunds to provide floral diversity for conservation of natural enemies. The brown planthoppers was lowest in the BIPM plots (25/10 hills) with a single application of insecticide while in farmers practice the numbers increased to 150/10 hills in spite of spraying four times **(Table 41).** This was mainly due to timing of application and sole dependence of insecticides for insect management. Mirids are more pest density dependant and hence were more in fields with higher hopper population whereas spider population was found to decrease as more insecticides were sprayed.

Table 41. Pest and natural enemies incidence at Nalgonda, Telangana, *kharif* 2018

Treatment	Species Richness	Population /10 hills				Yield (Kg/ha)	B:C ratio
		BPH	Mirids	Spiders	Drynids		
BIPM	11.0	25.00	53.53	12.25	7.42	8752	4.90
Farmers Practice 1	6.0	44.25	45.95	5.78	4.06	7144	4.07
Farmers Practice 2	4.0	150.21	121.25	3.11	2.4	6934	3.80
CD (0.05)		16.55	NS	2.13	4.30		

The trial was also conducted in three locations in three districts of the Koraput region of Odisha. The Koraput region of Odisha state is historically the world's leading area for rice diversification but is depicted as a 'backward' region. The tribal people have indigenous knowledge system for their various agricultural practices and conserve the landraces. The BIPM demonstration trial was conducted in six acres to popularize bio control agents for pests and disease of rice in a traditional organic system. The farmers used HandiKhad or pot manure regularly and neem oil for pest and disease management. These farmers' practices were compared with BIPM practices which included seed treatment with *Trichoderma* sp.wet seed treatment @ 10 g / litre of water / kg seed and basal and top dressing of FYM and vermicompost. In addition to these, pheromone traps were also placed @ 8/ ha with *Scirpophaga incertulas* lures changed twice over the crop period. *Trichogramma japonicum* 5 cc egg cards/ha, six times weekly from first week after transplanting.

Due to lack of high input system hoppers were not a serious threat here. The key pests observed were stem borer and leaffolder. Farmers' awareness on pheromone traps and bio-control agents was limited. The incidence of stem borers, leaffolder and false smut were significantly lower in the BIPM fields. The yield however was lower in this region in general due to the traditional practices followed and has great scope for improvement (**Table 42: 42A & 42B**).

Table 42. Pest and disease incidence at Odisha BIPM trial, *kharif* 2018

42. A.

	Leaf folder (%)		**Stem borer (% deadhearts/ whiteears)**		**Brown spot Incidence (%)**		**False smut Incidence (%)**	
Location	**IPM**	**FP**	**IPM**	**FP**	**IPM**	**FP**	**IPM**	**FP**
Patraput village, Jeypore block, Korapur district	4.60	12.00	7.60	13.20	2	10	4.40	11.80
Narla village, Narla block, Kalahandi district	8.20	19.40	7.80	14.20	Low	Low	0.80	7.60
Ekamba village Nandahandi block, Nabarangapur district	8.60	12.20	7.60	10.20	Low	Low	2.40	13.20
Mean	7.13	14.53	7.00	12.53			2.20	10.87
t test of significance	5.38**		5.45**				9.68**	

42. B.

	Yield (Kg/ha)		**Benefit cost Ratio**	
Location	**IPM**	**FP**	**IPM**	**FP**
Location 1	3480	2250	2.4	1.63
Location 2	3440	2350	1.63	1.51
Location 3	3520	2470	2.12	1.97

1.7.6 GBPUAT, Pantnagar

Large scale field demonstrations of bio-control technologies has been conducted at certified organic growers of Basmati rice at three different blocks *viz*. Kotabagh, Ramnagar (village Patkot and some area of Okhaldunga) and Batalghat (Mallisathi and some area of Okhaldunga) in district Nainital, Uttarakhand covering 764 farmers (average land holding 0.25 -1.0 acre) with a total acreage of 532.0 acres (221.7 ha) in association with Nature Bio-Foods Ltd. A total of 9.0 quintal of PBAT-3 (Th-14+Psf-173) was distributed to the farmers to conduct field trials.The performance of PBAT-3 along with farmer's practices was found highly satisfactory in managing sheath blight, bacterial blight and blast as compared to farmer's practices.

1.7.7 AAU, Jorhat

The trial has been laid out at Dangdhora (Panchayat –Titabor), Jorhat district with an area of 5 ha during *kharif*2018.The result of the experiment indicated that BIPM package and farmer's practice (Chemical control) were at par with each other in respect of the population build-up of rice stem borer and leaf folder. The dead heart and damaged leaf caused by *Scirpophaga*sp and *Cnaphalocrocis*sp. were 3.42 and 3.60% in BIPM package as against 2.85 and 2.85 in farmer's practice at 60 DAT, respectively. In case of WEH, the incidence was 2.83% in BIPM plots which were superior to farmer's practice plots (3.65) at 100 DAT without any significant difference in between the treatments. Maximum yield of 4965.3 Kg/ha was registered in BIPM plots which was significantly higher compared to farmer's practice plot with 4639 Kg/ha and minimum yield of 3373 Kg/ha in untreated control plot **(Table 43).**

The population of natural enemies like predatory spiders and cooccinellids per m^2 significantly high in BIPM plot in compared to farmers practice and untreated control plots. The net returns over control in BIPM package were Rs. 53729.50 as compared to Rs.44585.00 in farmers practice plot with cost: benefit ratio of 1:2.58 and 1:1.78, respectively **(Table 44).**

Table 43. Observation on incidence of Dead heart, WEH, LFDL and grain yield of rice

Treatments	Dead heart (%)		WEH (%)	LFDL (%)		Grain yield (kg/ha)
	45DAT	60DAT	100DAT	45DAT	60DAT	
BIPM Package	5.11	3.42 ^{a}	2.83 ^{a}	3.61 ^{a}	3.60 ^{a}	4965.3 ^{a}
Farmers practice	5.60	2.85 ^{a}	3.65 ^{a}	4.86 ^{a}	2.85 ^{a}	4639.0 ^{b}
Untreated control	6.28	6.12 ^{b}	6.32 ^{b}	7.09 ^{b}	5.92 ^{b}	3373.5 ^{c}
CD = 0.05	NS	2.07	2.53	2.68	1.53	221.16

Table 44. Cost benefit analysis

Treatment	Yield (Kg /ha)	Additional yield over chemical control (Kg /ha)	Value of yield/ ha (Rs/ha)	Cost of cultivation (Rs /ha)	Net return (Rs/ ha)	C:B ratio
BIPM plot	4965.3	1591.8	74479.50	20750.00	53729.50	2.58
Farmers' practice	4639	1265.5	69585.00	25000.00	44585.00	1.78
Untreated control	3373.5	-	50602.50	18000.00	32602.50	1.81

@Rs. 15/kg of rice grain

1.7.8 PAU, Ludhiana

Large scale demonstrations on the bio-suppression of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted in field areas of Patiala, Sangrur, Kapurthala, Jalandhar, Faridkot and Fazilka districts in *basmati* rice (var. Pusa 1121) over an area of 294 acres. The demonstrations included 5-6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000 parasitoids/ha at weekly intervals starting from 30 DAT and was compared with untreated control. Tricho-cards each having approximately 1000 parasitized eggs were cut into 100 strips and were stapled uniformly to the underside of the leaves in biocontrol treatment.

Based on the mean of all locations mean dead heart incidence in biocontrol fields were1.53 and 2.22% at 45 and 60 DAT, respectively **(Table 45)**. The corresponding figures in untreated control were 3.20 and 5.00%. The mean reduction of dead heart incidence in release fields was 53.89% over control. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields as compared to untreated control. The damage was 2.15 and 2.48% at 45 and 60 DAT, respectively as compared to 4.74 and 6.12% in untreated control with a mean reduction of 57.06%. The mean incidence of white ears was significantly lower in biocontrol field (2.66 %) as against untreated control (5.45 %) resulting in a reduction of 51.20% **(Table 46).** Grain yield in biocontrol field (26.6 q/ha) was significantly better as compared to 23.52 q/ha in untreated control, respectively. The yield increase in release fields was 13.10% more than untreated control. It can be concluded that 5-6 releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha resulted in lower incidence of rice insect pests and higher grain yield in organic *basmati* rice with an additional benefit of Rs. 7626/- per hectare.

Table 45. Large scale demonstrations of biocontrol of rice pests in organic *basmati* rice during 2018

Treatments	Dead hearts (%)				Leaffolder damaged leaves (%)			
	45 DAT	60 DAT	Mean	% reduction over control	45 DAT	60 DAT	Mean	% reduction over control
Biocontrol*	1.53^{a}	2.22^{a}	1.88^{a}	53.89	2.15^{a}	2.48^{a}	2.32^{a}	57.06
Untreated control	3.20^{b}	5.00^{b}	4.10^{b}	-	4.74^{b}	6.12^{b}	5.43^{b}	-

DAT – days after transplanting; *5-6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

Table 46.Large scale demonstrations of biocontrol of rice pests and yield of organic *basmati* rice during 2018

Treatments	White ears incidence (%)	% reduction over control	Paddy yield (q/ha)	% increase over control	Net returns over control (Rs./ha)
Biocontrol*	2.66^{a}	51.2	26.60^{a}	13.10	7626.00
Untreated control	5.45^{b}	-	23.52^{b}	-	

DAT – days after transplanting; *5-6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

1.7.9 NBAIR, Bengaluru

Large scale demonstration of biocontrol of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted in Rajabahar, Titabar, Jorhat district of Assam (Variety: Ranjit) over an area of 4.5 ha. The result revealed, mean dead heart incidence in BIPM fields was 6.27 and 5.69% at 45 and 60 DAT, respectively. The corresponding figures in farmer's practice were 5.9 and 3.28%. Similarly, leaf folder damage in BIPM field was 5.92 and 2.8% at 45 and 60 DAT, respectively as compared to 5.75 and 3.23% in Farmer's practice field. Per cent white earhead (2.74) was significantly low (F=3.73, P=0.05) in BIPM field compared to farmer's practice (3.78). Grain yield in BIPM field (49.98 q/ha) (F=104.66, P<0.0001) was significantly better as compared to 45.18 q/ha in farmer's practice, respectively **(Table 47).**

Table 47. Large scale demonstration of BIPM in rice during 2018

Treatment	Dead Heart (%)		White ear head (%) at (100 DAT)	Leaf folder damage (%)		Yield (q/ha)
	45 DAT	60 DAT		45 DAT	60 DAT	
BIPM package	6.27	5.69	2.74	5.92	2.8	49.98
Farmer's practice	5.9	3.28	3.78	5.75	3.23	45.18
P value	0.70	0.005	0.05	0.85	0.425	<0.0001

1.8 Testing of BIPM trial on paddy along with farmers practice and control

1.8.1 IGKV, Raipur

The result of the experiment with Swarna variety indicated thatmaximum % dead heart caused by stem borer was recorded in control (13.73) and minimum (8.024) in BIPM treatment. Similarly maximum white ear head was recorded in control (22.40) and minimum in BIPM **(Table 48).** The incidence of other rice pets like leaf folder, caseworm, hispa, BPH and GLH were also minimum in BIPM treated plot compared with the control.Significant maximum grain yield (28.41 kg) was obtained in BIPM treatment followed by farmer's practice (25.25 kg) and control (22.98 kg). The population of natural enemies like predatory spiders and cooccinellids were high in BIPM plot while compared to farmers practice and untreated control plots.

Table 48. Observation on incidence of rice stem borer (Dead heart and WEH)

Treatments	Pre-treatment	Dead Heart (%)	White ear head (%)
T1-BIPM	6.397 (14.621)	8.0244 (16.447)	15.68 (23.308)
T2-Farmer's Practice	6.648 (15.00)	11.896 (20.166)	19.22 (25.988)
T3-Control	6.755 (14.776)	13.735 (21.742)	22.40 (28.236)
CD	N/A	0.353	0.503
SEm$\pm$	0.249	0.118	0.168

1.9. Evaluation of fungal and bacterial isolates for crop health management in rice (GBPUAT)

The field experiment conducted at Crop Research Centre, Pantnagar to test efficacy of 11 potential bio-agents and one fungicide, carbendazim (standard check) on rice (var. Pant Dhan-4) for disease management and yield improvement. The bio-agents were given as seed bio-priming (10g /kg seed), soil application (10 g formulation with 100 g vermicompost), seedling root dip treatment (10g /lit) and as two foliar sprays (10g /lit), 1st at 47 and 2nd at 78 DAT. The experiment was laid in a randomized block design with three replications.

Minimum Sheath blight (*Rhizoctonia solani*) disease severity was recorded with Psf-173 (27.88%) followed by, PBAT-3 (28.91%), Commercial formulation (29.74), Carbendazim (29.83), Psf-2 (29.87%), Th-14 (30.40%), TCMS 36 (30.49%) and NBAIR-2 (30.72%), which did not differ significantly with each other but significantly better than control (45.02%). Minimum percentage of False smut (*Ustilaginoidea virens*) infected panicle/hill was observed with TCMS 36 (16.92%) which was significantly different from other treatments and better than control (25.91%) **(Table 49).**

Table 49. Efficacy of promising bio-agents against rice diseases (var. Pant Dhan-4)

Treatment	Sheath Blight		False Smut of Rice	
	Disease severity (%)	Disease Reduction (%)	Infected panicle /hill (%)	Disease Reduction (%)
TCMS 36	25.80 (30.49)	32.27	8.48 (16.92)	34.69
PBAT-3	23.39 (28.91)	35.78	10.07 (18.49)	28.63
Th-14	25.71 (30.40)	32.47	11.42 (19.74)	23.81
Th-17	31.01 (33.82)	24.87	12.12 (20.34)	21.49
Th-39	31.54 (34.15)	24.14	12.81 (20.94)	19.18
Th-19	29.34 (32.75)	27.25	11.71 (19.97)	22.92
Psf-173	21.93 (27.88)	38.07	13.82 (21.80)	15.86
Psf-2	24.92 (29.87)	33.65	12.48 (20.66)	20.26
NBAIR-1	27.55 (31.64)	29.72	12.73 (20.89)	19.37
NBAIR-2	26.16 (30.72)	31.76	11.98 (20.24)	21.88
Commercial	24.65 (29.74)	33.94	13.74 (21.74)	16.09
Carbendazim	24.80 (29.83)	33.74	14.48 (22.34)	13.77
Control	50.07 (45.02)	-	19.12 (25.91)	-
C.D	**3.24**		**1.51**	
C.V.	**5.99**		**4.31**	

*Figures in parenthesis are angular transformed values

Maximum number of tillers/plant was observed in Th-19 (12.600 tillers/plant) followed by PBAT-3 (12.53 tillers/plant) and was at par with other treatments but significantly better than Psf-2 (10.33 tillers/plant), commercial formulations (10.73 tillers/plant) and control (8.40 tillers/plant). Significantly maximum yield was obtained with PBAT-3 (58.50 q/ha) followed by TCMS 36 (56.50 q/ha) and Th-14 (58.50 q/ha) and superior than control (42.67 q/ha). Significantly maximum test weight of grain was recorded by NBAIR-2 (29.05 g), followed by Psf-173 (28.66 g) and Th-19 (28.20 g) which was signifiactly at par with each other but better than control (20.89g) **(Table 50).**

Table 50. Efficacy of promising bio-agents onplant growth and yield of rice (var. Pant Dhan-4)

Treatment	Tillers/hill (90 DAT) (no.)	Yield			
		Yield / plot (10 m^2) (kg)	Yield (q/ha)	Increase in yield (%)	Test wt (g)
TCMS 36	12.16	5.65	56.50	32.62	27.45
PBAT-3	12.53	5.85	58.50	37.32	26.96
Th-14	11.76	5.38	53.80	26.29	27.48
Th-17	11.60	4.91	49.10	15.25	24.43
Th-39	12.33	5.25	52.50	23.23	27.61
Th-19	12.60	4.95	49.50	16.19	28.20
Psf-173	12.53	5.14	51.40	20.65	28.66
Psf-2	10.33	5.10	51.00	19.71	27.36
NBAIR-1	12.06	4.91	49.10	15.25	25.46
NBAIR-2	11.96	5.29	52.90	24.17	29.05
Commercial	10.73	4.92	49.20	15.49	26.55
Carbendazim	11.13	5.03	50.30	18.07	22.36
Control	8.40	4.26	42.60	-	20.89
C.D	**2.06**	**0.73**			**1.72**
C.V.	**10.55**	**8.43**			**3.85**

1.10 Effect of delivery methods (foliar sprays) of PBAT-3 for crop health management in rice (GBPUAT)

Sheath blight and false smut were observed in the experimental field during the cropping season. Minimum sheath blight (*R. solani*) disease severity was recorded with PBAT-3 + Molasses (2%) + Cow urine (5%) + Vermiwash (27.41%) followed by, Fermented product of Cow urine + Neem leaves + Garlic (10%) (27.83%), PBAT-3 + Molasses (2%) +Cow urine (5%) (27.91%) and PBAT-3 (28.18%) which did not differ significantly with each other but significantly better than control (42.72%).

Minimum percentage of false smut (*U. virens*) infected panicle/hill was observed with PBAT-3 + Molasses (2%) (15.97%) which was significantly different from other treatments and better than control (24.67 %) **(Table 51)**.

Maximum number of tillers/plant was observed in PBAT-3 + Cow urine (5%) (12.56 tillers/plant) followed by PBAT-3 + Fermented product of Cow urine + Neem leaves + Garlic (10%) (12.50 tillers/plant), PBAT-3 + Fermented product of Cow urine + Neem leaves + Garlic (10%) (12.50 tillers/plant) PBAT-3 + Cow urine (5%) + Vermiwash (12.20 tillers/plant), PBAT-3 (12.13% tillers/plant).Fermented product of Cow urine + Neem leaves

+ Garlic (10%) (12.10% tillers/plant) and PBAT-3 + Molasses (2%) + Cow urine (5%) + Vermiwash (12.03% tillers/plant), which did not differ significantly from each other but significantly superior than control (9.00 tillers/plant). Significantly maximum yield was obtained with PBAT-3 + Cow urine (5%) (59.10 q/ha) and PBAT-3 + Molasses (2%) + Cow urine (5%) (59.10 q/ha) and was statistically at par with each other but significantly better than control (44.67 q/ha) significantly, maximum test weight of grain was recorded with PBAT-3 + Molasses (2%) + Cow urine (5%) + Vermiwash (29.38 g), followed by PBAT-3 + Molasses (2%) + Cow urine (5%) (29.03 g) and PBAT-3 + Molasses (2%) + Vermiwash (28.86 g) which was signifiactly at par with each other but better than PBAT-3 (Standard check) (26.66g) and Control (20.16g) (**Table 52).**

Table 51. Effect of delivery methods (foliar sprays) against rice diseases

Treatment	**Sheath Blight**		**False Smut of Rice**	
	Disease Severity (%)	**Disease Reduction (%)**	**Infected panicle /hill (%)**	**Disease Reduction (%)**
PBAT-3 + Molasses (2%)	26.47 (30.93)	27.59	7.58 (15.97)	35.26
PBAT-3 + Vermiwash	25.72 (30.46)	28.69	9.16 (17.59)	28.69
PBAT-3 + Cow urine (2%)	25.37 (30.22)	29.26	10.08 (18.48)	25.09
PBAT-3 + Cow urine (5%)	25.34 (30.21)	29.28	12.06 (20.28)	17.79
PBAT-3 + Fermented product of Cow urine + Neem leaves + Garlic (10%)	24.54 (29.65)	30.59	10.79 (19.16)	22.33
PBAT-3 + Molasses (2%) + Vermiwash	26.01 (30.64)	28.27	11.38 (19.67)	20.26
PBAT-3 + Molasses (2%) + Cow urine (5%)	21.93 (27.91)	34.66	12.79 (20.90)	15.28
PBAT-3 + Cow urine (5%) + Vermiwash	24.25 (29.48)	30.99	12.16 (20.37)	17.43
PBAT-3 + Molasses (2%) + Cow urine (5%) + Vermiwash	21.22 (27.41)	35.83	12.75 (20.90)	15.28
Fermented product of Cow urine + Neem leaves + Garlic (10%)	21.82 (27.83)	34.85	11.75 (20.03)	18.80
PBAT-3 (Standard check)	22.32 (28.18)	34.03	13.23 (21.31)	13.61
Carbendazim (0.1%)	34.80 (36.12)	15.44	14.10 (22.04)	10.66
Control	46.07 (42.72)	-	17.57 (24.67)	-
C.D	**1.84**		**1.85**	
C.V.	**3.51**		**5.44**	

Table 52.Effect of delivery methods (foliar sprays) onplant growth and yield of rice (var. Pant Dhan-4

Treatment	Tillers/hill (90 DAT) (no.)	Yield			
		Yield / plot (10 m^2) (kg)	Yield (q/ha)	Increase in yield (%)	Test wt (g)
PBAT-3 + Molasses (2%)	10.76	5.75	57.50	28.92	28.18
PBAT-3 + Vermiwash	10.93	5.21	52.10	16.81	27.63
PBAT-3 + Cow urine (2%)	10.46	5.58	55.80	25.11	28.15
PBAT-3 + Cow urine (5%)	12.56	5.91	59.10	32.51	25.76
PBAT-3 + Fermented product of Cow urine + Neem leaves + Garlic (10%)	12.50	5.25	52.50	17.71	27.95
PBAT-3 + Molasses (2%) +Vermiwash	12.06	4.91	49.10	10.08	28.86
PBAT-3 + Molasses (2%) +Cow urine (5%)	11.86	5.91	59.10	32.51	29.03
PBAT-3 + Cow urine (5%) + Vermiwash	12.20	5.60	56.00	25.56	27.66
PBAT-3 + Molasses (2%) + Cow urine (5%) + Vermiwash	12.03	4.81	48.10	7.84	29.38
Fermented product of Cow urine + Neem leaves + Garlic (10%)	12.10	4.56	45.60	2.24	27.13
PBAT-3 (Standard check)	12.13	5.20	52.00	16.59	26.66
Carbendazim (0.1%)	10.30	4.80	48.00	7.62	22.16
Control	9.00	4.46	44.60	-	20.16
C.D	**0.99**	**0.60**			**1.40**
C.V.	**5.10**	**6.77**			**3.08**

1.11. Evaluation of *Pseudomonas fluorescens* (Pantnagar Strain PBAT 3) against sheath blight in rice (PAU)

The trial conducted at PAU, Ludhiana with variety PR 121 revealed, per cent disease incidence in chemical control (23.50%) was significantly better than *Pseudomonas fluorescens*(PBAT-3) treated plot (51.50%) and untreated plot (64.0%), which were at par with each other **(Table 53).** The per cent disease severity in *P. fluorescens* (PBAT-3) treated plot (26.62%) was significantly better than untreated plot (43.33%) However, lowest severity 18.57% was recorded in chemical control. Highest yield (72.7q/ha) was recorded in Tilt 25 EC @ 500ml/ha followed by *P. fluorescens* (PBAT-3) treated plot (68.65q/ha) and untreated control (64.91q/ha).

It was concluded that *P.fluorescens (*PBAT-3) treatment revealed significantly lesser disease severity (26.62%) as compared to untreated plot (43.33%). However, chemical (Tilt 25 EC @ 500ml/ha) recorded significantly lowest disease incidence (23.50%), disease severity (18.57%) and higher yield (72.7q/ha).

Table 53.Evaluation of *Pseudomonas fluorescens* (PBAT-3) formulation against sheath blight in rice during 2018

Treatments	Disease Incidence (%)	Per cent disease severity (PDS)*	Yield (q/ha)
*P. fluorescens (*PBAT-3) Seed treatment @ 1.25 g/kg seed Seedling dip @ 1.25 g/ litre water Four foliar sprays 20,50,80 & 110 DAT @ 1.25 g/ litre water	51.50 [b] (45.84)	26.62 [b] (31.03)	68.65 [b]
Tilt /Bumper 25 EC @ 500 ml/ha	23.50[a] (28.19)	18.57 [a] (25.49)	72.7 [a]
Untreated control	64.0 [b] (53.22)	43.33 [c] (41.10)	64.91 [c]
CD (p=0.05)	(7.87)	(4.08)	(3.23)

*SES scale 0 – 9 scale (IRRI)

2. MAIZE

2.1 Evaluation of NBAIR entomopathogenic strains (endophytic EPF) and *Bt* against maize stem borer *Chilo partellus* (Swinhoe) in fodder maize (PJTSAU &PAU)

2.1.1 PAU, Ludhiana

Treatment details

Bb-5a isolate @ 10 ml/litre water
Bb-23 isolate @ 10 ml/litre water
Bb-45 isolate @ 10 ml/litre water
Ma-35 isolate @ 10 ml/litre water
Chemical control (chlorantraniliprole 18.5 SC @ 100 ml/ha)
Untreated control

Number of sprays: Two (10 and 20 days after germination)

Observations were recorded on leaf injury and dead hearts due to stem borer at 2 weeks after second spray. Data on yield were recorded duringharvest per plot basis and converted to q/ha. The data were subjected to analysis of variance using RBD after appropriate transformation. Chlorantraniliprole was significantly better than entomopathogenic fungi in reducing the leaf injury (1.33%) and dead hearts (0.56%) by maize borer **(Table 54).** Leaf damage and dead heart incidence in fungal isolates varied from 4.24-6.83 and 2.64 to 4.31%, respectively as compared to 8.13 and 5.28% in untreated control. Among the four isolates, Ma-35 isolate of *M. anisopliae* and Bb-5a isolate of *B. bassiana* were significantly effective in reducing the incidence of leaf injury (4.24 and 4.66%) and dead hearts (2.64 and 2.78%). Green fodder yield was highest in chlorantraniliprole (164.70 q/ha) and followed by Ma-35 (148.23q/ha) and Bb-5a (147.17 q/ha) which did not differed significantly and the yield was lowest in untreated control (130.3 q/ha).

Table 54. Field evaluation of NBAIR entomopathogenic strains (endophytic EPF) against stem borer *Chilo partellus* in fodder maize during 2018

Treatments	Leaf injury (%)	Dead hearts (%)	Green fodder yield (q/ha)
Bb-5a isolate of *B. bassiana*	4.66^{b} (2.37)	2.78^{b} (1.92)	147.17^{b}
Bb-23 isolate of *B. bassiana*	6.83^{c} (2.79)	4.31^{c} (2.29)	139.20^{bc}
Bb-45 isolate of *B. bassiana*	6.56^{c} (2.74)	4.17^{c} (2.26)	140.43^{bc}
Ma-35 isolate of *M. anisopliae*	4.24^{b} (2.27)	2.64^{b} (1.88)	148.23^{b}
Chlorantraniliprole 18.5 SC@ 100 ml/ha	1.33^{a} (1.52)	0.56^{a} (1.25)	164.70^{a}
Untreated Control	8.13^{c} (3.01)	5.28^{c} (2.49)	130.30^{c}
CD (p=0.05)	(0.29)	(0.27)	14.85

Figures in parentheses are square root transformed values

Evaluation of *Bt* formulations and bioagent against stem borer in *kharif* maize

Field experiment was conducted during *Kharif*, 2018 at farmer's field at Hoshiarpur district of Punjab to evaluate the efficacy of different *Bt* formulations and bioagent against maize stem borer in a randomized block design with a plot size of 100 $m^2$with three replications. The maize hybrid PMH 1 was sown with inter and intra row spacing of 60 x 20 cm.

Treatments details:

T_1 -Two sprays of commercial *Bt* formulation 1 @1250 g/ha on 10 and 20 days old crop
T_2 - Two sprays of commercial *Bt* formulation 2 @1500 ml/ha on 10 and 20 days old crop
T_3 - Two releases of *Trichogramma chilonis* @ 1,00,000 /ha on 10 and 17 days old crop
T_4 - Chemical control (chlorantraniliprole 18.5 SC @ 75 ml/ha)
T_5– Untreated control

Observations: Number of infested plants from 100 randomly selected plants at 7 and 14 days after treatment in each plot. The per cent dead heart incidence due to *C. partellus* was worked out and the yield was recorded at harvest on whole plot basis. Chlorantraniliprole was significantly better than other treatments in reducing dead hearts recorded after 7 (1.33%) and 14 (1.67%) days of application **(Table 55).** The dead heart incidence in both commercial *Bt* formulations were at par with each otherand followed by treatment with *Trichogramma* releases. However, all the treatments were significantly better than untreated control in reducing the dead heart incidence. Significantly higher yield (49.63 q/ha) was recorded in chlorantraniliprole followed by treatments with *Bt* sprays, which were at par with each other. The yield was significantly lower in untreated control (41.23 q/ha).

Table 55. Evaluation of *Bt* formulations and bioagent against stem borer stem borer *Chilo partellus* in *kharif* maize during 2018

Treatments	Mean dead hearts (%)		Yield (q/ha)
	7 DAT	14 DAT	
Two sprays of commercial *Bt* formulation 1 @ 1250 g/ha on 10 and 20 days old crop	3.00(1.99)	4.33 (2.31)	46.70
Two sprays of commercial *Bt* formulation 2 @ 1500 ml/ha on 10 and 20 days old crop	3.67 (2.15)	4.67 (2.37)	46.33
Two releases of *Trichogramma chilonis* @ 1,00,000 /ha on 10 and 17 days old crop	5.67 (2.58)	8.00 (3.00)	44.27
Chlorantraniliprole 18.5 SC @ 75 ml/ha	1.33 (1.52)	1.67 (1.63)	49.63
Untreated control	9.67 (3.26)	14.33 (3.91)	41.23
CD (p=0.05)	(0.41)	(0.37)	2.60

Figures in parentheses are square root transformed values; DAA – days after treatment

2.2Biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis.* (ANGRAU, MPUAT, PAU*)*

2.2.1 ANGRAU, Anakapalle

Treatments:
T1: Release of *Trichogramma chilonis* @ 100,000/ha/release at 15, 22 and 29 days after seedling emergence at 7- 10 day interval.
T2: Farmers' practice (Carbofuran 3 G @ 3 kg/ acre whorl application at 25-30 days after seedling emergence).
Results: Demonstration conducted in 12 acres at three locations in farmer fields of Srikakulam, Visakhapatnam and Vizianagaram districts during *rabi*, 2018. In all the three locations, maize stem borer, *Chilo partellus* damage was nil in biocontroltreatment and low (2.22%DH) in farmers practice and *Sesamia inferens* damage as shot holes was low (12.77 %) in *Trichogramma chilonis* release plot compared to chemical control plot (19.79%). Fall armyworm, *Spodoptera frugiperda* damage was low in biocontrol plot (17.22 %) compared to carbofuran (33.95%) **(Table 56)** Release of *T. chilonis* @ 100,000/ha/release at 15, 22 and 29 days after seedling emergence at 7-10 day interval resulted in 100, 35.47 and 49.2% reduction in *C. partellus*, *S. inferens*, *S. frugiperda* damage, respectively.

Table 56. Biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis*

Treatment	*C. partellus* dead heart (%)	Incidence (%)	
		S.inferens	*S. frugiperda*
Location 1: Chuchukonda, Visakhapatnam district			
T1: Field release of *Trichogramma chilonis* @ 75,000/ ha, 3 times from 15 DAS	0.00	15.00	16.65
T2 : Farmers practice : monocrotophos spraying @ 1.6 ml/lt at 25 days after seedling emergence followed by neem formulation @ 5 ml/lt after 15DAS	3.35	18.35	21.65
Location 2 : Pidisila, Vizianagaram district			
T1: Field release of *Trichogramma chilonis* @ 75,000/ ha, 3 times from 15 DAS	0.00	13.30	11.65
T2 : Farmers practice : monocrotophos spraying @ 1.6 ml/lt at 25 days after seedling emergence followed by neem formulation @ 5 ml/lt after 15DAS	3.30	22.67	18.35
Location 3 :Patharlapalli , Srikakulam district			
T1: Field release of *T. chilonis* @ 75,000/ ha, 3 times from 15DAS	0.00	10.00	23.35
T2: Farmers practice : monocrotophos spraying @ 1.6 ml/lt at 25 days after seedling emergence followed by neem formulation @ 5 ml/lt after 15DAS	0.00	18.35	61.70
Average			
T1: Field release of *Trichogramma chilonis* @ 75,000/ ha, 3 times from 15DAS	0.00	12.77	17.22
T2 Farmers practice monocrotophos spraying @ 1.6 ml/lt at 25 days after seedling emergence followed by neem formulation @ 5 ml/lt after 15 DAS	2.22	19.79	33.9
Percent reduction in T1 over T2	100.0	35.47	49.2

DAS: Days after seedling emergence

2.2.2 MPUAT, Udaipur

Treatment details:

T1: Three releases of *Trichogramma chilonis* @ 100,000/ha/release at 15, 22 and 29 days after crop germination

T2: Farmers' practice (to be recorded at each location)

T3: Untreated control

Observations:

Dead hearts from 20 randomly selected plants at 30 DAS

Yield (t/ha) and incremental benefit cost ratio

Table 57. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2018

Treatments	Dead hearts (%)	Incidence reduction in over control (%)	Yield (q/ha)	Yield increase over control (%)
T. chilonis@ 100,000/ha	8.67	49.28	31.10	20.40
Spinosad 45 SC @ 1.0ml/ 3 lit(farmers practice)	6.47	62.09	33.67	30.35
Untreated control	17.07	-	25.83	-

Results: The demonstrations on the releases of *Trichogramma chilonis* were conducted at farmer's fields in an area of 10 hectares in Udaipur district of Rajasthan. Each demonstration area was divided into three blocks representing three treatments, *viz*., three releases of *T. chilonis* @ 100,000 parasitoids /ha/release at 15, 22 and 29 days after crop germination, chemical control (farmers' practice) and untreated control. In chemical control, spinosad 45 SC @ 1.0ml/ 3 lire water was sprayed using 150 liters of water per hectare.

The dead heart incidence in fields with the releases of *T. chilonis* was 8.67% and in chemical control, it was 6.47%. The reduction in incidence over control was 49.28 and 62.09 % in T_1 and T_2, respectively. The yield in *T. chilonis* (T_1) (31.10 q/ha) and Spinosad 45 SC (T_2) (33.67 q/ha) fields were significantly more than in untreated control (25.83 q/ha) (**Table 57).**

2.2.3 PAU, Ludhiana

The demonstrations on the biological control of maize stem borer, C*hilo partellus* using *T. chilonis* releases were conducted at farmer's fields on an area of 534 acres in Hoshiarpur, Nawanshahr, Fazilka, Gurdaspur, Mohali, Mansa and Roop Nagar districts of Punjab in collaboration with maize Section, Department of Plant Breeding and Genetics, FASC Hoshiarpur, KVK Hoshiarpur, KVK Ropar, Regional Station Abohar and Regional Station Gurdaspur. Each demonstration area was divided into three blocks representing three treatments, *viz.* two releases of *T. chilonis* @ 1,00,000 parasitoids/ha, chemical control (farmers' practice) and untreated control. Tricho-cards each having approximately 1000 parasitized eggs were cut into 100 strips and were stapled uniformly to the underside of the central whorl leaves on 10 and 17 days old crop in biocontrol treatment. In chemical control, chlorantraniliprole 18.5 SC @ 75 ml/ ha was sprayed using 150 litres of water per ha. The observations were recorded on dead heart incidence and the yield was recorded at harvest on whole plot basis.

Based on the mean of all locations dead heart incidence in fields with the releases of *T. chilonis* was 6.55% and in chlorantraniliprole, it was 3.72% **(Table 58)**. However, both the treatments were significantly better than untreated control (14.43%). The reduction in incidence over control was 56.05 and 77.55% in biocontrol and chlorantraniliprole, respectively. Similarly, yield in biocontrol (44.04 q/ha) and chlorantraniliprole (46.51 q/ha) fields were significantly more than in untreated control (39.50 q/ha). The yield increase over control was 12.33% in biocontrol as compared to 18.81% in Chlorantraniliprole. The net returns over control in biocontrol package were Rs. 7218/- as compared to Rs.10742/- in chlorantraniliprole **(Table 59).**

Table 58. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *kharif* maize during 2018

Treatments	Dead hearts (%)	Reduction in incidence over control (%)	Yield (q/ha)	Yield increase over control (%)
T. chilonis @ 1,00,000 per ha*	6.55[b]	56.05	44.04[b]	12.33
Chlorantraniliprole 18.5 SC@ 75 ml/ha	3.72[a]	77.55	46.51[a]	18.81
Untreated control	14.43[c]	-	39.50[c]	-

Table 59. Cost Benefit analysis

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)
Biocontrol (release of *T. chilonis*)	44.04	4.54	7718.00	500.00	7218.00
Chlorantraniliprole 18.5 SC@ 75 ml/ha	46.51	7.01	11917.00	1175.00	10742.00
Untreated control	39.50	-	-	-	-

Price of maize Rs. 1700/- per quintal; * includes trichocard/insecticide + labour cost; Price of Coragen (chlorantraniliprole 18.5 SC) @ Rs. 1850/- per 150 ml

2.3 Adhoc field trial against fall Armyworm in *rabi* maize (ANGRAU, MPKV, OUAT, TNAU, UAS-R)

2.3.1 ANGRAU, Anakapalle

1.5 On-farm trial on efficacy of *Metarhizium anisopliae* bio-fungal formulation against the fall armyworm, *Spodoptera frugiperda* in maize (ANGRAU)

Experiments was conductedon farm trial farmer field at Anakapalle in 30 days age sweet corn crop severely infested with fall armyworm with adjacent crop of 6 acres sweet corn of 15-60 days crop age (staggered sowings). Two sprayings with *M. anisopliae* (talc formulation and conidiated rice) @ 5 g/lt in comparison with chemical insecticide, emamectin benzoate@0.4 g/ltspraying against late instars of fall armyworm noticed in 30 days age crop and second spraying at 25 day interval in November & December, 2018.Observed 25.33% mortality of FAW at 5-7 day after spraying *M. anisopliae* compared to 89.67 % mortality with emamectin benzoate. Sweet corn cob damage recorded was 23.67% in *M.anisopliae* sprayed plot and 10.33% in emamectin benzoate sprayed plot. Conducted On farm trials on maize fall armyworm using biocontrol agents (NBAIR strains of *Beauveria bassiana* – Bb45, *Metarhizium anisopliae* – Ma35) from 25 days after sowing , two sprays at 15 day interval at Patharlapilli (Srikakulam district) and Chollangipeta, Vizianagaram district during *rabi*, 2019 (February month). FAW damage was less in emamectin plot (21.66%) compared to Ma 35 (32%) and Bb45 (32.33%).

Treatments: 8

T1: *Trichogramma pretiosum* + NBAIR *Bt* 2% (3 sprays depending on pest incidence, first spray after 20-25 days after sowing (DAS) & then the next sprays at 10 days intervals)

T2: *T. pretiosum* + *M. anisopliae* NBAIR -Ma 35, 0.5% (3 sprays depending on pest incidence, first spray after 20-25 days of sowing & then the next sprays at 10 days intervals)

T3: *T. pretiosum* + *H.indica* NBAIR H38 (2 whorl applications @ 4kg/acre, first application after 20-25 days of sowing & then the next sprays at 10 days intervals)

T4: *T. pretiosum+ P.fluorescens (Pf DWD 1%)* (2-3 sprays @ 2g/litre depending on pest incidence, first spray after 20-25 DAS& then the next sprays at 10 days intervals)

T5: *T. pretiosum* alone (1 card per acre (2 releases, first release after one week of sowing & then second one after one week of first release)

T6: Pheromones @15 traps/acre (install one week after sowing and the lures replaced after 30 days)

T7: Insecticidal check (emamectin benzoate 0.4gm/lt)

T8: Untreated check (control)

T. pretiosum (1 card per acre, 2 releases, first release after one week of sowing &then second one after one week of first release).

Observations: Conducted *rabi* maize sowing with PAC751 variety on 28.01.2019and field release of *T. pretiosum* @1 card per acre from one week after sowing, two times at weekly interval in T1 to T5. Three sprayings were conducted in maize whorls as per the treatments from 20 DAS at 10 day interval and the data was recorded before each spraying.

Results: Fall armyworm damaged plants per plot and larvae per plot recorded at 20 DAS was not significantly different among the treatments (**Table 60A).** Fall armyworm dead larvae per plot recorded at 30 days after sowing was significantly high in T7 (48.33) followed by T2 (23.0) and T1 (22.0). At 40 days after sowing, fall armyworm damaged plants per plot were high in T8 (115.67), T6 (113.0) and T5 (109.67) and low in T1 (51.66) and T2 (55.67). (**Table 60B)** Upto 50 days after sowing, total damaged plants per plot recorded high in T8 (193.33) followed by T6 (190.67) and T5 (188.67); Total dead larvae per plot was high in T7 (42.33) followed by T2 (32.33 and T1 (28.0); High parasitized egg mass per plot recorded in T5 followed by T2 and T1 and predators per plot was high in T7 followed by T1 and T5. Fall armyworm mortality noticed at one day after spraying emamectin benzoate and at five to seven days after spraying *Bt*, *M. anisopliae*, *H. indica*, *P.fluorescens*. Tassel and maize cob damage by fall armyworm was not noticed in all the treatments and crop is at cob filling stage. Yield data will be recorded after harvest. Tassel and maize cob damage by fall armyworm was not noticed in all the treatments and crop is at cob filling stage and yield data will be recorded after harvest **(Table 60C) (Fig. 10).**

Table 60A. Fall armyworm incidence before and after first spray

Treatment	Before spray 20 DAS				After 1st spray 30 DAS		
	Damaged plants /plot	Larvae /plant	Egg parasitization /plot	Predators /plot	Damaged plants /plot	Dead larvae /plot	Predators /plot
T1 : TP +*Bt*	121.12	0.51	20.07	4.0	56.33	22.0 (25.94)	2.66
T2: TP+ Ma	164.2	1.29	20.87	4.33	65.33	23.0 (27.01)	3.33
T3: TP+Hi	171.11	0.82	9.8	3.66	64.0	10.33 (17.97)	2.33
T4: TP+Pf	87.46	0.56	11.83	5.0	76.33	14.67 (21.2)	2.33
T5:TP alone	171.24	0.9	21.67	3.33	70.33	0.0 (1.0)	2.0
T6: Pheromones	170.24	0.77	0.0	1.66	73.0	0.0 (1.0)	2.33
T7: Insecticidal check	143.23	1.02	0.0	3.33	31.0	48.33 (48.33)	10.0
T8: Untreated Check	156.63	1.19	0.0	1.33	69.0	0.0 (1.0)	3.66
CD (0.05)	NS	NS		NS	NS	13.17	NS
CV%	32.46	46.32		55.93	40.1	44.18	46.27

Values in parenthesis are angular transformed values

Table 60B. Fall armyworm incidence after second and third spraying

Treatment	After 2nd spray 40 DAS			After 3rd spray 50 DAS			
	Damaged plants /plot	Dead larvae /plot	Predators /plot	Damaged plants /plot	Dead larvae /plot	Parasitized egg mass /plot	Predators /plot
T1 : TP +*Bt*	51.66	3.0	1.66	6.0	3.0	0.0	3.33
T2 : TP+ Ma	55.67	6.67	1.66	6.66	2.66	0.33	0.66
T3: TP+Hi	65.0	2.33	1.33	3.33	7.0	0.66	0.66
T4: TP+Pf	74.66	2.0	1.66	8.33	2.66	0.33	1.33
T5: TP alone	109.67	0.0	1.33	9.33	0.0	0.0	2.66
T6: Pheromones	113.0	0.0	1.0	9.66	0.33	0.0	1.33
T7:Insecticidal check	0.0	0.0	3.33	0.0	0.0	0.0	0.0
T8:Untreated Check	115.67	0.0	1.0	8.66	0.33	0.0	1.66

Table 60C. Fall armyworm incidence after three sprays upto 50 days crop age

Treatment	After three sprayings upto 50 DAS			
	Damaged plants /plot	Dead larvae /plot	Parasitized eggmass /plot	Predators /plot
T1 : TP +*Bt*	114.0	28.0	20.07	11.33
T2 : TP+ Ma	127.67	32.33	21.2	10.0
T3: TP+Hi	132.33	19.67	10.13	8.0
T4: TP+Pf	159.33	19.33	12.17	10.33
T5: TP alone	188.67	0.0	21.67	9.33
T6: Pheromones	190.67	0.0	0.0	6.67
T7: Insecticidal check	31.0	48.33	0.0	17.67
T8: Untreated Check	193.33	0.0	0.0	7.67
CD (0.05)	40.14	19.3		NS
CV%	15.92	59.42		39.92

Fig. 10

2.3.2 MPKV, Pune

The experiment was laid out on the Research Farm of Agricultural Entomology Section, College of Agriculture, Pune. The Maize (var. Panchganga) was sown on 26th February, 2018 with 4.5 x 4.5 m plot size and 70 x 20 cm spacing in Randomized Block Design with 8 treatments replicated thrice.

Treatment details:

T_1: *T. pretiosum* 1 card per acre (2 release) + NBAIR*Bt* 2% @ 2.0 ml/l
T_2: *T. pretiosum* 1 card per acre (2 release) + *M. anisopliae* NBAIR @ 5 g /l
T_3: *T. pretiosum* 1 card per acre (2 release) + EPN*H. Indica* NBAIR H38@ 4kg/acre
T_4: *T. pretiosum* 1 card per acre (2 release) + *P. fluorescens (Pf DWD* 1%)@ 2ml/l
T_5: *T. pretiosum* 1 card per acre alone (2 release)
T_6: Pheromones traps @15 /acre
T_7: Chemical control (emamectin benzoate 0.4g/l).
T_8: Untreated control

Results: *T. pretiosum* was released one week after sowing 6th March, 2018 and second release on 13th March, 2018 and incidence of FAW is not observed, hence application of biopesticides and EPN was not given to the maize crop, final yield is awaited. Hence, trial is in progress.

2.3.3 TNAU Coimbatore

A field trial was laid out at Administrative block, TNAU with the following treatments on 13th march, 2019. The treatments were imposed on 21, 29 March and 12th April, 2019 and trial is in progress **(Fig. 11).**

Treatments

1. *T. pretiosum* (1 card per acre - after one week of planting) + NBAIR *Bt* (2 sprays) 2%
2. *T. pretiosum* (1 card per acre - after one week of planting) + *M. anisopliae* NBAIR (Ma-35) 2 sprays @ $1X10^8$cfu/ml
3. *T. pretiosum* (1 card per acre - after one week of planting) + EPN *H. indica* NBAIR H38 whorl application @ 4kg/acre
4. *T. pretiosum* (1 card per acre - after one week of planting) + *S. litura* NPV @ 2ml/liter
5. *T. pretiosum* (1 card per acre - after one week of planting) + *P. fluorescens (Pf DWD* 1%) (2 sprays)
6. Insecticidal check (emamectin benzoate 0.4gm/lt)
7. *T. pretiosum* (1 card per acre - after one week of planting) alone
8. Pheromones @15 traps/acre (one week after planting and lures replacement once in 25-30 days)
9. *T. pretiosum* (1 card per acre - after one week of planting) + NBAIR NPV (2 sprays) 2%
10. Untreated check (control)

Plot size 8×5m, three replications

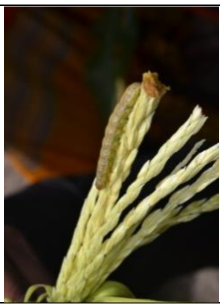
Damage symptoms			
			
Scrapping	Small to medium elongated holes	Parallel shot holes	Irregular shaped holes
			
Drooping of leave portion above the feeding area	Loss of top portion of leaves	Chewed up frass material	Faecal pellets in the leaf whorl
			
Larva in the terminal shoot	Feeding on tassel,	Feeding on terminal portion of cob.	Feeding stalk portion of cob.

Fig. 11 MAIZE FALL ARMYWORM

2.3.4 OUAT, Bhubaneswar

The experiment was laid out on the Research Farm of OUAT, Bhubaneswar and the maize (var. DKC-9141) was sown on 13th November, 2018 with 8 x 5 m plot size in randomized block design with 8 treatments replicated thrice.

TREATMENTS

T_1: *T. pretiosum* one card per acre (2 releases, 1st one week after planting and 2nd one seven days after 1st release) + NBAIR *Bt* 2% @ 2ml/l – 2 sprays starting from 25 days after planting followed by the 2nd sprays 20 days after 1st spray.

T_2: *T. pretiosum* release as per T_1+ *M. anisopliae* NBAIR- Ma 35, 0.5% spray @ 5g/l – 2 sprays as per T1

T_3: *T. pretiosum* release as per T_1+ EPN *H. indica* NBAIR H38 whorl application @4kg/ac- 2 applications as per T_1

T_4: *T. pretiosum*release as per T_1+ *P. fluorescens* (Pf DWD 1%) @ 20g/l -2 sprays as per T_1

T_5: *T. pretiosum* release as per T_1
T_6: Pheromone traps @ 15/ac (Installed one week after planting and lures were replaced at an interval of 30 days)
T_7: Insecticidal check (emamectin benzoate 0.4 g/l)-2 sprays at 20 days interval. 1st spray was given at 15 days after planting the seeds
T_8: Untreated check

Observations: Ten plants per plot were selected randomly and observations were taken on the following parameters such as No. of egg patches/10 plants, No. of larvae/ 10 plants, Plant damage (%), No. of predators/ 10 plants and green cob yield (t/ha).

Results: The number of egg patches& larvae per 10 plants, plant damage due to fall armyworm and number of predators/10 plants were highest in untreated check and lowest in chemical control as compared to different bio-products. On the other hand, green cob yield was highest (17.54t/ha) in chemical check and lowest (8.14t/ha) in untreated control. Among the tested bio-modules, trichocard releases+ *Bt* sprays expressed highest yield (16.05t/ha and lowest pest damage which is comparable to emamectin benzoate and closely followed by trichocard release + *Pseudomona*s sprays **(Table 61).**

Table 61.Bio-efficacy of bio-modules against fall armyworm in *rabi* maize at Bhubaneswar

Treatments	No. of egg patches /10 plants	No. of larvae/ 10 plants	Plant damage (%)	No. of predators /10 plants	Green cob yield (t/ha)
T_1:Trichocards 2 releases + *Bt* 2 sprays	3.10 (1.89)*	3.93 (2.10)	40.67	0.40 (0.95)	16.05
T_2:Trichocards 2 releases + *Metarhizium* 2 sprays	3.56 (2.01)	5.33 (2.41)	56.67	0.33 (0.91)	13.89
T_3:Trichocards 2 releases +2 sprays of EPN	4.00 (2.11)	5.93 (2.53)	60.00	0.53 (1.02)	9.97
T_4:Trichocards 2 releases +2 sprays of *Pseudomonas*	3.55 (2.01)	4.67 (2.28)	53.33	0.60 (1.05)	14.15
T_5:Trichocards 2 releases	3.99(2.11)	5.87(2.52)	58.00	0.80 (1.14)	13.01
T_6:Pheromone traps @15 traps/ac	4.44 (2.22)	6.00(2.55)	59.33	0.73(1.11)	10.98
T_7:Emamectin benzoate @0.4g/l 2 sprays	2.64 (1.77)	3.93(2.10)	37.33	0.27(0.87)	17.54
T_8:Untreated check	4.78(2.30)	6.80(2.70)	64.67	0.80(1.14)	8.14
S.E. (m)±	- (0.10)	- (0.07)	2.68	- (0.05)	0.66
C.D. (0.05)	- (0.30)	- (0.21)	8.12	- (0.16)	2.00

*Figure in parentheses are $\sqrt{(x+0.5)}$ transformed values

2.3.5 Demonstration of IPM modules for the management of Fall Armyworm in *Rabi* maize (UAS, Raichur)

Results will be presented at workshop

3. Sorghum

3.1 Adhoc field trial against fall armyworm in *rabi* sorghum (IIMR & UAS-R)

3.1.1: IIMR, Hyderabad

Following outbreak of fall armyworm, *Spodoptera frugiperda* during *kharif* 2018, adhoc field trial was taken upwith following treatments:

T1: *T. pretiosum* 1 card/acre (2 releases, first release one week of planting & second one after one week of release + spray of NBAIR *Bt* 2% twice at 20, 30 DAE

T2: *T. pretiosum* 1 card/acre (2 releases, first release one week of planting & second one after one week of release + spray of *M. anisopliae* Ma 35 0.5 % at 20, 30 DAE)

T3: *T. pretiosum* 1 card/acre (2 releases, first release one week of planting & second one after one week of release + EPN (*H. indica*) NBAIR H 38 (2 applications @ 4 kg/acre (20, 30 DAE)

T4: *T. pretiosum* 1 card/acre (2 releases, first release one week of planting & second one after one week of release + *Pseudomonas flourescens* (Pf DWD 1%) 2 applications @ 2 ml/liter (20, 30 DAE)

T5: *T. pretiosum* alone 1 card/acre (2 releases, first release one week of planting & second one after one week of release)

T6: Deployment of pheromones @ 15 traps/acre oneweek after planting

T7: Emamectin benzoate 0.4 gm/lt at 20, 30 DAE

T8: Untreated Control

Results: Moderate natural incidence of fall armyworm was observed. The worm attacked crop from early stage itself from 10 DAE of crop. It inflicted irregular cuts on the leaves and later stages in whorl. The damage was found to get reduced as soon as the panicle initiation stage approached.

Egg patches: The moth laid eggs in patches inside the whorls. There was significant reduction in the number of egg patches laid following the first round of treatments imposed as compared to control in all the treatments. The egg patches ranged from 0.66-2.66 eggs/10 plants/ plot and by the second round of treatments egg patches were not observed across the treatments **(Table 62).**

Larvae/10 plants: No of larvae were recorded before imposing treatment and it was found that there was significant reduction in the larval population in T7 (0.0 NOs/10 plants) after application of second round of treatment and it was on par with T2 (1.00 larvae/ 10 plants) and T1 (1.33). Among the biocontrol agents, treatment T2 resulted in 92.0% reduction in larval population over the initial population **(Table 62).**

Plant damage (%): The proportion of plants/ plot damaged by fall armyworm was assessed and it was found that there was significant reduction in the plant damage in T7 (0.0 NOs/10 plants) after application of second round of treatment and it was on par with T2 (1.17 %) and T1 (1.27 %). Among the biocontrol agents, treatment T2 resulted in 85.6% reduction in larval population over the damage **(Table 62).**

Yield: Grain yield /38.4 sq.mt was assessed and it was found that significantly highest yield was recorded in treatment T7 (4.790 kg) which was on par with T2 (7.015 kg) and T1 (6.979 kg). Among the biocontrol agents I treatment T2 there was 46.45% increase in yield over the control (Table 2). Overall among the biocontrol agents the treatment T2 (*T. pretiosum* 1 card/acre (2 releases, first release one week of planting & second one after one week of release + spray of *M. anisopliae* (Ma 35) 0.5% at 20, 30 DAE) was the best in terms of reduction in no of egg patches, larval population, plant damage and increased yield over the control. However, the treatment T7 (emamectin benzoate 0.4 gm/ltat 20, 30 DAE) was significantly the best and it was on par with T2.

Evaluation of biocontrol agents for management of *Spodoptera frugiperda, rabi* 2018-19, ICAR-IIMR, Hyderabad

Experiments on evaluation of biocontrol agents for management of *Spodoptera frugiperda* was conducted with maize var (C-43) and sown on 17th November 2018 with three replications.

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Table 62. Efficacy of biocontrol agents against Fall armyworm in *rabi* sorghum during 2018-19

Treatment	Egg patches/10 plants/ plot (Nos)		Larvae/10 plants/plot (nos) +			Damaged plants (%)/ plot (%) @			Grain yield (kg/plot)
	Pre	Post T1	Pre T	Post T1	Post T2	Pre T	Post T1	Post T2	
T1	1.66 (1.63)	0.667 (1.28)a	2.70(1.82)	1.33 (1.52)abc	1.00(1.38)abc	13.8(21.79)	2.07 (8.23)abc	1.27 (6.45)b	6.320abcd
T2	2.00 (1.73)	0.333 (1.14)a	2.30 (1.91)	1.00 (1.41)ab	0.33(1.14)ab	14.0(21.96)	2.90 (9.77)cd	1.17(6.17)b	7.015ab
T3	2.00 (1.73)	0.667 (1.28)a	2.30 (1.82)	1.66(1.63)bcd	1.33(1.52)bcd	14.4(22.29)	3.87 (11.32)de	1.37(6.71)b	6.979ab
T4	2.00 (1.72)	1.333 (1.52)ab	2.70 (1.82)	2.00(1.73)bcd	1.66(1.63)cd	15.6(23.22)	3.03 (10.02)d	2.03 (8.17)c	5.086de
T5	1.66 (1.63)	1.333 (1.52)ab	2.70 (1.91)	2.00(1.72)bcd	1.66(1.58)bcd	15.5(23.20)	1.53 (7.05)a	1.43 (6.79)bc	6.717abc
T6	1.66 (1.63)	0.667 (1.28)a	3.30 (1.91)	1.66(1.63)bcd	1.00(1.38)abc	14.6(22.41)	3.60 (10.90)de	3.17 (10.19)d	5.468cde
T7	2.00 (1.73)	0.333 (1.14)a	3.00 (2.06)	0.66(1.28)a	0.00(1.00)a	14.2(22.15)	1.83 (7.77)ab	0.00(0.0)a	7.470a
T8	1.66 (1.63)	2.667 (1.91)b	3.30 (2.00)	4.66(2.38)e	5.33(2.52)e	15.2(22.96)	16.57 (24.00)f	17.87(24.98)e	4.790e
CD (0.05)	NS	0.4	NS	0.3	0.5	NS	1.46	1.37	
CV (%)	12.4	15.9	13.9	11.4	17.4	8.70	7.45	8.93	

Post T1- 20 DAE; Post T2- 30 DAE

+ Figures in parantheses are square root transformed values

@ Figures in parantheses are arc sine transformed values values

3.1.2 UAS, Raichur

Experiments on evaluation of biocontrol agents for management of *Spodoptera frugiperda* was conducted with sorghum var (M 35-1) and sown on 11th November 2018 with three replications at Main Agricultural Research Station, Raichur. The parasitoid released on 3 February and 12th March, 2018.

Treatments Details

T1: *T. pretiosum* (1 card per acre to be installed after one week of planting) + NBAIR *Bt* (2 sprays) 2%
T2: *T. pretiosum* (1 card per acre to be installed after one week of planting) + *M. anisopliae* NBAIR (Ma 35) 2 sprays @ 1X10^{8} cfu/ml
T3: *T. pretiosum* (1 card per acre to be installed after one week of planting) + EPN *H. indica* NBAIR H38 whorl application @ 4kg/acre
T4: *T. pretiosum* (1 card per acre to be installed after one week of planting) + *Spodoptera litura* NPV @ 2ml/litre
T5: *T. pretiosum* (1 card per acre to be installed after one week of planting) + *P.fluorescens (Pf DWD 1%)* (2 sprays)
T6: Insecticidal check (emamectin benzoate 0.4gm/lt)
T7: T. pretiosum (1 card per acre to be installed after one week of planting) alone
T8: Pheromones @ 15 traps/acre (install one week after planting and lures to be replaced once in 25-30 days)
T9: Untreated check (control)

Observations: Select 10 plants randomly per plot and take observations on following parameters, like Number of egg patches per plot, Number of larvae per plant/plot, Number of damaged plant/5 plots, Number of dead larvae (due to bacteria/virus/fungus) per plot, Percent egg parasitization and larval parasitization, Number of predators per plant and final grain yield.

Results: Number of egg patches of FAW ranged from 141 to 164 per plot which was statistically non-significant. Minimum of 74 larvae per plot was noticed in T_3 *T. pretiosum* (1 card per acre followed by application of EPN *H. indica*) which was followed by sole release of *T. pretiosum.* Highest per cent parasitisation was noticed in continuous release of *T. pretiosum* which recorded 30.25%. The highest grain yield of 6.85 /ha was noticed in T_3 *T. pretiosum* (1 card per acre followed by application of EPN *H. indica*) which was at par with all the treatments including untreated control **(Table 63).**

Table 63.Efficacy of biocontrol agents against Fall armyworm in *rabi* sorghum during 2018-19

Sl. No.	Particulars	Egg patches per plot (No.)	Larvae per plant/plot (No.)	Damaged plant (No.)	Dead larvae (No.)	Parasitisation (%)	Grain yield (q/ha)
T_1	*T. pretiosum* (1 card per acre to be installed after one week of planting) + NBAIR *Bt* (2 sprays) 2%	164	106	96	02	20.25	6.25
T_2	*T. pretiosum* (1 card per acre to be installed after one week of planting) + *M. anisopliae* NBAIR (Ma 35) 2 sprays @ $1X10^8$ cfu/ml	155	98	88	11	19.75	6.50
T_3	*T. pretiosum* (1 card per acre to be installed after one week of planting) + EPN *H. indica* NBAIR H38 whorl application @ 4kg/acre	146	74	62	28	21.50	6.75
T_4	*T. pretiosum* (1 card per acre to be installed after one week of planting) + *S. litura* NPV @ 2ml/liter	158	102	123	0	21.00	6.15
T_5	*T. pretiosum* (1 card per acre to be installed after one week of planting) + *P. fluorescens (Pf DWD 1%)* (2 sprays)6.	141	108	120	0	21.50	6.25
T_6	Insecticidal check (emamectin benzoate 0.4gm/lt)	143	64	45	34	0	6.85
T_7	*T. pretiosum* (1 card per acre to be installed after one week of planting) alone	157	92	129	0	30.25	6.25
T_8	Pheromones @15 traps/acre (install one week after planting and lures to be replaced once in 25-30 days)	163	128	125	0	5.00	6.50
T_9	Untreated check (control)	148	156	130	0	3.50	6.10
S Em±		**0.18**	**0.43**	**0.38**	**0.09**	**0.18**	**0.35**
CD (P=0.05)		**NS**	**1.29**	**1.14**	**0.27**	**0.55**	**NS**

4. FINGER MILLET

4.1 Evaluation of entomopathogenic fungi formulations against millet borers in finger millet (IIMR)

4.1.1 IIMR, Hyderabad

Three isolates of *Beauveria bassiana* (Bb 5a, Bb 23 and Bb 45), one isolate of *Metarhizium anisopliae* were evaluated for their efficacy for managing pink borer of finger millet (*Sesamia inferens*) during *kharif* 2018 at ICAR-IIMR, Hyderabad on var (5614) with 4 replication and sown on 10th July, 2018. The biocontrol agents were applied twice at 20 and 40 DAE as high volume spray and the natural infestation of pink borer was low.

Table 64. Evaluation of entomofungal formulations against pink borer in finger millet (*kharif* 2018), ICAR-IIMR, Hyderabad

Sl No	Treatment	Pre treatment (DH %)	DH% (30 DAE)	Pre treatment (WEH %)	WEH % (at harvest)	Yield (kg/plot)
T1	Bb-5a @ 10 ml /lt	8.68a	4.33c	7.67a	3.26c	2.79 bc
T2	Bb-23 @ 10 ml /lt	8.38a	3.74bc	7.96a	2.21ab	3.24 ab
T3	Bb-45 @ 10 ml /lt	8.40a	2.55a	7.76a	1.56a	3.56 ab
T4	Ma-35 @10 ml /lt	8.25a	2.62ab	7.90a	2.45bc	3.44ab
T5	Carbofuran 3G @ 20 kg/ha	8.33a	1.84a	7.74a	1.36a	3.75 a
T6	Untreated/Control	8.23a	14.0d	7.82a	6.60d	1.97 c
	Mean	8.38	4.85	7.80	2.91	3.12
	CD (0.05)	NS	1.17	NS	0.97	0.83
	CD (0.01)	NS	1.63	NS	1.35	1.14
	CV (%)	12.64	16.14	10.2	22.30	17.53
DH- Deadhearts; WEH- White earheads; DAE- Days after emergence						

Dead hearts (DH): There were significant differences in the treatments and the DH caused in finger millet were least in T5 (1.84% DH) and it was on par with T3 (2.55% DH). There was 86.9 and 81.8% reduction in DH over the control where in 14.0% DH was recorded **(Table 64).**

White earheads (WEH): There were significant differences in formation of WEH and white ear heads caused in finger millet were least in T5 (1.36 %) and it was on par with T3 (1.56%). There was 66.5 and 62.9 % reduction in WEH over the control where 6.6 % white ear heads were observed **(Table 64).**

Grain yield (Kg/plot): Highest grain yield was obtained inT5 (3.75 kg/plot) which was on par with T3 (3.56 kg/plot), T4 (3.4 kg/plot) and T2 (3.24 kg/plot). There was 90.4 % and 80.7% increase in grain yield over the control. Overall based upon the reduction in damage to finger millet by pink borer and yield the treatment T5 (Application of carbofuran 3G granules @ 20 kg/ha) was the best and it was on par with T3 (Bb-45 @ 10 ml /lt). The experiment would be repeated in *Kharif* 2019 for confirmation of results.

PULSES

5. PIGEONPEA

5.1 Evaluation of NBAIR *Bt* formulation on pigeonpea against pod borer complex (ANGRAU, MPKV, PAU, TNAU, UAS, Raichur, PDKV)

5.1.1 ANGRAU, Anakapalle

Treatments: Three
T1: NBAII *Bt*G4 2% @ 2.0 ml/lt - 3 sprays at pre flowering, post flowering and pod formation stage.
T2: Chemical control (2 sprayings with chlorpyrifos 2.5 ml/lt at flowering followed by acephate @1.5 g/lt at pod formation)
T3: Control

NBAIR *B. thuringiensis* G4 2% @ 2.0 ml/lt as sprays at pre flowering, post flowering and pod formation stage was compared with chemical sprayings of chlorpyrifos 2.5 ml/lt at pre flowering followed by acephate @1.5 g/lt at flowering and chlorantarniliprole @ 0.3 ml/lt at pod formation. Flower damage due to *Maruca virtata* webber was low in chemical treatment plot (2.37 webs/plant) followed by *Bt* treatment plot (3.17 webs/plant) compared to untreated control plot (4.79 webs/plant). Chemical control plot gave 50.52 % reduction and NBAIR *Bt* spraying gave 33.82% reduction in *Maruca* webber damage over untreated control. Pod damage recorded low in *Bt* plot (34.5%) compared to chemical control plot (35.29%) and high in untreated control (39.69%) **(Table 65).**

Table 65. Evaluation of NBAIR *Bt* formulation on pigeonpea against pod borer complex

Treatment	Number of leaf webs (*Maruca*) per plant				Number of leaf webs (*Maruca*) per plant after spraying	Percent reduction in leaf webs over control	Pod damage (%)	Percent reduction in pod damage over control	Pod yield kg/ha	Percent increase in yield
	Before spray	After 1st spray	After 2nd spray	After 3rd spray						
T1: NBAII *Bt*G4 2% @ 2.0 ml/lt - 3 sprays at pre flowering, post Flowering and pod formation stage.	0.45	1.1	1.27	0.347	3.17	33.82	34.5	13.08		
T2: Chemical control (3 sprayings with Chlorpyrifos 2.5 ml/lt at preflowering, acephate @1.5 g/lt at post flowering and chlorantraniliprole 0.3 ml/lt at pod formation)	0.47	0.66	1.24	0.294	2.37	50.52	35.29	11.09		
T3 : Untreated control	0.46	1.42	2.46	0.452	4.79		39.69			
CD (0.05)	NS	NS	0.12	0.1	0.53		NS			
CV%	29.3	26.7	21.5	23.98	17.92		17.99			

5.1.2 MPKV, Pune

A field experiment was conducted in the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. The pigeonpea seeds var. Phule Vipula was sown at 45 x 10 cm spacing in 4.5 x 6 m plots on 04/07/2018. The trial was laid out in RBD with three treatments and eight replications. Three sprays were given at pre flowering on 5.10.2018, post flowering spray on 20.10.2018 and pod formation stage spary on 5.11.2018. The larval population of *H. armigera* and *M. testulalis, E.atomosa* were recorded a day before treatment application as pre-count and post counts at 3 and 7 days after each spray. Pigeonpea crop is harvested on 03.01.2019. The data on larval population were transformed into √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 variance.

Three sprays of chlorantraniliprole 18.5% SC at fortnightly interval was significantly superior over other treatments in suppressing the larval population of *M. testulalis* (av. 4.51 larvae/plant), *E. atomosa* (av. 2.45 larvae/plant) and *H. armigera* (av. 1.07 larvae/plant) and recorded minimum pod (6.60 %) and seed (5.32%) damage with maximum 16.60 q/ha yield **(Tables 66, 67, 68 and 69)**. It was however, at par with the NBAII-*Bt* G4 @ 2% in respect of pod damage (8.90%), grain damage (6.03%) and yield (15.12 q/ha) on pigeonpea.

Table 66. Evaluation of NBAIR *Bt* formulation against legume pod borer *M. testulalis* on pigeonpea

No. of *M. testulalis* larvae/25 inflorescence on pigeonpea								
Treatment	**Pre-count**	**I Spray**		**II Spray**		**III Spray**		**Cumul. Average**
		3rd DAS	**7th DAS**	**3rd DAS**	**7th DAS**	**3rd DAS**	**7th DAS**	
T1: NBAII *Bt* G4 20%@ 20 ml/lit	4.27 a *(2.18)	3.36 a (1.96)	2.40 a (1.70)	9.60 a (3.18)	7.20 a (2.77)	6.50 b (2.65)	4.58 b (2.25)	5.42 a (2.38)
T2: chlorantraniliprole 18.5% @ 0.4 ml/lit	4.58 a (2.25)	3.25 a (1.94)	2.02 a (1.59)	8.30 a (2.97)	5.88 a (2.53)	4.98 a (2.34)	2.57 a (1.75)	4.51 a (2.20)
T3: Untreated Control	4.18 a (2.16)	7.70 b (2.86)	11.72 b (3.50)	25.20 b (5.07)	30.02 b (2.52)	24.17 c (4.97)	21.57 c (4.70)	17.79 b (3.60)
SE ±	**0.05**	**0.05**	**0.08**	**0.08**	**0.09**	**0.10**	**0.12**	**0.08**
CD at 5%	**NS**	**0.14**	**0.24**	**0.25**	**0.27**	**0.30**	**0.32**	**0.25**
CV (%)	**6.68**	**6.93**	**9.93**	**6.24**	**7.12**	**8.41**	**11.35**	**8.09**

(DAS- D ays after spray * Square root ($\sqrt{x+0.5}$) transformed values)

Table 67. Evaluation of NBAIR *Bt* formulation against pod borer, *E. atomosa* on pigeonpea

Treatments	No. of *E. atomosa* larvae/plant on pigeonpea					
	Precount before 2nd spray	**2nd Spray**		**3rd spray**		**Cumulative effect of two sprays**
		3 DAS	**7 DAS**	**3 DAS**	**7 DAS**	
T1: NBAII *Bt* G4 2%@ 2 ml/lit	6.30 a (2.61)	4.14 b (2.15)	2.16 a (1.63)	1.16 b (1.29)	0.90 a (1.18)	2.93 a (1.77)
T2: chlorantraniliprole 18.5% @ 0.4 ml/lit	6.20 a (2.59)	2.76 a (1.81)	1.82 a (1.52)	0.80 a (1.14)	0.68 a (1.09)	2.45 a (1.63)
T3: Untreated Control	6.45 a (2.61)	6.82 c (2.71)	8.40 b (2.98)	9.68 c (3.19)	11.71 b (3.49)	8.61 b (3.00)
SEm ±	**0.04**	**0.04**	**0.06**	**0.04**	**0.07**	**0.05**
CD at 5%	**NS**	**0.11**	**0.17**	**0.12**	**0.22**	**0.16**
CV (%)	**3.94**	**7.23**	**7.80**	**5.78**	**10.62**	**7.07**

Table 68. Evaluation of NBAIR *Bt* formulation against pod borer, *H. armigera* on pigeonpea

Treatments	No. of *H. armigera*larvae/plant on pigeonpea					
	Precount before 2nd spray	**2nd Spray**		**3rd spray**		**Cumulative effect of two sprays**
		3DAS	**7DAS**	**3DAS**	**7 DAS**	
T1: NBAII *Bt*G4 2%@ 2 ml/lit	4.15 a (2.16)	3.54 b (2.01)	1.58 (1.44)	0.74 (1.11)	0.40 a (0.95)	1.57 a (1.38)
T2: Chlorantraniliprole 18.5% SC@ 0.4 ml/lit	4.22 a (2.17)	2.46 a (1.72)	1.13 a (1.28)	0.48 a (0.99)	0.22 a (0.85)	1.07 a (1.21)
T3: Untreated Control	4.07 a (2.14)	5.45 c (2.44)	7.40 b (2.81)	8.52 b (3.00)	9.81 b (3.21)	7.80 b (2.87)
SE ±	**0.03**	**0.09**	**0.10**	**0.09**	**0.05**	**0.08**
CD at 5%	**NS**	**0.28**	**0.29**	**0.28**	**0.17**	**0.26**
CV (%)	**3.94**	**12.62**	**14.85**	**12.62**	**9.31**	**12.35**

Table 69.Effect of NBAIR *Bt* formulationon pod damage and yield of pigeonpea

Treatments	Pod damage (%)	Grain damage (%)	Yield (q/ha)
T1: NBAII *Bt* G4 2%@ 2 ml/lit	8.90 [a]	6.03 [a]	15.12 [a]
T2: Chlorantraniliprole 18.5% SC@ 0.4 ml/lit	6.60 [a]	5.32 [a]	16.60 [a]
T3: Untreated Control	8.27 [b]	26.90 [b]	8.67 [b]
SE ±	**0.83**	**0.75**	**0.59**
CD at 5%	**2.61**	**2.38**	**1.86**
CV (%)	**13.88**	**16.49**	**10.72**

5.1.3 PAU, Ludhiana

We didn't receive NBAIR *Bt* formulation this year for evaluation against pigeonpea pod borer complex.

5.1.4 TNAU, Coimbatore

The details of the experiment are as follows.

Location	: Vellamadai
Redgram Variety	: CORG 8
Date of planting	: 01.08.18

Treatments:
T_{1} : NBAII *Bt*G4 2% @ 2.0 ml/lt - 3 sprays at pre flowering, post flowering and pod formation stage.
T2: Chemical control (Flubendiamide @0.3 ml/lt; Nagastra 2ml/lt)
T3: Control
Replications: Eight
Plot size: 100 m^2
Spacing: 4 x 2 m

Observations:
1. No. of gram and legume/pod borer complex (*Helicoverpa armigera*) / *Maruca vitrata* /plant
2. Per cent pod damage
3. Grain yield (kg/ha)

Results: Evaluation of NBAII *Bt*G4 liquid formulations in comparison with the insecticide showed that NBAII-*Bt*G4 @ 2% spray was effective in reducing the larval population of *H.armigera* and *Maruca vitrata* in all stages *viz.*, pre flowering, post flowering and pod emergence with lesser pod and seed damage. Pod damage in NBAII *Bt*G4 and insecticide treated plots was statistically on par with each other and lesser than the damage in control **(Table 70).** Both the *Bt* formulation and the chemical sprays gave higher grain yield of 625 and 590 Kg/ha respectively than control (415 Kg/ha). The CB ratio was maximum (2.13) in NBAII *Bt*G4 treatment.

Table 70. Evaluation of NBAIR *Bt* formulation on pigeonpea against pod borer complex

Treatments	Pre flowering - Damage %		Post flowering - Damage %		Pod Damage %		Yield Kg/ha	CB ratio
	M.v	***H.a***	***M.v***	***H.a***	***M.v***	***H.a***		
NBAIR –*Bt*G 4 @ 2% spray	2.20 (8.53)[a]	2.06 (8.252)[a]	3.50 (10.78)[a]	2.47 (9.04)[a]	4.55 (12.31)[a]	3.93 (11.43)[a]	625 (2.79)[a]	2.13
Flubendiamide spray @ 0.3 ml/lt	2.65 (9.36)[b]	1.23 (6.36)[a]	4.25 (11.89)[b]	4.28 (11.94)[a]	7.20 (15.66)[b]	4.47 (12.20)[a]	590 (2.77)[a]	1.64
Control	6.70 (15.01)[c]	25.28 (30.18)[b]	8.90 (17.35)[c]	16.72 (22.20)[b]	13.65 (21.68)[c]	13.41 (21.48)[b]	415 (2.61)[b]	
SEd CD CV	0.1873 0.5202 2.09	4.1260 9.5147 45.09	0.1137 0.3158 1.04	1.8897 4.3577 20.20	0.3373 0.9366 2.50	2.7787 6.4078 29.95	0.2181 0.605 1.99 2.13	

5.1.5 UAS, Raichur

Expt. No. 3. Evaluation of NBAIR *Bt* G 4 formulation against pigeonpea pod borer complex

1.	Crop	: PigeonPea
2.	Variety	: TS3 R
3.	Date of Sowing	: 18-07-2017
4.	Location	: Mamadapur
5.	Area	: 2 ha
6.	Treatment imposition	: Three sprays of NBAIR *Bt* G 4 on 26.10.2018, 13.11.2018 and 29.11.2018 Two sprays of insecticides in farmers field 1. Flubendiamide 39.33 SC @0.10 ml/ lt 2. Chlorantriniliprole 18.5 SC @ 0.25 ml/l
7.	Observation	In each acre eight quadrants were made and observations were recorded on per cent pod damage and grain yield and analysed statistically.
	Results	: A day before spray, larval population ranged from 2.68 to 2.72 per plant. At seven days after spray, NBAIR *Bt* G 4 recorded 1.18 larvae per plant while in farmer practice it was 0.72 larva per plant and similar trend in larval reduction was at ten days after spray. NBAIR *Bt* G 4 recorded 9.74% pod damage with a grain yield of 6.25q/ha while in farmers practice the per cent pod damage was 6.98 with a grain yield of 7.10 q/ha **(Table 71).** Overall the grain yield was very low and it may be attributed to the lack of moisture. Annual rainfall of Raichur is 630 mm and received only 230 mm with erratic distribution.

Table 71. Evaluation of NBAIR *Bt* G 4 in comparison with farmers practice

Sl. No.	Particulars	Larval count (No/plant)			Pod damage (%)	Grain Yield (q/ha)
		1 DBS	7 DAS	10 DAS		
1.	NBAIR *Bt* G 4	2.68 (1.78)	1.18 (1.30)	1.06 (1.25)	9.74 (18.19)	6.25
2.	Farmers Practice	2.72 (1.79)	0.72 (1.10)	0.54 (1.02)	6.98 (15.32)	7.10
S Em ±		**0.04**	**0.03**	**0.05**	**0.31**	**0.18**
CD (P=0.05)		**NS**	**0.11**	**0.15**	**1.04**	**0.53**

5.1.6: PDKV, Akola

Experimental details:

Date of sowing: 26.06.2018

Variety	**PKV Tara**
Treatments	Three **Biocontrol** prays - NBAII *Bt*G4 2% @ 2.0 ml/lt - at pre flowering, post Flowering and pod formation stage. **Chemical control** Spray – Chlorantraniliprole 18.5 SC @ 150 ml spray – Monocrotophos 36 SL @ 625 ml **Control**
Replications	8 replications Divide each block into 8 equal sized units, each unit to be considered as replication (each unit = one replication)
Area	T1 – 2000 m^2 T2 – 2000 m^2 T3 – 2000 m^2
Observations	Pod borer complex (*Helicoverpa*, Plume moth, podfly) Per cent pod damage Grain yield (kg/ha)

Results

Significant differences among the treatments. The data on number of larvae per plant is the mean of four observations and it was found that maximum 4.34 *Helicoverpa* larvae per plant was recorded in untreated control where significantly minimum was recorded in treatment T2 which received 2 chemical insecticidal sprays (**Table 72 A,B,C)**. Treatment T1 with *Bt* spray has recorded significantly less number of larvae as compared to untreated control but more than treatment T2. Similarl trend was observed with plume moth larvae with 0.09 larvae per plant was recorded in insecticidal treatment (T2) followed by treatment with *Bt* spray (T1) with 0.50 larvae per plant and significantly maximum larvae of 0.94 per plant was found in untreated control.

The mean observation of 2 sprays on pod damage revealed that significantly minimum damage was recorded in insecticidal treatment (T2) with 0.67 % pod damage due to lepidopteran pod borers followed by *Bt* treatment (T1) with 4.37 % pod damage and both the treatments were significantly superior to untreated control (12.40 %). The data on pod borer damage at harvest also revealed significant differences among the treatments, significantly minimum damage of 2.09 % being recorded in insecticidal treatment (T2). It was followed by treatment T1 with *Bt* spray recording 28.82 % pod damage which was significantly superior to untreated control which recorded significantly maximum pod damage of 42.54 %.

Table 72A. Effect of different treatments on pod borers, their damage and yield of pigeonpea

Treatments	**Mean no. of larvae/plant**		**Mean pod damage after 2 sprays (%)**	**Pod borer damage at harvest**	**Grain damage due to pod fly (%)**	**Yield (qt/ha)**
	H. armigera	**Plume moth**				
T1 – *Bt*	**1.31 (1.35)***	**0.50 (1.00)***	**4.37 (12.51)****	**28.82 (32.36)****	**8.57 (16.96)****	**14.67**
T2 – Insecticidal sprays	0.22 (0.85)	0.09 (0.77)	0.67 (5.14)	2.09 (6.65)	6.12 (14.03)	17.39
T3 – Control	4.34 (2.20)	0.94 (1.20)	12.40 (19.73)	42.54 (40.67)	10.59 (18.93)	9.87
SE(m)	0.10	0.05	0.44	1.47	0.85	0.71
CD at 5 %	0.30	0.15	1.35	4.51	2.59	2.17
CV	17.15	11.13	10.07	15.69	14.36	14.34

* Figures in parentheses are square root transformation values

** Figures in parentheses are Arcsine transformation values

The grain damage due to pod fly was recorded by split opening the pods at harvest and it was found that treatment T2 was significantly superior with 6.12% grain damage whereas rest of treatments were significantly less effective and at par with each other.

The data on yield revealed significant differences among the treatments, treatment T2 receiving insecticidal application recorded significantly maximum yield of 17.39 quintals per hectare and were significantly superior to rest of the treatments. Treatment receiving *Bt* spray (T1) has recorded 14.67 qt/ha yield and was significantly superior over untreated control.

Table 72B. Effect of different treatments on number of lepidopteran pod borer larvae

Treatments	Number of *H. armigera* larvae/plant				Number of *E. atomosa* larvae/plant			
	7 DAFS	14 DAFS	7 DASS	14 DASS	7 DAFS	14 DAFS	7 DASS	14 DASS
T1 – *Bt*	0.63 (1.01)	1.25 (32.36)	2.00 (1.52)	1.38 (1.31)	0.50 (0.95)	0.38 (0.88)	0.50 (0.95)	0.63 (1.01)
T2 – Insecticidal sprays	0.00 (0.71)	0.00 (0.71)	0.25 (0.84)	0.63 (0.99)	0.00 (0.71)	0.00 (0.71)	0.13 (0.77)	0.25 (0.84)
T3 – Control	2.25 (1.59)	2.88 (1.79)	5.25 (2.32)	7.00 (2.69)	0.88 (1.12)	0.63 (1.01)	1.25 (1.27)	1.00 (1.18)
SE(m)	0.09	0.12	0.16	0.16	0.09	0.08	0.09	0.09
CD at 5 %	0.30	0.36	0.48	0.47	0.28	0.25	0.29	0.27
CV	20.45	23.13	25.44	23.80	22.46	20.13	21.38	19.69

Figures in parentheses are square root transformation values

Table 72C. Effect of different treatments on pod borers, their damage and yield of pigeonpea

Treatments	Per cent pod borer damage days after spraying			
	7 DAFS	14 DAFS	7 DASS	14 DASS
T1 – *Bt*	3.59 (10.80)	4.85 (12.48)	5.06 (12.75)	3.95 (11.38)
T2 – Insecticidal sprays	0.19 (1.53)	0.33 (1.99)	0.67 (3.63)	1.48 (6.74)
T3 – Control	10.11 (18.50)	10.69 (19.05)	13.50 (21.43)	15.30 (22.93)
SE(m)	0.60	0.65	1.16	0.72
CD at 5 %	1.84	2.00	3.54	2.20
CV	16.51	16.48	25.99	14.83

Figures in parentheses are Arcsine transformation values

5.2. Demonstration of *Trichoderma* spp. for the management of *Fusarium* wilt in pigeonpea (AAU- Anand)

Objectives: To demonstrate the use of *Trichoderma* for the management of *Fusarium* wilt in pigeonpea
Year of commencement: *kharif* 2018-19
Location: Farmer field, Vadodara, Gujarat
Area: 1 ha

Variety	:	Desi variety
Treatments	:	T1: Seed treatment - *Trichoderma harzianum* @ 10g/ kg seeds Soil application of *Trichoderma harzianum* @ 10 kg/ha multiplied in 250 kg FYM 10 days prior to its application and apply at the time of sowing T2: Chemical control T3: Untreated control
Replications	:	Divide each block into 8 equal sized units, each unit to be considered as replication (each unit= one replication)
Observations	:	Disease incidence (%)/Plant stand (%) at 30, 45, 60 DAS Yield (q/ha)

Results: No incidence of *Fusarium* wilt during experimental period

6. MUNGBEAN

6.1 Integration of botanical/microbials and insecticide spray schedule for the management of pod borer complex in mungbean (PAU, Ludhiana)

The experiment was conducted at Entomological Research Farm, Punjab Agricultural University, Ludhiana on Mungbean (variety ML 2056). The experiment was conducted in randomized block design in plot size of 20 m^2. There were ten treatments with three replications each (T**able 73)**. The time schedule of first and second sprays in each treatment was at initiation of pod formation respectively. The observations on pod damage and grain yield were recorded after fifteen days.

All the treatments were significantly better than untreated control in reducing the pod damage **(Table 73).** Minimum percent pod damage (6.90%) was recorded in treatment (T9) with both sprays of spinosad 45 SC @ 150 ml/ha each. It was at par with treatment (T3) (First spray of commercial *Bt* formulation @ 1.25 litre/ha and second of spinosad 45 SC @ 150 ml/ha each. (7.38 %) and treatment (T2) both sprays of *Bt* formulation @ 1.25 litre/ha (7.75 %). Significantly higher incidence was recorded in untreated control (15.64 %). Significant increase in yield was also recorded in all treatments over control. Maximum yield was 11.07 q/ha in treatment where both the sprays were of spinosad 45 SC @ 150 ml/ha and it was followed by T3 (10.89 q/ha) (1st spray of *Bt* formulation @ 1.25 litre/ha & 2nd of spinosad 45 SC @ 150 ml/ha), T2 (10.87q/ha) (both spray of *Bt* formulation @ 1.25 litre/ha) and T6 (10.81%) (1stspray of azadirachtin 1% and 2nd of spinosad 45 SC @ 150 ml/ha). However, lowest yield was in untreated control (8.63 q/ha) and it was concluded that treatment T3 (1st spray of *Bt* & 2nd spray of spinosad 45 SC), T2 (both sprays of *Bt*) were at par with T9 (both sprays of spinosad 45 SC) in management of pod borer complex in mungbean.

Table 73. Integration of botanical/microbials and insecticide spray schedule for the management of pod borer complex in mungbean

T. No.	Treatments		Percent pod damage*	Yield (q/ha)
	First spray	Second spray		
T1	*B.thuringiensis* @1.25l/ha	Azadirachtin 1% 1.25l/ha	9.93 ^{c}(18.32)	9.45^{c}
T2	*B. thuringiensis* @1.25l/ha	*B. thuringiensis* @1.25l/ha	7.75 ^{ab}(16.14)	10.87 ^{b}
T3	*B. thuringiensis* @1.25l/ha	Spinosad 45 SC @ 150 ml/ha	7.38 ^{ab}(15.75)	10.89 ^{b}
T4	Azadirachtin 1% 1.25l/ha	Azadirachtin 1% 1.25 l/ha	11.91 ^{d}(20.17)	9.83 ^{c}
T5	Azadirachtin 1% 1.25l/ha	*B. thuringiensis* @1.25l/ha	11.21 ^{d}(19.54)	9.48 ^{c}
T6	Azadirachtin 1% @1.25l/ha	Spinosad45 SC @ 150ml/ha	7.84 ^{b}(16.23)	10.81 ^{b}
T7	Spinosad 45 SC @ 150 ml/ha	Azadirachtin 1% @ 1.25litre/ha	9.99 ^{c}(18.40)	9.56 ^{c}
T8	Spinosad 45 SC @ 150 ml/ha	*B. thuringiensis* @1.25l/ha	10.27^{cd}(18.67)	10.11 ^{bc}
T9	Spinosad 45 SC @ 150ml/ha	Spinosad 45 SC @ 150 ml/ha	6.90 ^{a}(15.22)	11.04 ^{a}
T10	Untreated control		15.64 ^{e}(23.20)	8.63 ^{e}
CD (p=0.05)			(0.94)	0.83

*Pooled mean of three readings; Figures in parentheses are arc sine transformed values.

7. COWPEA

7.1 Evaluation of entomopathogenic fungi against pod bug *Riptortus pedestris* on cowpea, *Vigna unguiculata* (KAU, Thrissur)

Two entomopathogenic fungi *viz*. *Beauveria bassiana* (NBAIR strain) and *Metarhizium anisopliae* (NBAIR strain) were evaluated against the pod bug *Riptortus pedestris* on cowpea at farmer's field in Kuruvai, Vadakkenchery from March 2018 to May, 2019. The experiment was conducted with cowpea var. Anaswara, four treatments with 5 replications (**Table 74**).

Treatments:

T1: *Beauveria bassiana* (NBAIR strain) 10^8 spores/ml at 10 days intervals
T2: *Metarhizium anisopliae* (NBAIR strain) 10^8 spores/ml at 10 days intervals
T3: Thiacloprid 30 g a.i ha^{-1} at 10 intervals
T4: Untreated control

There was no significant difference between the treatments in terms of pod damage or yield and the experiment is being repeated.

Table 74. Effect of entomopathogenic fungi on pod bug infestation in cowpea

	Mean pod damage per plot (%)					
Treatment	**Pre count**	**3 DAS1**	**6 DAS1**	**9 DAS1**	**11 DAS2**	**YIELD**
T1: *B.bassiana*	62.55 (52.49)	42.61 (40.73)	48.37 (44.05)	32.69 (34.1)	50.71 (45.42)	1.12
T2:*M.anisopliae*	47.72 (43.63)	42.74 (40.71)	51.70 (46.02)	34.17 (35.29)	64.19 (54.27)	0.908
T3: Chemical	38.81 (35.35)	45.91 (42.68)	49.22 (44.46)	44.28 (41.41)	47.15 (43.36)	1.54
T4: Control	36.17 (35.63)	52.54 (46.56)	65.23 (53.93)	44.44 (41.51)	75.13 (62.06)	0.925
	NS	NS	NS	NS	NS	NS

Values in parenthesis are Arcsine transformed values

7.2. Field evaluation of ICAR-NBAIR entomopathogenic strains against cowpea aphid (*Aphis craccivora*) (KAU-Thrissur, IIVR)

7.2.1: KAU-Thrissur

Field evaluation of ICAR-NBAIR entomopathogenic strains against cowpea aphid was carried out in two separate locations at College of Horticulture, Vellanikkara from August to December, 2018 (**Table 75**).

Design: RBD   Variety: Anaswara
Replications: 4   Plot size: $40m^2$/replication

Treatments:

T1: Bb-5a isolate of *Beauveria bassiana* $1x10^8$cfu/ml (5ml/litre) at 15 days interval
T2: Ma-6 isolate of *Metarhizium anisopliae* $1x10^8$cfu/ml (5ml/litre) at 15 days interval
T3: Vl-8 isolate of *Lecanicillium lecanii* $1x10^8$cfu/ml (5ml/litre) at 15 days interval
T4: Imidacloprid 50g ai/ha at 15 days interval

T5. Untreated control

Table 75. Effect of entomopathogenic fungi on aphid infestation in cowpea

Mean number of aphids per plant					
Treatment	**Pre count**	**5DAS$_1$**	**10 DAS$_1$**	**5 DAS$_2$***	**Yield**
T1: Bb-5a	165.43	157.43	121.86	87.12	8.18
T2: Ma-6	193.60	176.20	137.23	98.69	5.70
T3: Vl-8	176.20	148.63	122.86	56.18	8.61
T4:Imidacloprid	174.80	70.73	23.46	22.72	9.41
T5: Control	166.46	175.96	179.80	120.33	6.58
CD @ 5%	NS	47.91	50.89	39.53	NS

7.2.2 IIVR, Varanasi

The experiment was conducted during September to December, 2018 at the experimental farm of ICAR-IIVR, Varanasi. Since, there was no aphid incidence; *Aphis craccivora* on cowpea (Kashi Nidhi) the said experiment could not be completed.

7.3 Screening of promising fungal and bacterial isolates for management of anthracnose disease in cowpea (KAU-Kumarakom)

Experiment was laid out toScreen of promising fungal and bacterial isolates for management of anthracnose disease in cowpea (Var: Lola) with plot size 8 × 5 m with four replications. Mode of application was seed treatment with bioagents (10g or 10 ml/kg) followed by foliar spray @15, 30 and 45 DAS.

Treatments

T1: *Pichia guilliermondi* (Y-12) @ 2×10^8 spores/ml – 10ml/lt
T2: *Hanseniasporauvarum*(Y-73) 2×10^8 spores/ml – 10ml/lt
T3: *Trichoderma harzianum* (Th-3)@ 2×10^8 spores/g – 10g/lt
T4: *Trichoderma viride* (KAU strain) @ 2×10^8 spores/g – 10g/lt
T5: *Pseudomonas fluorescens* (KAU strain) @ 1×10^8 spores/g -20g/L
T6: Carbendazim @ 2g/kg (seed treatment) and 2g/L spray
T7: Untreated control

Observations: Disease incidence, Yield (kg/plot)

Results: It is found that the fungal isolate *Hanseniaspora uvarum* (Y-73) gave 59 percent control of the disease and was on par with chemical check. The efficacy of *Trichoderma harzianum* (Th-3), *T. viride* (KAU strain) and *P. fluorescens* (KAU strain) were the next best effective treatments (**Table 80.**)

Table 76. Efficacy of fungal and bacterial isolates on anthracnose disease of vegetable cowpea

Treatment	Percent Disease Index*	Percent reduction over control	Yield (kg/plot)
T1: *P. guilliermondi* (Y-12) @ 2 $\times 10^8$ spores/ml – 10ml/lt	78.81 (63.27)	11.81	20.37
T2: *H. uvarum*(Y-73)2$\times 10^8$ spores/ml – 10ml/lt	36.35 (37.01)	59.32	25.74
T3: *T. harzianum*(Th-3) @ 2$\times 10^8$ spores/g – 10g/lt	48.56 (44.17)	45.66	23.72
T4: *T. viride* (KAU strain) @ 2$\times 10^8$ spores/g – 10g/lt	44.40 (41.66)	50.31	25.69
T5: *P. fluorescens* (KAU strain) @ 1$\times 10^8$ spores/g -20g/L	50.78 (45.94)	43.17	22.43
T6: Carbendazim @ 2g/kg (seed treatment) and 2g/L spray	24.42 (29.60)	72.67	26.29
T7: Untreated control	89.36 (73.11)		19.35
CD (0.05)	11.78		**NS**

*Values in parantheses are arcsine transformed

8. CHICKPEA

8.1. Integration of botanical/microbials and insecticide spray schedule for the management of *Helicoverpa armigera* on chickpea (PAU)

The experiment (chickpea variety PBG 7) was sown at Entomological Research Farm, Punjab Agricultural University, Ludhiana on 14th November, 2018 in a randomized block design with a plot size of 20 m^2. There were ten treatments with three replications.

Treatments

T. No.	1st Spray	2nd Spray
T1	*Bacillus thuringiensis*@ 2.0 kg/ha	Azadirachtin 300 ppm @ 2.0 litre/ha
T2	*B. thuringiensis*@ 2.0 kg/ha	*B.thuringiensis*@ 2.0 kg/ha
T3	*Bacillus thuringiensis*@ 2.0 kg/ha	Chlorantraniliprole18.5SC @ 137.5 ml/ha
T4	Azadirachtin 300 ppm @ 2.0 litre/ha	Azadirachtin 300 ppm @ 2.0 litre/ha
T5	Azadirachtin 300 ppm @ 2.0 litre/ha	*B.thuringiensis*@ 2.0 kg/ha
T6	Azadirachtin 300 ppm @ 2.0 litre/ha	Chlorantraniliprole18.5 SC @ 137.5 ml/ha
T7	Chlorantraniliprole18.5SC @ 137.5 ml/ha	Azadirachtin 300 ppm @ 2.0 litre/ha
T8	Chlorantraniliprole18.5SC @ 137.5 ml/ha	*B.thuringiensis*@ 2.0 kg/ha
T9	Chlorantraniliprole18.5SC @ 137.5 ml/ha	Chlorantraniliprole18.5SC @ 137.5 ml/ha
T10	Untreated control	

Results: The experiment is in progress

8.2 Management of *Helicoverpa armigera* by Hear NPV in chickpea ecosystem (NBAIR) in collaboration with UAS-R) (UAS, Raichur)

The experiment (chickpea var JJ-11) was sown at Entomological Research Farm, UAS, Raichur on 27th November, 2018 in a randomized block design with a plot size of 0.5 acre There were ten treatments with three replications.

Treatments:
T1: HearNPV NBAIR (1.5 × 10^{12} POBs/ha) @ 2.00 ml
T2: HearNPV UASR (1.5 × 10^{12} POBs/ha) @ 2.00 ml
T3: Farmers Practice
Flubendiamide 39.35 SC @0.10 ml/ lt
Chlorantriniliprole 18.5 SC @ 0.25 ml/l

Results: One day before treatment imposition larval population ranged from 3.64-3.88 larvae /plant which was statistically non-significant. HearNPV NBAIR @ 2 ml/l recorded 1.22

larvae/plant and it was at par with HearNPV UASR @ 2 ml/l which recorded 1.38 larvae /plant at three days after spray. While the farmer practice recorded lowest larval population of 0.94 larva /plant which was statistically superior over the HearNPV treatments and similar trend was noticed at seven days after spray. HearNPV NBAIR @ 2 ml/l recorded 7.78% pod damage which was at with HearNPV UASR @ 2 ml/l which recorded 8.16% pod damage. Farmers practice treatment recorded 5.32% pod damage which was statistically superior over HearNPV treatments. HearNPV NBAIR @ 2 ml/l recorded 11.68 q/ ha grain yield and it was at par with Hear NPV UASR @ 2 ml/l (10.84 q/ha) while in farmer practice highest grain yielded of 13.62 q/ha was noticed **(Table 77).**

Table 77. Management of *Helicoverpa armigera* by HearNPV in chickpea ecosystem (NBAIR in collaboration with UAS-R)

Sl. No.	Particulars	Larval count (No/plant) *			Pod damage (%) #	Grain Yield (q/ha)
		1 DBS	3 DAS	7 DAS		
T_1	*HearNPV*NBAIR (1.5×10^{12} POBs/ha)	3.72 (2.05)	1.22 (1.31)	1.06 (1.25)	7.78 (16.20)	11.68
T_2	*HearNPV* UASR (1.5×10^{12} POBs/ha)	3.88 (2.09)	1.38 (1.37)	1.18 (1.30)	8.16 (16.60)	10.84
T_3	Farmers Practice	3.64 (2.03)	0.94 (1.20)	0.58 (1.04)	5.32 (13.34)	13.62
S Em±		**0.06**	**0.03**	**0.08**	**0.38**	**0.53**
CD (P=0.05)		**NS**	**0.11**	**0.25**	**1.16**	**1.60**

*Figures in parentheses are square root transformed values
#Figures in parentheses are arcsine transformed values

8.3 Biological suppression of pod borer, *Helicoverpa armigera* (Hubner) infesting chickpea (MPUAT)

The experiment (chickpea Location specific recommended variety) was sown in a randomized block design and there were four treatments with five replications.

Treatment details:
T1: *Beauveria bassiana*@ 1×10^8 conidia /gm @ 5 gm/l at 7 days interval at pod initiation stage, 2 sprays
T2: *Bacillus thuriengiensis*@ 1 kg/ha at 7 days interval, at pod initiation stage, 2 sprays
T3: Quinalphos 25EC @ 250g a.i/ha, at pod initiation stage, 2 sprays
T4: Untreated control

Observations: Number of larvae/m row length before spray and 3, 7, 10 and 15 days after spray, total and damaged pods at harvest, record natural enemies from 5 plants in each plot and pod yield were recorded on whole plot basis.Each block was divided into five plots to record the incidence of pod borer, per cent pod damage and grain yield and each plot was considered as a replication.

Results: Before treatment, the larval population ranged from 3.9-4.3 larvae/ plant which was statistically non-significant. The maximum reduction was recorded in quinalphos 25 EC @ 250g a.i/ha treatment (1.8 larvae/ plant) and the minimum reduction was observed in *Bt.* @ 1 kg/ha (3.2 larvae/plant) at ten days after spray; whereas, the untreated control recorded least reduction in larval population (5.0 larvae/plant). Minimum per cent pod damage was recorded in treatment ofquinalphos 25 EC @ 250g a.i/ha (8.20%) and maximum was in *Bt*@ 1 Kg/ha (13.00%). Maximum grain yield was recorded in quinalphos 25 EC @ 250g a.i/ha (17.40 q/ ha) while minimum was in *Bt.* @ 1 kg/ha (13.80 q/ha) (**Table 78**).

Table 78. Effect of entomopathogens on chickpea pod borer, *Helicoverpa armigera* (Hubner) at MPUAT

S. No.	Treatments	Larval count (Mean number/plant)					Pod damage (%)	Grain Yield (q/ha)
		PTP	3 DAS	7 DAS	10 DAS	15 DAS		
1.	*B. bassiana*@ 1×10^8 conidia /gm @ 5 gm/l	4.3	3.9	2.8	2.3	3.0	11.50	15.20
2.	*Bt*@ 1 Kg/ha	4.1	3.8	3.0	2.7	3.2	13.00	13.80
3.	Quinalphos 25 EC @ 250g a.i/ha	3.9	3.4	2.0	1.8	2.6	8.20	17.40
4.	Untreated control	4.0	4.6	5.1	5.0	5.8	16.60	11.30

8.4. Evaluation of fungal and bacterial isolates for chickpea disease management (GBPUAT, Pantnagar)

A field experiment was conducted at Crop Research Centre, GBPUA&T, Pantnagar during *rabi* 2018-19 to test the efficacy of bioagents against chickpea wilt complex and yield of chickpea. The experiment was laid out with fourteen treatments in a randomized block design in three replications with a plot size of $4x2.5m^2$. Chickpea var. PG-186 was sown on 31 November, 2018.

Mode of application: Soil application with bio-agent along with vermicompost (100g / kg) per plot, Seed bio-priming with bioagent (10g/kg seed), Foliar sprays cum drench of bioagents 1st at 30 DAS, 2nd and 3rdat the interval of 45 day.

Experimental Detail:

Methods of application: Bioagents were applied as seed treatment (10g /kg seed) and as three foliar sprays cum drench (10 g /lit; 1st at 30, 2nd at 75 DAS and 3rd at 120 DAS), seed treatment with carbendazim (1g/kg seed) and foliar spray (1g/lit.) served as standard control while without any treatment served as control.

Plant mortality and mature plant wilt: Maximum percentage of seed germination was observed with PBAT-3 (66.9%), which was significantly different from other treatments and control (62.1%). Maximum plant stand, 60 DAS and 120 DAS, respectively was recorded with PBAT-3 (231.3 and 229.3) followed by carbendazim (224.3 and 222.3) and BARC (221.0 and 220.0), which were significantly different from each other but better than control (208.6 and 205.3). Minimum number of mature plant wilt (3.7) at 120 DAS was observed with Psf-173, NBAIR1-Th and BARC, while maximum in control (10.5) followed by NBAIR2- Ta (10.33%) after 120 days of sowing **(Table 79).**

Table 79. Efficacy of promising bio-agents against seed and plant mortality and mature wilt of chickpea in field

Treatment	Plant Stand (15 DAS)	Germination (15 DAS)	Healthy Plant Stand		Mature plant wilt (120 DAS)	Total plant stand (120 DAS)	Wilted plant
			60 DAS	120 DAS			
	(No.)	(%)	(No.)	(No.)	(No.)	(No.)	(%)
TCMS- 36	226.3	64.7	221.0	218.7	4.7	223.4	2.1
PBAT-3	234.3	66.9	231.3	229.3	4.3	233.6	1.9
Th-14	225.0	64.3	221.3	219.0	4.7	223.6	2.1
Th-17	224.6	64.2	218.0	214.0	8.3	222.3	3.7
Th-39	231.7	66.2	219.7	216.7	9.3	225.9	4.1
Th-19	215.7	61.6	211.3	206.0	6.7	212.6	3.1
Psf-173	224.7	64.2	217.7	214.3	3.7	219.9	1.7
Psf-2	222.7	63.6	212.7	213.0	6.0	219.0	2.7
NBAIR1-Th	227.7	65.0	223.3	223.3	3.7	226.9	1.6
NBAIR2- Ta	214.3	61.2	209.0	207.7	5.3	212.9	2.5
BARC	224.3	64.1	221.0	220.0	3.7	223.6	1.6
Sanjeevni TV	223.3	63.8	216.3	214.3	4.3	218.6	1.9
Carbendazim	225.3	64.4	224.3	222.3	2.1	224.4	1.9
Control	217.3	62.1	208.7	205.3	10.5	215.8	4.9
CD (0.05)	**2.7**	-	**1.6**	**1.2**	**1.7**	-	-
CV (%)	**0.7**	-	**0.4**	**0.3**	**7.8**	-	-

*350 counted seeds were sown in each plot

8.5. Evaluation of bioagent consortium in glasshouse (pot experiments) and in field for crop health management in chickpea (GBPUAT, Pantnagar).

A glasshouse and field experiment was conducted at, GBPUA&T, Pantnagar during *Rabi* 2018-19 to test the efficacy of bio-agents consortium against chickpea wilt complex and yield of chickpea (var PG-186). The experiment was laid out with 12 treatments in a randomized block design in three replications with a plot size of 4x2.5m^2.

Mode of application:

Seed bio-priming @ 10g/kg seed.

In filed application of bioagents along with vermicompost (50g/500g) per plot.

In glasshouse soil will be pre inoculated with *Fusarium* (5g inoculum/pot) one week before sowing followed by bioagents along with vermicompost (10g/100g) per pot.

Three foliar sprays cum drench with bioagents1st at 30 days after sowing and 2nd and 3rd at 45 days interval.

Efficacy consortium under glass house condition

Mixed formulation shown better performance over individual isolates with respect to its effect on seed germination and seedling mortality. In mixed formulations treatments highest germination percentage observed in Th14+Psf173 (96.67%) followed by carbendazim Th17+Psf 173(95 %) when compared to control (88.33%). At the initial stage of the seedling growth almost all the treatments were shown equal growth. 45 days after sowing treatment (Th14+ Psf2) shown a significant growth on plant height of chick pea (39.97 cm) followed by (Th14+ Psf173) which gave 39.77cm growth and carbendazim 38.40 cm which was at par with each other but significantly different from control (31.37 cm) **(Table 80).**

Table 80. Efficacy of bioagents consortium under glass house condition

Treatment	Germination (%) 10 DAS	Healthy Plant Stand		Plant Growth (cm) 45 DAS
		30 DAS (No.)	45 DAS (No.)	
T1- Th17+Psf 173	96.67	17	17	34.30
T2 - Th 17+Psf 2	94.98	18	18	34.37
T3-Th17+Th14	91.93	17	16	35.63
T4-Th14+Psf2	93.33	17	17	39.97
T5-Th14+Th17	90.23	18	17	36.60
T6-Th17	93.33	17	17	37.13
T7-Th14	89.90	18	18	35.77
T8- Psf2	91.62	17	17	35.13
T9-Psf-173	94.98	18	17	36.67
T10-Th14+Psf173	95.00	18	18	39.77
T11-Carbendazim	95.00	19	19	38.40
T12-Control	88.33	16.67	16.67	31.37
CD (0.05)	-	**1.77**	**1.36**	**1.23**
CV (%)	-	**7.50**	**5.86**	**2.53**

Plant mortality and mature plant wilt under Field: Maximum percentage of seed germination was observed with Th14 + Psf173 (66.9%), while minimum percentage of seed germination was recorded in control (54.9 %). Maximum plant stand, 60 DAS and 120 DAS respectively was recorded with consortium Th14 + Psf173 (230.3 and 226.3) followed by Th17 + Psf 173 (224.4 and 223.7) and Th14 + Th17 (223.0 and 220.7), which did not differ significantly from each other but better than control (187.9 and 185.2).Minimum Number of mature plant wilt (3.7) at 120 DAS was observed with consortium Th17+Psf 173 (3.0), while maximum in control (5.7) after 120 days of sowing **(Table 81).**

Table 81. Efficacy of promising bioagents against seed and plant mortality and mature wilt of chickpea in field

Treatment	Plant Stand (15 DAS)	Germination (15 DAS)	Healthy Plant Stand		Mature plant wilt (120 DAS)	Total plant stand (120 DAS)	Wilted plant
			60 DAS	120 DAS			
	(No.)	(%)	(No.)	(No.)	(No.)	(No.)	(%)
Th17+Psf 173	227.7	65.0	224.4	223.7	3.0	226.0	1.3
Th17+Psf 2	200.0	57.1	196.8	192.5	3.3	195.8	1.7
Th17+Th14	207.0	59.1	204.3	200.3	5.0	205.3	2.5
Th14+Psf2	200.3	57.2	196.0	194.7	3.5	198.2	1.8
Th14+Th17	227.7	65.0	223.0	220.7	4.3	225.0	1.9
Th17	198.4	56.7	195.3	192.5	5.0	197.5	2.5
Th14	193.0	55.1	189.3	184.3	4.5	188.8	2.3
Psf2	194.3	55.5	192.7	190.2	2.4	192.6	1.3
Psf-173	222.7	63.6	218.3	215.7	3.7	219.4	1.6
Th14+Psf173	234.3	66.9	230.3	226.3	5.0	231.3	1.8
Carbendazim	223.0	63.7	220.0	218.0	3.4	221.4	1.5
Control	192.3	54.9	187.9	185.2	5.7	190.9	3.0
CD (0.05)	9.0	-	8.4	8.2	0.5	-	
CV (%)	3.1	-	3.6	3.3	9.3	-	-

*350 counted seeds were sown in each plot

9. SOYBEAN

9.1 Demonstration on biological suppression of *Spodoptera litura* with*Nomuraea rileyi* in soybean (MPKV, Pune)

The large scale demonstration was conducted on the Kuran farm of College of Agriculture, Pune during *kharif* 2018. The seeds of soybean var. JS- 9305 were sown at 45 x 10 cm distance in 5 x 4 m plots on 29.6.2018 on 5 ha area.

Treatments: Comprised with need based 2 applications of *N. rileyi*and farmer's practice- two sprays of chlorpyrifos 0.05% and untreated control. Application of insecticides at fortnightly interval, First sprays were given on 3.9.2018 and second spray was given on 18.9.2018.

Observations: 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. Soybean crop was harvested on 27.10.2018. At harvest, grain yield per plot were recorded and then converted into quintal per ha.

Results: The results indicated from **Table 82**, it is revealed that two sprays of *N. rileyi* (2.0 x 10^8cfu/g) was significantly superior in suppressing the larval population of *S. litura* (2.13 larvae/m row) due to fungal infection with 16.21 q/ha yield.

Table 82. Efficacy of *N. rileyi* against *Spodoptera litura* on soybean

Treatment	Larval population/m row				Yield (MT/ha)
	Pre-count	First spray 7DAS	Second spray 7DAS	Average	
T1: *N. rileyi* @ 2.0 x 10^8cfu/ g) - 2.5kg/ha	3.88^a (2.09)	2.50^a (1.73)	1.75^a (1.50)	2.13^a (1.62)	16.21^a
T2: Farmers practice- chlorpyrifos 0.05%	3.50^a (2.00)	3.00^a (1.87)	2.13^a (1.62)	2.57^a (1.75)	14.49^a
T3: Untreated control	3.38^a (1.97)	5.00^b (2.35)	12.50^b (3.61)	8.75^b (2.98)	12.44^b
SE ±	0.07	0.06	0.08	0.07	0.66
CD at 5%	NS	0.19	0.25	0.22	2.01
CV (%)	9.90	8.83	10.58	9.71	13.06

COMMERCIAL CROPS

10. COTTON

10.1 Management of pink bollworm by using *Trichogrammatoidea bactrae* in *Bt*cotton (UAS-R, PDKV, PJTSAU)

10.1.1: UAS-Raichur

Treatment Details:

T_1:

1. Erection of pheromone traps (Funnel type) @ 10/acre
2. Release of *T. bactrae* @ 1,00,000/ ha 6-8 releases from 55 DAS
3. Application of azadiractin 1500 ppm @ ETL

T_2: Spray of insecticides as per label claim for PBW (Profenophos 50 EC @ 2.0 ml/lt at 55 DAS 2. Thiodicarb 75WP @ 1.0 gm/lt at 75 DAS, 3. Lamdacyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS)

T_3: Control

Observation: In each block eight quadrants of size 500 sqmt were made in T_1 and T_2 while in T_3 a quadrant of size 100 sqmt was considered to record the observations. To record the larval incidence of pink bollworm 10 bolls were randomly selected and dissected to record the number of PBW larvae in each block. Per cent rosette flower were counted in each quadrant and expressed as per rosette flower. At harvest per cent locule damage was worked out in each quadrant and expressed in per cent. In each treatment seed cotton yield was recorded and analysed statistically.

Results: The results indicated that the number of PBW larvae in T_1 and T_2 was 11.62 and 8.32 larvae per 10 bolls, respectively while in T_3 maximum of 19.68 larvae per 10 bolls were noticed. Rosette flower in T_1 (4.36%) and T_2 (2.28%) which differed statistically and T_3 recorded highest rosette flower of 8.42%. Highest locule damage of 40.16% was noticed in T_3 which was statistically inferior to T_1 and T_2 which recorded 12.64 and 7.84 % locule damage, respectively. Similarly, highest seed cotton yield of 32.56 q/ha was noticed in T_2 while T_1 recorded 28.62 q/ha and lowest seed cotton yield of 15.82 q/ha was recorded in T_3 **(Table 83).**

Table 83. Management of Pink bollworm by using *Trichogrammatoidea bactrae* in *Bt*cotton ecosystem during 2018-19

Sl. No	Particulars	PBW larvae per 10 bolls*	Rosette flower (%) at 50% flowering #	Locule damage (%) #	Seed cotton yield (q/ha)
1.	**T1**: 1. Erection of pheromone traps (Funnel type) @ 10/acre 2. Release of *T. bactrae* @ 100000/ ha 11 releases from 55 DAS 3. Application of azadiractin 1500 ppm @ ETL	4.36 (12.05)	11.68 (3.49)	12.64 (20.83)	28.62
2.	**T2**: 1. Profenophos 50 EC @ 2.0 ml/lt at 70 DAS 2. Thiodicarb 75 wp @ 1.0 gm/lt at 90 DAS 3. Lamdacyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS	2.28 (8.68)	8.32 (2.97)	7.84 (16.26)	32.56
3.	**T3**: Control	8.42 (16.87)	19.68 (4.49)	40.16 (39.33)	15.82
S Em±		**0.31**	**0.13**	**0.65**	**1.08**
CD (P=0.05)		**1.04**	**0.40**	**1.96**	**3.25**

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

10.1.2: PDKV, Akola

Treatments

T1: Standard practice of plant protection till 55th day or appearance of PBW.

i) Erection of pheromone traps (Funnel type) @ 10/ plot.

ii) Releases of *Trichogrammatoidea bactrae* 100,000/ha/release, 6-8 releases starting from 55 days after germination.

T2: Spraying of insecticides as per label claim for PBW / SAUs at each centre during PBW infestation.

1st spray – Triazophos 40EC @ 20 ml/10 Lt

2nd spray – Spinosad 45SC @ 2.2 ml/10 Lt

3rd spray – Beta-cyfluthrin 2.5%@10 ml/10 Lt

4th spray – Fenpropathrin 10EC @ 10 ml/10 Lt

T3: Control

Observations: No. of rosette flowers, No. of green bolls (20 bolls per plot – No. of larvae and boll damage), No. of good open bolls and bad open bolls at harvesting (at least 100 balls to be observed & five observation/plot) and number of pink bollworm larvae.For sucking pest management – Spraying of flonicamid 50 WG @ 2 g/ 10 Lt and acetamiprid 20% @ 15 g/10 Lt will be done.

Results: The data on number of rosette flowers, presented in **Table 84 A, B, C, D and Fig. 12** revealed that there were significant differences among the treatments although the infestation was overall low on flowers. Significantly minimum rosette flowers of 0.03 per 5 plants per plot was recorded in treatment T1 which was followed by the insecticidal treatment (T2), both being at par with each other and significantly superior over untreated control.

The data on green boll damage has recorded significant differences, T1 being the most effective recording significantly lowest mean green boll damage of 1.88% per plot and was at par with treatment T2 with 2.50% green boll damage /plot.

The data during cotton picking was recorded on per cent good and bad open bolls and it was revealed that treatments T1 and T2 has recorded 2.33% bad open bolls, both the treatments being at par with each other and significantly superior over untreated control which has recorded 4.12 % bad open bolls. The data on yield of seed cotton revealed that the treatment T2 recorded significantly maximum yield of 934.93 kg seed cotton, followed by treatment T1 recording 812.76 Kg seed cotton. Both these treatments were significantly superior over untreated control that has recorded significantly minimum yield of 446.24 kg/ha seed cotton.

Table 84A. Effect of different treatments on damage due to pink bollworm and seed cotton yield

Treatment	No. of rosette flowers/5 plants	Green boll damage (%)	Bad open bolls (%)	Seed Cotton Yield (Kg/ha)
T1 – *Trichogrammatoidea* releases (6 releases)	0.03 (0.73)	1.88 (1.32)	2.35 (1.68)	812.76
T2 – Insecticidal sprays (sprays of 4 insecticides)	0.06 (0.75)	2.50 (1.53)	2.33 (1.66)	934.93
T3 –Untreated Control	0.59 (1.03)	6.25 (2.45)	4.12 (2.14)	446.24
SE(m)	0.03	0.31	0.09	28.95
CD at 5 %	0.10	0.94	0.27	88.67
CV	8.67	19.34	15.20	11.20

Figures in parentheses are square root transformation values

Table 84B. Effect of different treatments on number of rosette flowers

Treatment	No. of rosette flowers					
	62 DAS	69 DAS	76 DAS	83 DAS	90 DAS	97 DAS
T1 – *Trichogrammatoidea* releases (6 releases)	0	0.00 (0.71)	0	0.00 (0.71)	0.00 (0.71)	0.13 (0.77)
T2 – Insecticidal sprays (sprays of 4 insecticides)	0	0.25 (0.84)	0	0.00 (0.71)	0.13 (0.77)	0.00 (0.71)
T3 –Untreated Control	0	0.63 (1.01)	0	0.75 (1.08)	0.63 (1.01)	0.38 (0.90)
SE(m)	-	0.06	-	0.06	0.07	0.06
CD at 5 %	-	0.18	-	0.17	0.20	0.19
CV	-	14.94	-	14.16	17.92	14.95

Figures in parentheses are square root transformation values

Table 84C. Effect of different treatments on percent green bolls

Treatment	Per cent Green boll damage	
	110 DAS	130 DAS
T1 – *Trichogrammatoidea* releases (6 releases)	0	1.88(1.32)
T2 – Insecticidal sprays (sprays of 4 insecticides)	0	2.50(1.53)
T3 –Untreated Control	0	6.25(2.45)
SE(m)	-	0.31
CD at 5 %	-	0.94
CV	-	19.34

Figures in parentheses are square root transformation values

Table 84D. Effect of different treatments on percent green bolls

Treatment	Bad open bolls (%)		
	130 DAS	140 DAS	150 DAS
T1 – *Trichogrammatoidea* releases (6 releases)	1.13(1.23)	2.75(1.73)	3.13(1.89)
T2 – Insecticidal sprays (sprays of 4 insecticides)	2.13(1.56)	2.25(1.52)	2.63(1.74)
T3 –Untreated Control	3.00(1.83)	4.50(2.20)	4.88(2.29)
SE(m)	0.15	0.17	0.10
CD at 5 %	0.47	0.52	0.31
CV	24.06	24.58	13.53

Figures in parentheses are square root transformation values

Rosette flower and PBW in Rosette flower

Bad open bolls

Green boll damage

Fig. 12

10.1.3 PJTSAU

The trial was conducted at Agricultural Research Station, Adilabad with 3 treatments and each treatment replicated seven times on BG II cotton hybrid.

Details of Treatments:

T1: Standard practice of plant protection till 55th day or appearance of PBW. The following inputs were administered meant for PBW management.

Erection of pheromone traps (Funnel type) @ 10/ plot.
Releases of *Trichogrammatoideabactrae* 1,00,000/ha/release, 6-8 releases starting from 55 days after germination.
Application of azadirachtin 1500 ppm @ 5ml/l at ETL
T2: Spraying of insecticide during PBW infestation.
T3: Control

Observations: No. of healthy open bolls and infested open bolls (at least 100 bolls were observed @ five observations/plot) along with number of pink bollworm larvae.About 20 green bolls from 20 random plants were dissected once a week from mid-October to mid-December at economic threshold level of 10% damage with live pink bollworm larvae and/or 8 pink bollworm moths per pheromone trap per 3 consecutive nights in at least 2 traps per field.No. of eggs were recorded & no. of parasitized eggs (around 20-50 eggs were collected in each observation) were observed and yield at harvest was recorded.

Results: Despite low incidence of PBW during*kharif*, 2018-19, the module with pheromone traps (Funnel type) @ 10/ plot + releases of *T.bactrae* 100,000/ha/release, 6-8 releases starting from 55 days after germination + application of 5% neem seed kernel extractfared better than untreated control in terms of infestation by PBW**(Table 85).**

Table 85. Efficacy of PBW management module on incidence of PBW and yield in cotton

	Treatment	Mean No./Plant		
		Larvae /20 green bolls	Green boll damage (%)	Locule damage in green bolls (%)
1.	Module 1: Erection of pheromone traps (Funnel type) @ 10/ plot.+ Releases of *T.bactrae*100,000/ha/release, 6-8 releases starting from 55 days after germination+ azadirachtin 1500 ppm @ 5ml/l at ETL	5.43	23.33	6.33
2.	Module 2: Spraying of insecticide during PBW infestation	6.33	26.43	7.83
3.	Control Plot	12.89	49.83	12.43

10.2 Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton (MPKV, PJTSAU)

10.2.1: MPKV, Pune

The trial was conducted on Research Farm of Agril. Entomology Section, College of Agriculture, Pune, *Bt*cotton var- SWCH-4749 BG-II of US Agri, 90 x 90 cm, 4.5 × 4.5 m, RBD, 6/4, 28/06/2018. Three sprays of biopesticides and chemical insecticide were given at fortnightly interval on 28/09/2018, 13/10/2018 and 28/10/2018. The sucking pests were recorded on 5 plants per plot from each treatment per plot in three replicates before treatment as pre-count and post counts were taken 10 days after each spray. Seed cotton yield per plot was recorded and converted into q/ha.

Treatments: T1: *Metarhizium anisopliae* (1×10^8 conidia /g) @ 5 g/litre
T2: *Lecanicillium lecanii* (1×10^8 conidia /g) @ 5 g/litre
T3: *Beauveria bassiana* (1×10^8 conidia /g) @ 5 g/litre
T4: Azadirachtin 1500 ppm @ 2ml/ suspension
T5: Dimethoate 30EC (0.05%) (Standard chemical check)
T6: Untreated control

Observations: The observations recorded on 5 plants /plot from each treatment / plot in three replicates before treatment as pre-count and post counts were taken 10 days after each spray. Recorded sucking pests population (aphids, jassids, thrips, whiteflies) on 3 leaves (terminal shoots)/ plant and seed cotton yield / plot was recorded and converted into q/ha.

Results: Amongst the biopesticides with *Lecanicillium lecanii*(1×10^8conidia /g) @ 5 g/litre recorded lowest population of sucking pests *viz.,* aphids (4.80), jassids (2.90), thrips (2.40) and whitefly (1.72) on 3 leaves per plant compared to the untreated control which recorded aphids (38.10), jassids (13.26), thrips (30.66), and white flies (10.57) on 3 leaves / plant (Table 11). The *Lecanicillium lecanii* (1×10^8 conidia /g) @ 5 g/litre recorded seed cotton yield 17.85 q/ha which is at par with Dimethoate 0.05% (18.56 q/ha).

10.2.2: PJTSAU, Hyderabad

The trial was conducted at Agricultural Research Station, Adilabad with six treatments and each treatment replicated five times on BG II cotton hybrid.

Details of Treatments:

T1: *Metarhizium anisopliae* (1×10^8 conidia/g) @ 5 g/ litre
T2: *Lecanicillium lecanii* (1×10^8 conidia/g) @ 5 g/ litre
T3: *Beauveria bassiana* (1×10^8 conidia/g) @ 5 g/ litre
T4: NSKE @ 5% suspension
T5: Imidacloprid @ 0.05% spray
T6: Control

Observations: The first spray was given on occurrence of the pest and rest continued till abundance of the pest. Sucking pests (aphid, jassid, whitefly, thrips) population 5 randomly selected plants (terminal shoots) from each plot were recorded before treatment and 7 days after each treatment. Insect cadavers along with leaves were brought in the laboratory and incubated under optimal condition. After 5 days cadavers were observed for signs of fungal infection and sporulation. The population of other sucking pests was also recorded and yield per plot was recorded at harvest.

Results: Among the biological evaluated, *Lecanicillium lecanii* followed by application of azadirachtin 1500 ppm @ 5ml/l at ETL hosted significantly less number of sucking pests such as jassids, aphids & whiteflies as compared to control and equivalent to insecticidal check indicating *L. lecanii* as a viable alternative to insecticidal applications in cotton for the management of sucking pests (**Table 86 & 87).**

Table 86. Efficacy of entomofungal agents and botanicals for the management of suckingpests in cotton

	Treatment	Mean No./Plant			
		Aphids	Jassids	Thrips	Whitefly
1.	*Metarhiziumanisopliae*(1×10^8conidia/g) @5 g/ litre	0.92	9.47	0.93	0.32
2.	*Lecanicilliumlecanii*(1×10^8 conidia/g) @5 g/ litre	0.67	6.32	1.23	0.12
3.	*Beauveriabassiana*(1×10^8 conidia/g) @5 g/ litre	1.06	9.21	0.97	0.47
4.	Azadirachtin 1500 ppm@ 5ml/l	0.83	7.39	0.78	0.32
5.	Imidacloprid (Chemical Check) 0.05%	0.97	8.09	0.34	0.17
6.	Untreated Control (Water spray)	1.32	12.32	1.28	0.42
	CD at 5% (p=0.05)	NS	0.234	NS	NS

Table 87. Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton

Treatment	Average population / 3 leaves / plant												Yield (q/ha)
	Aphids			Jassids			Thrips			Whitefly			
	Pre-count	3 DAS	7 DAS	Pre-count	3 DAS	7 DAS	Pre-count	3 DAS	7 DAS	Pre-count	3 DAS	7 DAS	
T1: *M. anisopliae* (1 × 10^8conidia /g) @ 5 g/lit.	23.34 [a] (4.88)	18.76 [b] (4.39)	6.80 [b] (2.70)	7.70 [a] (2.86)	6.28 [b] (2.60)	3.30 [b] (1.95)	13.20 [a] (3.70)	10.35 [c] (3.29)	3.10 [b] (1.90)	4.04 [a] (2.13)	3.02 [b] (1.88)	2.10 [a] (1.61)	15.92 [b]
T2: *L. lecanii* (1 × 10^8conidia /g) @ 5 g/lit.	22.96 [a] (4.84)	16.68 [b] (4.14)	4.80 [a] (2.30)	7.80 [a] (2.88)	5.82 [b] (2.51)	2.90 [b] (1.84)	12.96 [a] (3.67)	9.32 [c] (3.13)	2.40 [b] (1.70)	4.10 [a] (2.14)	2.52 [b] (1.74)	1.72 [a] (1.49)	17.85 [a]
T3: *B. bassiana* (1 × 10^8conidia /g) @ 5 g/lit.	24.22 [a] (4.97)	21.82[c] (4.72)	11.06 [c] (3.40)	8.14 [a] (2.94)	6.27 [b] (2.60)	4.49 [c] (2.23)	12.88 [a] (3.66)	11.50 [c] (3.46)	4.97 [c] (2.34)	4.15 [a] (2.16)	3.25 [b] (1.94)	3.38 [b] (1.97)	14.28
T4:Azadirachtin 1500 ppm @ 2 ml/lit	23.46 [a] (4.89)	18.20 [b] (4.32)	8.40 [b] (2.98)	8.40 [a] (2.98)	5.40 [b] (2.43)	4.20 [b] (2.17)	13.30 [a] (3.72)	8.15 [b] (2.94)	4.26 [c] (2.18)	3.74 [a] (2.06)	2.42 [b] (1.71)	2.22 [b] (1.65)	15.42 [b]
T5: Dimethoate 0.05 %	23.10 [a] (4.86)	2.10 [a] (1.61)	3.06 [a] (1.89)	8.30 [a] (2.97)	1.36 [a] (1.36)	1.68 [a] (1.47)	12.70 [a] (3.63)	1.30 [a] (1.34)	1.60 [a] (1.45)	4.32 [a] (2.19)	0.70 [a] (1.09)	1.09 [a] (1.26)	18.56 [a]
T6: Untreated control	20.30 [a] (4.56)	28.42 [d] (5.38)	38.10 [d] (6.21)	8.20 [a] (2.95)	7.13 [b] (2.76)	13.26 [d] (3.71)	12.80 [a] (3.65)	18.20 [d] (4.32)	30.66 [d] (5.58)	4.28 [a] (2.19)	10.57 [c] (3.33)	10.57 [c] (3.33)	7.44 [d]
SE ±	0.14	0.16	0.14	0.10	0.13	0.12	0.15	0.10	0.12	0.15	0.10	0.12	0.31
CD at 5%	NS	0.48	0.41	NS	0.39	0.35	NS	0.29	0.37	NS	0.29	0.37	0.95
CV (%)	17.26	16.46	16.38	6.69	16.84	17.39	17.39	16.19	19.78	17.39	16.19	19.78	15.76

(DAS- D ays after spray * Square root ($\sqrt{x+0.5}$) transformed values)

10.3 Biointensive Pest Management in *Bt* cotton ecosystem (AAU-A, UAS-R)

10.3.1AAU- Anand

Objectives: To demonstrate BIPM module in *Bt* cotton
Year of commencement: 2017-18
Location: Farmer's field, Karena, Karjantaluk, Vadodara district
Area: 5 ha

Treatments:
T1: BIPM package
Seed bio-priming with *Trichoderma harzianum*@ 10g/kg of seeds.
Maize as border crop
Pheromone traps @ 10/ha for bollworms.
Release of *Trichogrammatoideabactrae*
@ 100,000/ha (6-8 releases starting from 55^{th} DAS or with appearance of PBW).
Application of Azadirachtin1500 ppm
@ 5 ml/ lit for sucking pests.
Spray of *Lecanicillium lecanii* (1×10^{8}) @ 5g/lit.
Spray of *Pseudomonas fluorescens* 2% solution against foliar diseases.

T2: Farmers' practice
Observations: No. of good open bolls and bad open bolls, number of pink bollworm larvae, average number of sucking pest population/ leaf,*viz.*, aphids, jassid, whiteflies and thrips were counted and recorded before spray, 3 and 7 days after each spray and yield (q/ha) was recorded**(Table 88A, B,C, D, E**).

Table 88A. Effect of different modules on pink bollworm in *Bt* cotton

Treatments	PBW infested bolls/100 bolls/replication (%)				
	45 DAS	65 DAS	85 DAS	105 DAS	125 DAS
BIPM package	6.37	10.62	15.37	11.25	9.12
Farmers' practices	3.25	6.37	11.00	7.87	6.37
P value	0.01	0.0004	0.01	0.0004	0.01

Table 88B. Effect of different modules on pink bollworm larval population

Treatments	No. of PBW larvae/ total PBW infested bolls/replication				
	45 DAS	65 DAS	85 DAS	105 DAS	125 DAS
BIPM package	2.25	4.87	6.12	3.87	2.50
Farmers' practices	1.25	2.75	3.25	1.87	1.12
P value	0.04	0.004	0.008	0.04	0.01

Table 88C. Effect of different modules on aphid population in *Bt* cotton

Treatments	aphid/leaf				
	First spray			Second spray	
	BS	3 DAS	7 DAS	3 DAS	7 DAS
BIPM package	11.28	9.48	3.27	7.48	3.14
Farmers' practices	12.29	6.82	2.85	5.45	2.64
P value	NS	0.001	NS	0.02	NS

Table 88D. Effect of different modules on thrips population in *Bt* cotton

Treatments	Thrips/leaf				
	First spray			Second spray	
	BS	3 DAS	7 DAS	3 DAS	7 DAS
BIPM package	12.86	8.12	3.12	5.82	2.96
Farmers' practices	11.14	6.92	2.14	5.26	2.06
P value	NS	NS	NS	NS	NS

Note: BS: Before spray, DAS: Days after spray

Table 88E.Effect of different modules on cotton seed yield

Treatments	Cotton seed yield (q/ha)
BIPM package	20.70
Farmers' practices	23.13
P value	0.03

Results: Significant difference was observed between BIPM package and farmers practice with regard to number of good open bolls and bad open bolls and it was observed that the incidence levels of PBW was less as compared to previous year incidence. More number of PBW damaged bolls were recorded at 85 DAS i.e.15.37 % infested bolls in BIPM package and 11.00% infested bolls in farmers practice block. In case of sucking pests, there was an incidence of thrips and aphid only. No whitefly and jassid infestation noticed. Significant difference in bio-efficacy of different modules on aphid population was observed at 3 DAS whereas no significant difference between the modules at7 DAS. With regard to thrips population BIPM package found equally effective as compared to farmers practice. Farmers practice module recorded 23.13 q/ha cotton seed yield which was significantly higher than the yield recorded in BIPM package (20.70 q/ha)
Disease incidence: very low incidence of leaf reddening disease (2-3%) was recorded in both the modules.

10.3.2 UAS, Raichur

Treatment Details
T_1: 1. Seed treatment with *T. harzianum* @ 10 gm/kg of seed
2. Maize as a border crop

3. Pheromone traps @ 10/ha
4. Release of *T. bactrae* @ 1.0 lakh/ha 6-8 releases 55 DAG
5. Application of azadirachtin 1500 ppm @ 5 ml/lit
6. *Lecancillium lecanii* @ 1× 10^8 spores/gm @ 5 g/lit
7. *Pseudomonas fluorescens* @ 2%
T_2: Famers Practice (1. Imidacloprid 17.8SL @ 0.3 ml /l at 35 DAS; 2. Fipronil 5SC @ 1 ml /l at 50 DAS; 3. Profenophos 50EC @ 2.0 ml/lt at 70 DAS; 4.Thiodicarb 75WP @ 1.0 gm/lt at 90 DAS.

Observations:
Sucking Pests: Both nymphs and adults of thrips were recorded on top three leaves and expressed as number of thrips per leaf. Both nymphs and adults of leafhoppers were recorded at top, middle and bottom leaves and expressed as number of leafhoppers per leaf. Similarly aphid population was recorded at top three leaves at the early stage of the crop and at late stage of the crop top, middle and bottom leaves were considered and expressed as number of aphids per leaf. Whiteflies population were recorded on top three leaves and expressed as number per leaf.
Pink bollworm: Per cent rosette flower was worked out by considering number of rosette flower in five randomly selected plants in each quadrant. To record the larval population of pink bollworm 10 bolls were randomly collected, dissected and counted the number of larvae per 10 bolls. At the time of picking locule damage, good open bolls (GOB) bad open bolls (BOB) and seed cotton yield was recorded in each treatment and analyzed statistically.

Results: Sucking pest population *viz*., thrps, leafhoppers, aphids and whiteflies population was more in biointensive practice (7.32, 9.18, 4.14 and 0.64 thrips, leafhoppers, aphids and whiteflies/leaf) compared to farmer practice (2.78, 3.62, 1.58 and 0.12 thrips, leafhoppers, aphids and whiteflies/ leaf). Biointensive practice recorded 10.64, 30.56 and 20.02 PBW larvae, GOB and BOB per plant, respectively and in farmers practice it was 8.32, 38.46 and 12.52 PBW larvae, GOB and BOB per plant, respectively. Maximum locule damage of 28.50 % was noticed in biointensive practice, while in farmer practice it was 15.75%. In biointensive practice the seed cotton yield was 30.50 q/ha while in farmer practice it was 33.75 q/ha **(Table 89).**

Table 89.Biointensive Pest Management in *Bt* cotton during 2018-19

Sl. No.	Treat ment	Thrips/ leaf	Leaf hoppers/ leaf	Aphids/ leaf	Whitefly/ leaf	PBW larvae /10 bolls	GOB /plant	BOB /plant	Locule damage (%)	Seed cotton yield (q/ha)
1.	T1	7.32 (2.80)	9.18 (3.11)	4.14 (2.15)	0.64 (1.07)	10.64 (3.34)	30.56 (5.57)	20.02 (4.53)	28.50 (32.27)	30.50
2.	T2	2.78 (1.81)	3.62 (2.03)	1.58 (1.44)	0.12 (0.79)	8.32 (2.97)	38.46 (6.24)	12.52 (3.61)	15.75 (23.38)	33.75
S Em±		0.13	0.08	0.03	0.05	0.04	0.33	0.18	0.38	1.01
CD (P=0.05)		0.41	0.25	0.11	0.15	0.12	1.01	0.55	1.14	3.05

T_1: 1. Seed treatment with *T. harzianum* @ 10 gm/kg of seed, 2. Maize as a border crop, 3. Pheromone traps @ 10/ha, 4. Release of *T. bactrae* @ 1.0 lakh/ha 11 releases 4 DAG, 5. Application of azadirachtin 1500 ppm @ 5 ml/lit, 6. *Lecancillium lecanii* @ 1x 10^8 spores/gm @ 5 g/lit,7. *Pseudomonas fluorescens* @ 2%

T_2: 1. Imidacloprid 17.8 SL @ 0.3 ml /l at 35 DAS, 2. Fipronil 5 SC @ 1 ml /l at 50 DAS, 3. Profenophos 50 EC @ 2.0 ml/lt at 70 DAS, 4. Thiodicarb 75 WP @ 1.0 gm/lt at 90 DAS, 5. Lamdacyhalothrin 5EC @ 0.5 ml/lt @ 110 DAS.

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

10.4: Monitoring of whitefly, its natural enemies and pink bollworm in cotton (PAU, Ludhiana)

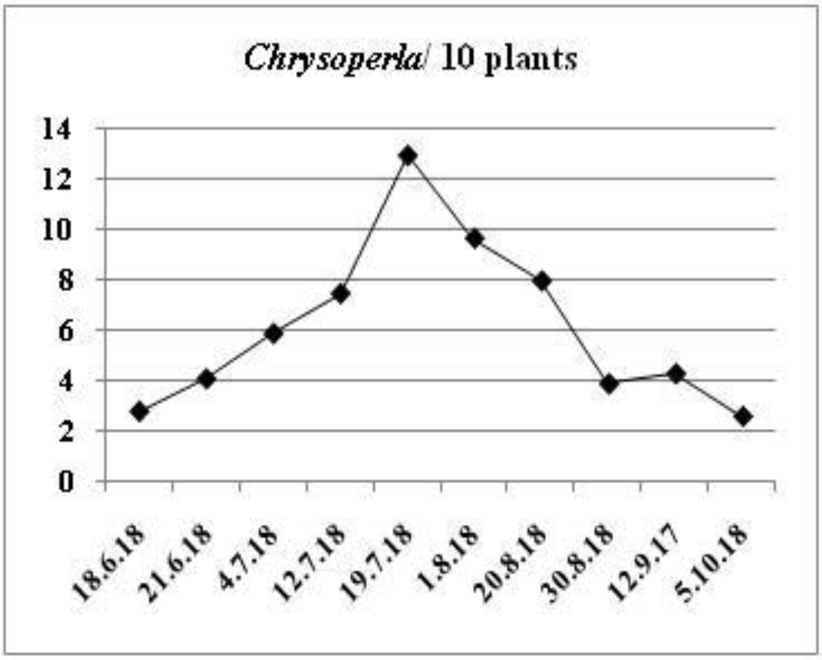
Regular surveys were conducted in cotton growing areas of Punjab (Fazilka, Bathinda, Mansa and Muktsar districts) to monitor whitefly population on cotton crop during *kharif* 2018. The population of whitefly remained low to moderate except at few locations in Khuiyansarvar block of Fazilka.

Natural enemies: The population of predators was recorded on whole plant basis from 20 plants selected at random. Infested cotton leaves (nymphs & pupae of whitefly) were collected and brought to the biocontrol laboratory to record the emergence of parasitoids. Seventeen species of natural enemies were recorded including 8 species of insect predators; 2 species of parasitoids and 7 species of spiders **(Table 90).**

Table 90. List of insect predators, spiders and parasitoids recorded in cotton growing areas of Punjab during *kharif*, 2018

Natural enemies	Family	Order
Insect predators		
Chrysoperlazastrowisillemi(Esben-Peterson)	Chrysopidae	Neuroptera
*Coccinellaseptempunctata*Linneaus	Coccinellidae	Coleoptera
*Coccinellatransversalis*Fabricius	Coccinellidae	Coleoptera
Cheilomenessexmaculata(Fabricius)	Coccinellidae	Coleoptera
Brumoidessuturalis(Fabricius)	Coccinellidae	Coleoptera
*Serangiumparcesetosum*Sicard	Coccinellidae	Coleoptera
Zanchiusbreviceps(Wagner)	Miridae	Hemiptera
*Geocoris*sp.	Geocoridae	Hemiptera
Spiders		
*Neosconatheisi*Walckenaer	Araneidae	Araneae
*Argiope*sp.	Araneidae	Araneae
*Oxyopes*sp.	Oxyopidae	Araneae
*Thomisus*sp	Thomosidae	Araneae
*Runcinia*sp.	Thomosidae	Araneae
*Hyllus*sp.	Salticidae	Araneae
*Chrysilla*sp.	Salticidae	Araneae
Parasitoids		
Encarsialutea(Masi)	Aphelinidae	Hymenoptera
Encarsia sophia (Girault& Dodd)	Aphelinidae	Hymenoptera

Predators: Among predators, *Coccinellaseptempunctata*, *Cheilomenessexmaculata* and *Brumoidessuturalis*, *Serangiumparcesetosum*, *Chrysoperlazastrowisillemi*, *Zanchiusbreviceps*, *Geocoris* sp. and spiders (*Neosconatheisi*, *Argiope*sp, *Oxyopes* sp., *Thomisus*sp., *Runcinia*sp., *Hyllus*sp. and *Chrysilla*sp.) were recorded. Out of these, *Chrysoperla* was the predominant species. The population of *Chrysoperla* increased till mid-July, but declined thereafter. However, spider population was at peak during end-August **(Fig. 13).** The mean population of coccinellids, *Chrysoperla* and spiders varied from 0.0 to 2.0, 0.0 to 21.0 and 0.0 to 20.0 per 10 plants, respectively **(Table 91).**



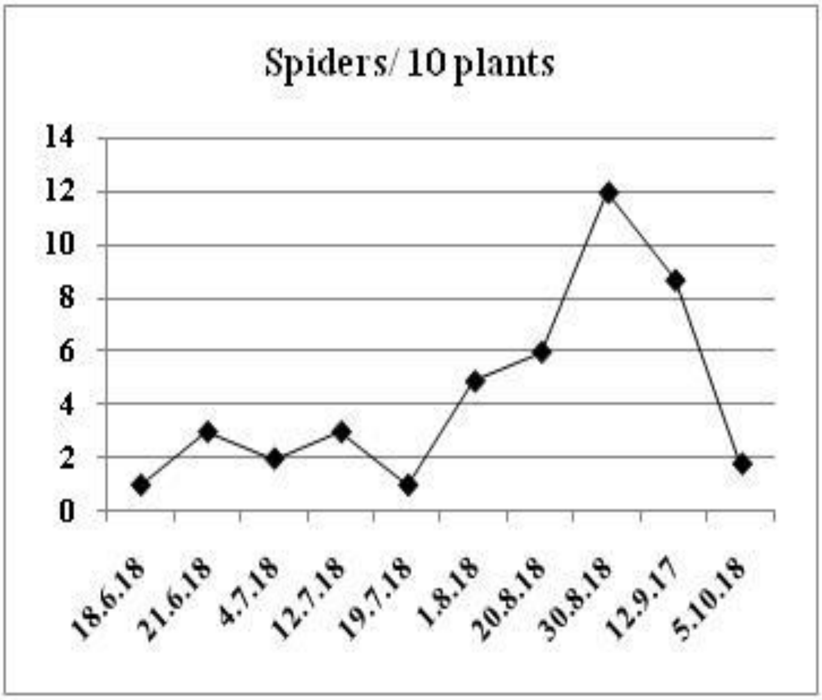


Fig. 13 Population trends of *Chrysoperla* and spiders in cotton growing areas of Punjab during 2018

Table 91. Population of predators recorded during survey in cotton during 2018

Date	Districts	Villages covered	Population of predators/ 10 plants		
			*Chrysoperla**	Spiders	Coccinellids
18.6.18	Muktsar, Fazilka, Faridkot	WaadaDaraka, Aulakh, EnaKhera, Koliawaali, KhemaKhera, Khuban, SitoGuno, Sardarpur	2.8 (1.0-6.0)	1.0 (0.0-2.0)	0.0
21.6.18	Muktsar, Fazilka, Faridkot	Khara, Aulakh, EnaKhera, Koliawaali, Khuban, SitoGuno	4.1 (1.0-8.0)	3.0 (1.0-8.0)	0.2 (0.0-1.0)
4.7.18	Muktsar, Fazilka, Faridkot	WaadaDaraka, Aulakh, BhaiKaKera, KhemaKhera, Khuban, SitoGuno	5.9 (1.0-10.0)	2.0 (1.0-7.0)	0.1 (0.0-1.0)
12.7.18	Muktsar, Fazilka, Faridkot	Khara, Aulakh , Koliawaali, KhemaKhera, Khuban, Sham Khera	7.5 (1.0-13.0)	3.0 (1.0-9.0)	0.0
19.7.18	Muktsar, Fazilka, Faridkot	BhaiKaKera, KhemaKhera, Sham KheraKhuban, Sitoguno	13.0 (1.0-19.0)	1.0 (1.0-5.0)	0.18 (0.0-2.0)
1.8.18	Mansa, Bathinda	Aklia, Joga, Ralla, Tamkot, RamditteWala, Maakha, Banawaala, Behniwal, Jagga Ram Tirth, Talwandi Sabo, Jeewan Singh Wala, Kot Shamir	9.7 (0.0-21.0)	4.9 (1.0-11.0)	0.1 (0.0-1.0)
20.8.18	Muktsar, Fazilka, Faridkot	WaadaDaraka, Aulakh, EnaKhera, KhemaKhera, Khuban, Sitoguno	8.0 (1.0-17.0)	6.0 (1.0-10.0)	0.0
30.8.18	Muktsar, Fazilka, Faridkot	WaadaDaraka, Khara, Aulakh, EnaKhera, Koliawaali, Khuban	3.9 (0.0-7.0)	12.0 (8.0-20.0)	0.1 (0.0-1.0)
12.9.17	Muktsar, Fazilka	Aulakh, EnaKhera, BhaiKaKera, Khuban, ShaamKhera, Sitoguno	4.3 (1.0-8.0)	8.7 (0.0-12.0)	0.0
5.10.18	Muktsar, Fazilka	Khara, Aulakh, BhaiKaKera, KhemaKhera, Khuban, SitoGuno	2.6 (1.0-7.0)	1.8 (0.0-3.0)	0.0

* include eggs, larvae, pupa & adults; Figures in parentheses indicate range at different locations

Parasitoids: *Encarsialutea* (Masi) and *Encarsiasophia* (Girault& Dodd) were the two parasitoids that emerged from whitefly nymphs. Out of 23972 nymphs observed, 1200 were found to be parasitized **(Table 92)**. The mean parasitization of whitefly by *Encarsia* spp. in different cotton growing areas of Punjab was 5.01% (range = 2.04 to 18.62%). The parasitization was comparatively more in unsprayed plots as compared to sprayed plots (**Table 93**).

Table 92. Parasitization of whitefly by *Encarsia* spp. recorded during survey on cotton in Punjab during 2018

Districts	Number of whitefly nymphs observed	Number of parasitized nymphs	Parasitization (%)
Mansa	1101	205	18.62
Muktsar	3161	211	6.68
Bathinda	3739	277	7.41
Fazilka	8534	355	4.16
Ludhiana	7437	152	2.04
Total/Mean	23972	1200	5.01

Table 93. Parasitization of whitefly by *Encarsia* sp. under sprayed and unsprayed cotton (fixed plots) during 2018

Districts	Variety	Parasitization (%)	
		Unsprayed	Sprayed
Bathinda	RCH 650 *Bt*	4.14	0.87
Mansa	RCH 773 *Bt*	16.11	3.17
Fazilka	RCH 773 *Bt*	15.67	2.68
Ludhiana	RCH 773 *Bt*	2.48	0.44

Pink bollworm: No pink bollworm damage was recorded in BG II cotton, however very low incidence was observed in non-*Bt* and *desi* cotton at end of crop season.

10.5 Population dynamics of whitefly, *Bemisia tabaci*and its natural enemies in cotton: A study in farmers' field in North Zone (NCIPM, New Dheli)

Objectives

- To study the seasonal dynamics of whitefly, its predators and parasitoids in cotton crop in different locations in farmers' fields in North Zone.
- To study natural occurrence of entomopathogens associated with whitefly, *B. tabaci* in cotton crop ecosystem.

Results: Whitefly population (adults/ 3 leaves) remained below ETL in June and crossed ETL at few locations during July-August and thereafter remained below ETL in all locations. In the month of October, population of whitefly and other pests was negligible. Mean population (average of the season) of whitefly was maximum in Fazilka (12.77) followed by Sirsa (6.79), Muktsar (3.86), Sriganganagar (3.03) and Hanumangarh (2.33). There was significant difference in whitefly population between different districts during July 2-4 (P=0.0007, df=14) and August 6-7 (P=0.005, df=14). During 6-7 June whitefly population was not significantly different in all surveyed districts (P=0.062, df=14). During 2-4 July whitefly was recorded very low in 45 days old crop, compared to >60 days crop where it reached ETL and in some fields crossed well above the ETL especially in Rajpura, Nihalkhera villages in Fazilka and at Santpura village in Hanumangarh (Raj) closed to the border of Muktsar (Punjab). During 19-20 July, data on whitefly population showed insignificant difference due to large deviation in in different locations within the same district. The variation in different fields may due to the application of different management strategy by different farmers. During July 19-20 whitefly in Fazilka was near ETL with large number of nymph on lower leaves. Lower leaves of few cotton plants showed blackening due to sooty mould growth on the honey dew secreted by the whitefly nymph. In Sadulshahar (Shriganganagar) and Sangaria (Hanumangarh) it was below ETL. However, in Chautala (Sirsa), it was observed above ETL (30-35/3 leaves). During August 6-7, whitefly population was below ETL in most of the surveyed fields except few fields in Fazilka **(Fig. 14)**. During the cotton crop season farmers had applied 4-6 spray of pesticides which includes thiamethoxam, pyriproxyfen, flonicamid, spiromesifen, diafenthiuron, spinetoram, ethion,imidacloprid, profenofos etc.

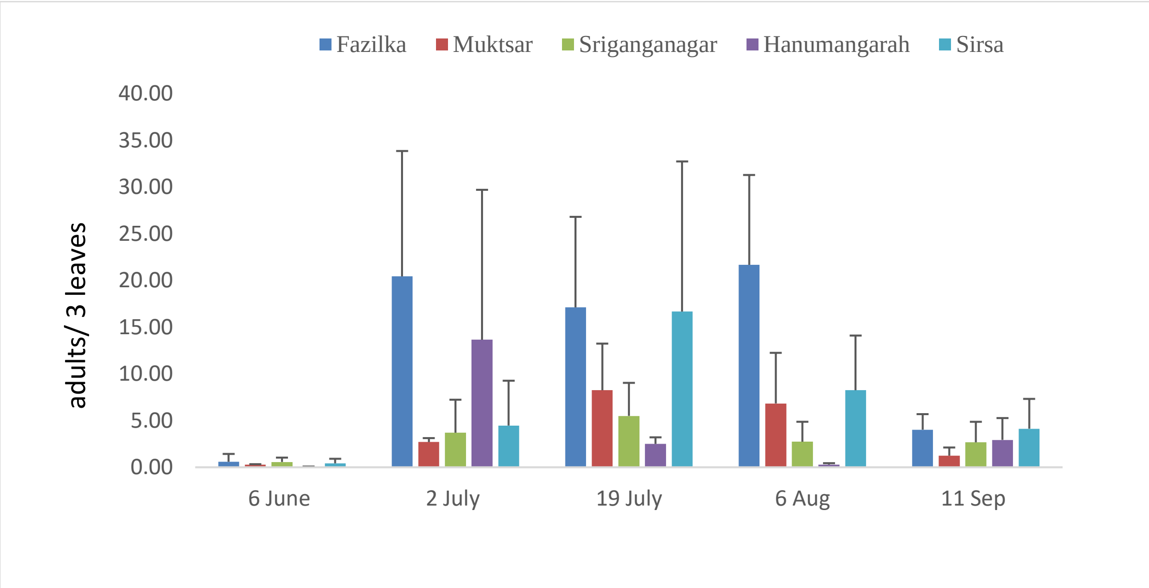


Fig. 14 Dynamics of whitefly in cotton in North Zone

Among natural enemies predators chrysopid and spiders were the dominant and presence of *Geocoris* bug was also noticed. Population of coccinelid beetles was not found in most of the fields. Average population (Mean of the season) of Chrysopid (egg/larvae / plant) was maximum in Sirsa (2.21) followed by Fazilka (0.89), Sriganganagar (0.67) and Hanumangarh (0.47). Spider population (adults/spiderlings/plant) was maximum in Sriganganagar (0.83) followed by Fazilka (0.81), Muktsar (0.78), Sirsa (0.61) and Hanumangarah (0.17). Population of chrysopid in the month of June was negligible but spiders were present in large numbers from the beginning of the season and continue throughout the season **(Fig. 15 & 16).**

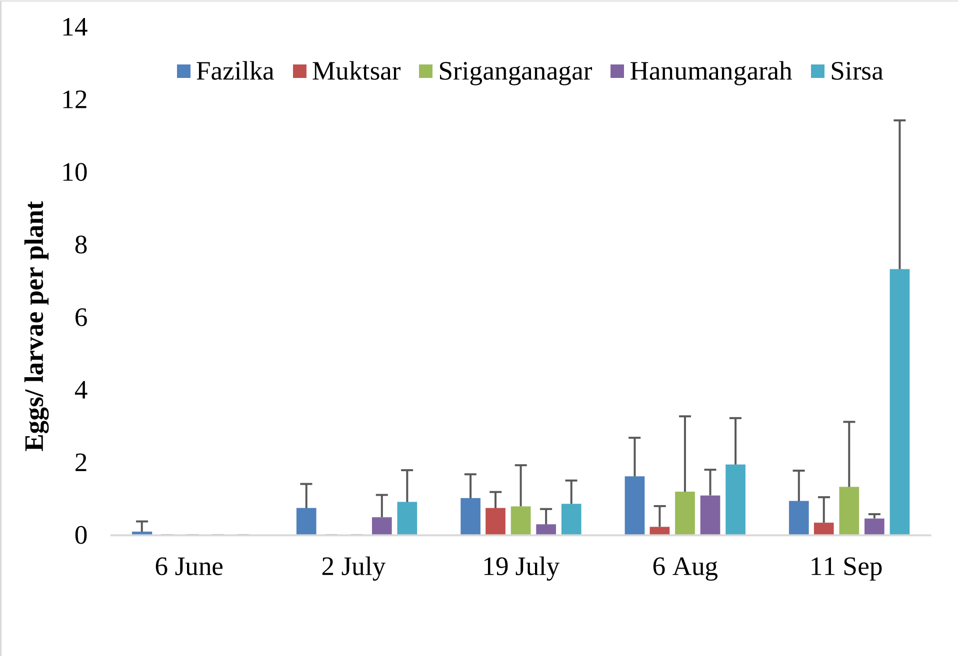


Fig. 15 Dynamics of Chrysopid in cotton in North Zone

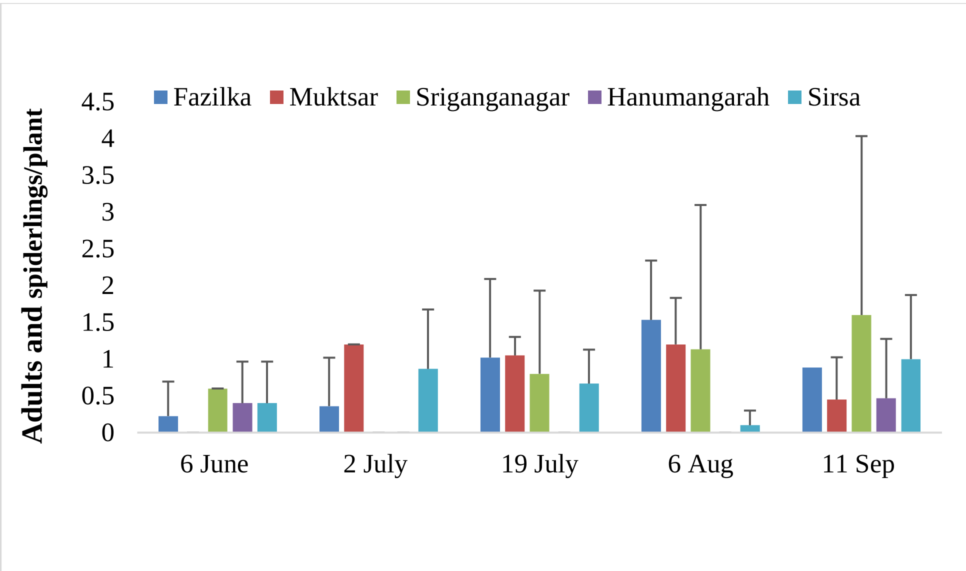


Fig.16 Dynamics of Spiders in cotton in North Zone

During observation on parasitization of whitefly nymphs in the laboratory total (sum of all locations throughout the season) 4374 whitefly nymph/pupae were counted, out of which 2192 were found parasitized. Mean (average of the season) parasitization (per cent) of whitefly nymphs by *Encarsia*spp or other parasitoids was recorded maximum in Fazilka (45.87, Range 28.74-60.90) followed by Muktsar (45.10 Range 23.08-55.94), Sirsa (43.66 range 26.00-54.25), Hanumangarah (34.10 range 22.27-45.49) and Sriganganagar (30.31; range 19.62-51.95). Parasitization was maximum in July and August which coincide with the population of whitefly nymphs thereafter it declined due to decline whitefly population and spray of insecticides **(Fig. 17).** Similar trend was observed with predators also. The study clearly indicated that the heavy parasitization of whitefly by *Encarsia* and other species of parasitoids played a crucial role in regulating the population of whitefly below ETL during entire cotton season except few occasion and no severe outbreak of whitefly was observed. It shows that naturally occurring parasites and predators are capable of regulating pest population, if not disturbed by human interventions. It has happened due to increased awareness among farmers about harmful effect of pesticides, so no farmer had applied any insecticide till first week of July and thereafter minimum pesticides was applied compared to last year.

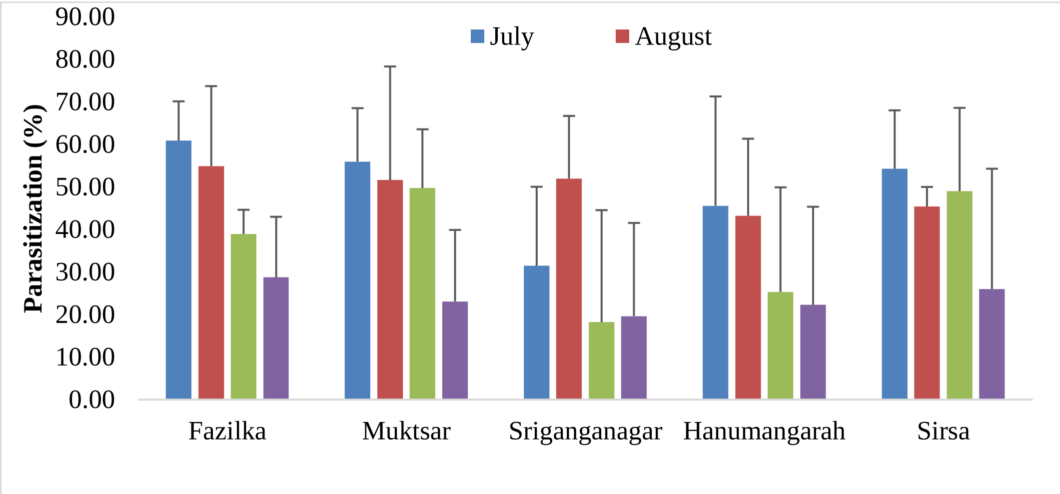


Fig. 17 Parasitization of whitefly nymphs by *Encarsiaspp* in cotton in north zone

To study natural occurrence of entomopathogens associated with whitefly, *B. tabaci* in cotton crop ecosystem, whiteflies collected from the fields were surface sterilizedwith sodium hypochloride and inoculated on PDA. So far no entomopathogenic fungal growth was observed from the whitefly.Meetings with line department, State department of Agriculture and farmers were also organised to sensitize farmers about the role of biocontrol agents in cotton pest management and trained them about the identification of pests and their natural enemies.

Creating awareness among farmers about IPM in cotton with major emphasis on conservation of natural enemies at KhuiyanSarwar block, District Fazilka (Punjab) along with state department of Agriculture under Mission Tandrust Punjab.

11. SUGARCANE

11.1. Efficacy of entomopathogenic nematodes and entomofungusfor the management of whitegrub in sugarcane ecosystem (ANGRAU, MPKV, UAS-R)

11.1.1 ANGRAU, Anakapalle

Treatments:
T1: *Heterorhabditis indica* WP @12 kg/ha in 250 kg FYM per ha.
T2: *Metarhizium anisopliae* (NBAIR) @2.5 kg/ ha in 250 kg FYM per ha.
T3: Chemical control (Chlorantraniliprole 18.5SC @ 0.3 ml / lit)
T4: Untreated control

Conducted the demonstration at Chebrolu, Peddapuram, Borrampalem villages, East Godavari district of Navabharath ventures (Sugar division) operational area, Samalkotain farmers' fields of 10 acres with white grub damage. Entomopathogenic nematode, *H. indica* @12 kg/ha mixed with 150 kg moist sand ; *M. anisopliae* @ 2.5kg/ha mixed with 250 kg FYM per ha in comparison with chemical control, chlorantraniliprole 18.5SC @0.3 ml/lt applied in sugarcane furrows after the onset of monsoon rains. Entomopathogenic nematode, *H. indica* was found significantly effective in reducing whitegrub damage compared to entomofungus, *M. anisopliae*. Percent reduction in plant damage due to white grub recorded high in *H. indica*(81.17%), *M. anisopliae* (78.83%) and chlorantraniliprole 18.5SC (54.17%) over untreated control **(Table 94).**

Table 94. Efficacy of entomopathogenic nematodes and entomofungusfor the management of white grub in sugarcane ecosystem

Treatment	White grub damage (%)				Reduction in white grub damage over control (%)	Number of white grubs / 10m row			Reduction in grub population over control (%)
	Before Treatment	one month after treatment	Two months after treatment	Up to 2MAT		Before Treatment	one month after treatment	Two months after treatment	
T1: *Heterorhabditis indica* WP @12 kg/ha in 150 kg sand per ha.	1.0	1.13	0.0	1.13	81.17	1.25	0.25 (1.435)	0.0	68.13
T2: *Metarhizium anisopliae*@ 5 kg/ ha in 250 kg FYM /ha.	1.0	1.27	0.0	1.27	78.83	1.13	0.0	0.0	66.71
T3: Chemical control (Chlorantraniliprole 18.5SC @ 0.3 ml / lit)	1.13	1.25	1.5	2.75	54.17	1.38	1.38	0.0	82.19
T4 : Untreated control	1.13	3.67	2.33	6.0					
CD (0.05)	NS	0.38	0.43			NS	0.41	0.79	
CV%	30.86	31.43	34.01			37.54	31.22	31.92	

11.1.2: MPKV, Pune

Field efficacy of EPN strains against white grubs in sugarcane

The experiment was laid out on the farmers' field at Kasurdi village of DaundTahasil in Pune district. Sugarcane variety Co. 86032 with 8 x 5 m plot size and 90 x 60 cm spacing was sown on 15.6.2018 in RBD having six treatments replicated four times.

Treatments:

T1: *H. indica* WP
T2: *H. bacteriophora* WP
T3: *S. carpocapsae* WP
T4: *S. abbasi* WP
T5: Chemical (Fipronil)
T6: Control

Results: Two applications of EPN strains and insecticide were given on 7.9.2018 and 7. 10.2018 and yield of sugarcane is awaited. Hence, trial is in progress.

Field efficacy of dose application of EPN against white grubs in sugarcane

The experiment was laid out on the farmers, field at Kasurdi village of DaundTahasil in Pune district, Sugarcane (var. Co. 86032) with 8 x 5 m plot size and 90 x 60 cm spacing was sown on 15.6.2018 in RBD having six treatments replicated four times.

Treatments:
T1: *H. indica* @ 1.0 $\times 10^5$/ m^2 (NBAIR WP formulation)
T2: *H. indica* @ 2.0 $\times$ 10^5/ m^2 (NBAIR WP formulation)
T3: *H. indica*@ 3.0 $\times 10^5$/ m^2 (NBAIR WP formulation)
T4: *H. indica* @ 1.0 $\times$ / m^2 (Commercial WP formulation)
T5: *H. indica* @ 2.0 $\times 10^5$/ m^2 (Commercial WP formulation)
T6: *H. indica* @ 3.0 $\times 10^5$/ m^2 (Commercial WP formulation)
T7: Chemical (Chlorpyrifos/fipronil)
T8: Control

Results: Two applications of *H. indica*and insecticide were given on 7.9.2018 and 7. 10.2018 and yield of sugarcane is awaited. Hence, trial is in progress.

11.1.3 UAS, Raichur

Efficacy of entomopathogenic fungi *Metarhiziumanisopliae* (ICAR-NBAIR Ma4) for the management of whitegrub in sugarcane during 2016-17

1	**Treatments Details**	
	i. Bioefficacy and effect on predatory population	
	T_1 : *M.anisopliae* (ICAR-NBAIR-Ma4)(1 × 10^8 conidia/g)	2.5 kg/ha in 250 Kg FYM/ha (two times application)
	T_2 :*B.bassiana* (ICAR-NBAIR-Bb5a) (1 × 10^8 conidia/g)	2.5 kg/ha in 250 Kg FYM/ha (two times application)
	Neem Cake 500	500 Kg per ha
	Phorate 10 G	15 Kg per ha
	ii. Phytotoxicity	
	T_1 : *M.anisopliae* (ICAR-NBAIR-Ma 4 strain) (1 ×10^8 conidia/g)	2.5 kg/ha in 250 Kg FYM/ha
	T_2 : *M.anisopliae* (ICAR-NBAIR-Ma 4 strain) (1 × 10^8 conidia/g)	5 kg/ha in 250 Kg FYM/ha
2	**Time of application**	*M. anisopliae* NBAIR Ma 4 enriched FYM @ 250kg/ha was applied to the soil two times. The first application was done in June, 2016 and the second application was done in July 2016 after one month of first application.

Observation: In each acre, eight quadrants were made and observations were recorded on plant damage due to white grub for three rows of 10 meter length in each treatment at monthly interval till harvest. White grub population per 10 meter row in root zone by digging the standard pit of 0.5 × 0.5 m within the clump. Total cane yield was recorded and expressed as ton per hectare. Monthly data on white grub population, plant damage and cane yield were analysed statistically.

Results: The pre-treatment observations on plant damage due to white grub ranged from 42.50 to 46.75%. In the post treatment observations, the plant damage due to white grub was lowest (7.50%) in *M. anisopliae*(ICAR-NBAIR Ma 4) treated plots which was statistically superior over rest of the treatments and followed by *B. bassiana*(ICAR-NBAIR-Bb5a) which recorded 13.25% plant damage. The standard check, Phorate 10 G recorded 20.50% plant damage which was followed by neem cake (30.50% plant damage). Highest plant damage of 62.75 % was noticed in untreated control **(Table 95)**.

White grubs population ranged from 12.50 to 13.25 grubs /10 m row length during pre-treatment. During post-treatment, lowest number of 2.82 grubs /10 m row length was recorded in *M. anisopliae* (ICAR-NBAIR Ma 4) treated plots, which was significantly superior over all other treatments and it was followed by *B. bassiana* (ICAR-NBAIR-Bb5a) which recorded 4.35 grubs /10 m row length. Among the treatments, Phorate 10 G and Neem cake recorded 6.10 and 7.80 grubs / 10 m row length, respectively. Untreated control recorded 21.50 grubs /10 m row length **(Table 95)**.

The highest cane yield of 164.75 t/ha was recorded in *M. anisopliae*(ICAR-NBAIR Ma 4) which was significantly superior over and it was followed by *B. bassiana*(ICAR-NBAIR-Bb5a) which recorded 150.50t/ha. The standard check, Phorate 10 G recorded 141.75 t/ha while neem cake recorded 132.85t/ha cane yield. Lowest cane yield of 108.65 t/ha was recorded in untreated control **(Table 95)**.*M. anisopliae*(ICAR-NBAIR-Ma4) (1×10^8 conidia/g) was found to be optimum dose in reducing white grub population with higher cane yield sugarcane.

Table 95.Efficacy of entomopathogenic fungi *M. anisopliae* (ICAR-NBAIR-Ma4) for the management of white grub in sugarcane during 2016-17

Sl. No.	Particulars	Per cent plant damage due to white grubs*			No. of white grub/10 m row length#			Cane yield (t/ha)
		Precount	Six month after treatment imposition	Reduction over control (%)	Precount	After treatment imposition	Reduction over control (%)	
T_1	*M. anisopliae*- Ma 4 (1×10^8 conidia/g) @ 2.5 kg/ha in 250 Kg FYM per ha	42.55 (40.72)	7.50[a] (15.89)	88.04	13.25 (3.71)	2.82[a] (1.81)	86.88	164.75[a]
T_2	*B. bassiana* - Bb 5a (1×10^8 conidia/g) @ 2.5 kg/ha in 250 Kg FYM per ha	44.50 (41.84)	13.25[b] (21.35)	78.88	12.75 (3.64)	4.35[b] (2.20)	79.76	150.50[b]
T_3	Neem Cake 500 @ 500 Kg / ha	46.75 (43.14)	30.50[d] (33.52)	51.39	12.50 (3.61)	7.80[d] (2.88)	63.72	132.85[c]
T_4	Phorate 10 G @ 15 Kg / ha	42.50 (40.69)	20.50[c] (26.92)	67.33	13.05 (3.67)	6.10[c] (2.53)	71.62	141.75[c]
T_5	Untreated control	46.50 (42.99)	62.75[e] (52.39)	-	13.50 (3.74)	21.50[e] (4.69)	-	108.65[d]
SEm±		**0.23**	**1.85**	**-**	**0.16**	**0.09**	**-**	**4.12**
CD (P=0.05)		**NS**	**5.55**	**-**	**NS**	**0.28**	**-**	**12.37**

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

Efficacy of entomopathogenic fungi *Metarhiziumanisopliae* (ICAR-NBAIR-Ma4) for the management of white grub in sugarcane during 2017-18

1	**Treatments Details**	
	i. Bioefficacy and effect on predatory population	
	T_1 : *M.anisopliae* (ICAR-NBAIR-Ma4) (1×10^8 conidia/g)	2.5 kg/ha in 250 Kg FYM/ha (two times application)
	T_2 :*B.bassiana* (ICAR-NBAIR-Bb5a) (1×10^8 conidia/g)	2.5 kg/ha in 250 Kg FYM/ha (two times application)
	Neem Cake 500	500 Kg per ha
	Phorate 10 G	15 Kg per ha
	ii. Phytotoxicity	
	T_1 : *M.anisopliae* (Ma 4 strain) (1×10^8 conidia/g)	2.5 kg/ha in 250 Kg FYM/ha
	T_2 : *M.anisopliae* (Ma 4 strain) (1×10^8 conidia/g)	5 kg/ha in 250 Kg FYM/ha
2	**Time of application**	*M. anisopliae* NBAIR Ma 4 enriched FYM (@ 250kg/ha was applied to the soil two times after the onset of S-W monsoon. The first application was done in July, 2017 and the second application was done in August, 2017 after one month of first application.

Observation: In each acre, eight quadrants were made and observations were recorded on plant damage due to white grub for three rows of 10 meter length in each treatment at monthly interval till harvest. White grub population per 10 meter row in root zone by digging the standard pit of 0.5 × 0.5 m within the clump. Total cane yield was recorded and expressed as ton per hectare. Monthly data on white grub population, plant damage and cane yield were analysed statistically.

Results: Before treatment imposition the plant damage due to white grub ranged from 31.50 to 34.50%. Six months after treatment imposition, *M. anisopliae* ICAR-NBAIR Ma4) recorded lowest of 5.51% which was statistically superior over rest of the treatments. *B. bassiana* (ICAR-NBAIR-Bb5a) recorded 10.50% plant damage while Phorate 10 G and Neem cake recorded 18.50 and 24.75%, respectively. Untreated control recorded highest plant damage of 58.50% **(Table 96).**

Number of white grubs ranged from 9.75 to 11.25 grubs / 10 m row length during pre-treatment. In the post-treatment observations, lowest number of 1.85 white grubs in 10 m row length was recorded in *M. anisopliae* (ICAR-NBAIR Ma4) plots which was significantly superior over rest of the treatments. *B. bassiana* (ICAR-NBAIR-Bb5a) recorded 3.50 grubs /10 m row length. Phorate 10 G (4.25 grubs/10 mrl) and neem cake (5.50 grubs/10 mrl). Untreated control recorded 18.25 grubs / 10 m row length **(Table 96).**

The highest cane yield of 174.75 t/ha was recorded in *M. anisopliae* (ICAR-NBAIR Ma4) treatment and it was followed by *B. bassiana*(ICAR-NBAIR-Bb5a) which recorded 156.50 t/ha cane yield. Phorate 10G and Neem cake recorded 152.65 t/ha and 144.80 t/ha cane yield, respectively. The lowest cane yield of 114.50 t/ha was recorded in untreated control **(Table 96)**. *M. anisopliae*(ICAR-NBAIR-Ma4) (1×10^8 conidia/g) was found to be optimum dose in reducing white grub population with higher cane yield sugarcane.

Table 96. Efficacy of entomopathogenic fungi *M. anisopliae* (ICAR-NBAIR-Ma4) for the management of white grub in sugarcane during 2017-18

Sl. No.	Particulars	Per cent plant damage due to white grubs*			No. of white grub/10 m row length#			Cane yield (t/ha)
		Precount	Six month after treatment imposition	Reduction over control (%)	Precount	Six month after treatment imposition	Reduction over control (%)	
T_1	*Metarhiziumanisopliae*- Ma 4 (1 × 10^8 conidia/g) @ 2.5 kg/ha in 250 Kg FYM per ha	34.50 (35.97)	5.51[a] (3.56)	90.58	10.50 (3.32)	1.85[a] (1.53)	89.96	174.75[a]
T_2	*Beauveriabassiana* - Bb 5a (1×10^8 conidia/g) @ 2.5 kg/ha in 250 Kg FYM per ha	32.75 (34.91)	10.50[b] (18.91)	82.05	11.25 (3.43)	3.50[b] (2.00)	80.82	156.50[b]
T_3	Neem Cake 500 @ 500 Kg per ha	31.50 (34.14)	24.75[d] (29.83)	57.64	9.75 (3.20)	5.50[d] (2.45)	69.86	144.80[c]
T_4	Phorate 10G @ 15 Kg per ha	33.75 (35.52)	18.50[c] (25.47)	68.39	10.25 (3.28)	4.25[c] (2.18)	76.71	152.65[b]
T_5	Untreated control	31.50 (34.41)	58.50[e] (49.89)	-	10.75 (3.35)	18.25[e] (4.33)	-	114.50[d]
SEm±		**0.35**	**1.73**	**-**	**0.18**	**0.17**	**-**	**3.19**
CD (P=0.05)		**NS**	**5.19**	**-**	**NS**	**0.52**	**-**	**9.58**

*Figures in parentheses are arcsine transformed values

#Figures in parentheses are square root transformed values

11.2 Large scale demonstration of *Trichogrammachilonis*against sugarcane borers (ANGRAU, MPKV, OUAT, PJTSAU, PAU, UAS-Raichur, SunAgro)

11.2.1 ANGRAU, Anakapalle

Treatments:

T1: Releases of *T. chilonis* (temperature tolerant strain of *T. chilonis* should be released) @ 50,000/ha at weekly intervals 8-10 releases from 30 days after planting/ rationing for early shoot borer and at node formation against internode borer.

T2:Farmers' practice (Four insecticide sprays with chlorpyrifos @ 2.5 ml/lt from 30 days after planting at 7-10 day interval)

Results:

Large scale demonstration using temperature tolerant strain *T. chilonis* was conducted in one acre at RARS farm and in 30acres area of 9 farmers plots in 9 villages, East Godavari district, Navbharath ventures (Sugar division) operational area, Samalkota. Conducted field releases of temperature tolerant strain of *T. chilonis*@ 50,000/ha at weekly interval from 30 days after planting against early shoot borer, 8 releases (5 releases in May and 3 releases in June) and 4 releases from node formation during July-August against internode borer **(Fig. 18).** Average cumulative incidence of early shoot borer incidence (4.68%DH); internode borer (22.85%) was low in temperature tolerant strain *T. chilonis* release – 8 +4 times compared to farmer's practice of chlorpyrifos sprays two times (15.45% DH and 31.82%)) in farmers fields. Cane yield and incremental benefit cost ratio recorded high in temperature tolerant strain *T. chilonis* release plot (63.6 t/ha and IBCR: 49.93) compared to farmers practice (58.03t /ha and IBCR: 7.31) (Table7). Early shoot borer incidence upto 120 days recorded low in temperature tolerant strain *T. chilonis* release (8+4 times) plot at RARS, Anakapalle (7.25% DH) with significantly low internode borer incidence (51.2%) and internode borer intensity (3.79%) resulted in higher cane yield (75.81 t/ha), sucrose (19.9%) with high incremental benefit cost ratio (73.85) compared to farmer's practice of chlorpyrifos sprays four times (7.33% DH ; 64.17 % INB incidence; 70.6 t/ha; 18.4% sucrose and 12.95 incremental cost benefit ratio) **(Table 97 and 98).**

Table 97. Efficacy of temparature tolerant *Trichogramma chilonis* against sugarcane borers in farmers fields

Treatment	Location	Cumulative ESB %DH	INB incidence %	INB intensity %	Cane yield t/ha	Sucrose %	IBCR
T1 : TTC releases (8+4 times)	Inukona Veerabadra rao,Sirivada	11.4	28.24	2.14	72.71	18.99	66.64
T2: Farmers practice (chlorpyrifos 4sprays)	Nagulapall Appa rao, Sirivada	12.66	30.1	4.66	69.0	18.81	11.01
T1 : TTCreleases (8+4 times)	Pattamsetti Nagaragh va,Kandrakota	1.44	22.14	2.94	71.67	19.23	64.73
T2:Farmers practice (chlorpyrifos 4 sprays)	Saik Kasim Sahib, Kandrakota	16.57	41.52	5.87	65.89	18.97	9.96
T1 : TTC releases (8+4 times)	Mundru Srinivas, Kattamuru	1.95	20.83	3.22	50.82	19.1	26.5
T2: Farmers practice (chlorpyrifos 4 sprays)	Mundru Srinivas, Kattamuru	13.2	28.22	6.15	46.63	19.03	3.46
T1: TTC releases (8+4 times)	Bathina Srinivas, Soorampalem	3.93	20.2	3.17	59.19	18.86	41.85
T2: Farmers practice (chlorpyrifos 4 sprays)	Parimi Veeraju , Yallamilli	19.4	27.45	5.85	50.58	18.55	4.8
Average							
T1 : TTC releases (8+4 times)		4.68	22.85	2.87	63.6	19.05	49.93
T2:Farmers practice (chlorpyrifos 4 sprays)		15.45	31.82	5.63	58.03	18.84	7.31

Table 98. Efficacy of temparature tolerant *Trichogramma chilonis* against sugarcane borers in March plant crop

Treatment	ESB %DH 35 DAP	ESB %DH 60 DAP	ESB %DH 90 DAP	ESB %DH 120 DAP	Cumulative ESB (%DH)	INB incidence (%)	INB intensity (%)	INB index	Cane yield (t/ha)	Sucrose (%)	Incremental benefit cost ratio	Benefit Cost ratio
T1 : Temperature tolerant *Trichogramma chilonis* (8+4 releases) in May plant crop 2009A107	2.72	3.92	0.54	0.07	725	51.25	3.796	1.706	75.81	19.98	73.85	2.09
T2: Farmers' practice- Four insecticide sprays with chlorpyrifos @ 2.5 ml/lt	2.28	3.81	1.24	0.0	7.33	64.17	4.639	1.309	70.6	18.47	12.95	1.85
t-test					NS	*	*	*		NS		
t cal					0.12	-1.9	-1.21	-1.12		0.1		

ESB- Early shoot borer; INB – Internode borer; DH – Dead heart

Fig. 18 Large scale demonstration of *T. chilonis* against sugarcane borers

11.2.2 MPKV, Pune

The large scale demonstration on biological suppression of borer complex in sugarcanewas carried out. Theeffectiveness of *T. chilonis* TTS against ESB in sugarcane was conducted on the Dairy farm of Manjri, College of Agriculture, Pune. Planting of sugarcane (cv. Co 86032) @ 25,000 sets/ha was done on 13.2.2018 to 15.2.2018 over 5.0 ha with at 90 x 30 cm plant spacing. Nucleus culture of the parasitoid was obtained from the NBAIR, Bengaluru and mass cultured in the biocontrollaboratory. The treatments comprised eight releases of *T. chilonis* TTS @ 50,000 adults/ha at weekly interval, farmers' practice- three sprays of chlorpyrifos 0.05% and untreated control. A control plot maintained at 200 m distance from parasitoid released plot. Each treatment plot divided into 10 subplots as replicates. Release of parasitoids started from 25/3/2017. 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.
Eight releases of *T. chilonis*TTS @ 50,000 parasitoids/ha at weekly interval starting from 40 days after emergence of shoots found significantly superior to untreated control in reducing the ESB infestation (from 22.35 to 6.38 % dead hearts) and increased number of tillers (9.55 tillers/clump) as well as cane yield (138.70 MT/ha) **(Table 99).** It was, however, statistically comparable with chemical control.

Table 99. 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	16.85 [a]	6.38 [a]	8.08 [a]	9.55 [a]	138.70 [a]
T2: Farmers practice-chlorpyrifos 0.05%	16.78 [a]	7.75 [a]	8.05 [a]	8.99 [a]	136.95 [a]
T3: Untreated control	16.32 [b]	22.35 [b]	7.85 [b]	6.90 [b]	122.17 [b]
CD (p = 0.05)	**NS**	**1.95**	**NS**	**0.72**	**4.28**

*****In Maharashtra among the borer complex only early shoot borer is a pre-dominant pest in sugarcane ecosystem.

11.2.3 OUAT, Bhubaneswar

Area covered: 5ha of sugarcane (87A-298); **Location:** Gogal village of Dharmasala block in Jajpur District; **No. of beneficiaries:** 7

Treatments
T1: Release of *Trichogramma chilonis* (temperature tolerant strain) @ 50,000/ha at 10 days interval starting from 45 days after sowing against early shoot borer (ESB). Eight (8) releases were made from February to June, 2018. Release of *T. japonicum* was made against top shoot borer (TSB) and internode borer(INB) at 10 days interval starting from August, 2018 and Eight releases of *T. japonicum* were made(BIPM package).
T2: Farmers practice (spraying of mixed insecticides like profenophos 40% + cypermethrin 4%, chlorpyrifos 50% + cypermethrin 5% and triazophos 35 + delta methrin 1% each at 3ml/l)
T3: Untreated control
Replications: 8; **Plot size:** 10x10m

Results: The crop was sown in first week of December 2017 and release of *T. chilonis* and *T. japonicum* were done as per treatment schedule and compared with farmers practice and untreated control. Maximum infestations due to ESB, INB and TSB in BIPM package were 8.17%, 3.51% and 1.67%, respectively as against 7.23%, 4.03% and 2.12% in FP indicating comparable level of infestation. But, much higher levels of infestation of ESB (27.34%), INB (8.92%) and TSB (2.96%) were recorded in untreated control. Highest cane yield (75.755 t/ha) and B: C ratio (1.09) were recorded in BIPM package which is comparable to FP. Lowest yield (70.074 t/ha) and B: C ratio (1.04) were noted in untreated control **(Table 100) (Fig. 19).**

Fig. 19

Table 100. Effect of *Trichogramma* spp. against borer pests of sugarcane (87A-298)

Treatments	**Borer pests**	**Dead heart (%)**											**Cane Yield (t/ha**	**B:C ratio**
		Feb 18	**Mar 18**	**Apr 18**	**May18**	**Jun 18**	**July18**	**Aug 18**	**Sep 18**	**Oct 18**	**Nov 18**	**Dec 18**		
Release of *Trichogramma* spp. @ 50,000/ha at 10 days interval	ESB	6.14	8.17	6.37	4.38	2.80	1.67	0.00	0.00	0.00	0.00	0.00	75.755	1.09
	IB	0.00	0.00	0.00	0.47	0.00	0.00	2.32	3.16	3.51	2.13	2.51		
	TSB	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.67	0.00	0.00		
Farmers' practice (Pesticide application)	ESB	5.47	6.89	7.23	5.71	3.12	2.12	0.00	0.00	0.00	0.00	0.00	75.508	1.05
	IB	0.00	0.00	0.00	0.53	0.00	0.00	2.61	3.33	4.03	2.32	2.46		
	TSB	0.00	0.00	0.00	0.00	0.00	0.00	2.12	0.00	0.33	0.00	0.00		
Untreated control	ESB	16.33	27.34	20.14	14.82	8.13	5.12	0.00	0.00	0.00	0.00	0.00	70.074	1.04
	IB	0.00	0.00	2.13	4.12	0.00	1.67	8.92	7.89	7.00	8.12	8.23		
	TSB	0.00	0.00	0.00	0.00	0.00	0.00	2.82	0.83	2.96	1.26	1.13		
S.E. (m) ±													**0.250**	
C.D. 0.05													**0.757**	

11.2.4: PJTSAU, Hyderabad
Details of treatments and replications

T1: Six releases of *T. chilonis* (temperature tolerant strain of *T. chilonis* was released) @ 50,000/ha at weekly intervals.
T2: Farmers' practice (as per sprays recommended insecticide)

Each block was divided into 5 equal sized units (each unit was considered as one replication)
Methodology and observations:
Pre-release infestation, *i.e.*, per cent dead hearts / water shoots due to ESB and other borers
Post-release count of percent dead hearts at monthly interval from initiation of parasitoid release up to 4 months
Data on cane yield
Number of millable canes, juice quality
Incremental benefit cost ratio recorded at harvest

Outcome of the demonstration:

The module with releases of *T. chilonis*@ 50,000/ha at weekly intervals 6 releases fared better than farmers' practice in terms of infestation levels as well as net gains **(Table 101).**

Table101. Impact of *T. chilonis* releases on ESB and yield parameters in sugarcane

Treatments	Cumulative incidence of early shoot borer (%)	Cane yield (t/ha)
Six releases of *T. chilonis* (temperature tolerant strain of *T. chilonis* was released) @ 50,000/ha at weekly intervals.	8.43	72.87
Farmers' practice	9.71	67.76

11.2.5: PAU-Ludhiana

i. Stalk borer, *Chiloauricilius*

A) Incollaboration with sugarmills: Large scale demonstrations on the effectiveness of *T. chilonis* against stalk borer, *C.auricilius* were carried out on an area of 8150 acres in collaboration with four sugar mills of the state i.e. Nawanshahr Co-operative Sugar Mills Ltd. Nawanshahr (SBS Nagar), Morinda Co-operative Sugar Mills Ltd. Morinda (Roop Nagar), Nahar Sugar Mills Pvt. Ltd. Amloh (Fatehgarh Sahib) and Rana Sugar Mills Ltd. Buttar Seviyan (Amritsar). The egg parasitoid, *T. chilonis*was released from July to October in the mill areas at 10 days interval @ 50,000/ha. The mean incidence of *C. auricilius*in IPM fields was 2.93%. The corresponding figure in control (non-adopted) fields was 7.00%. It can be concluded that in large-scale demonstrations, 12 releases of *T. chilonis*@ 50,000 per ha at 10 days internal during July to October reduced the incidence of stalk borer by 58.2% **(Table 102).**

Table 102. Large-scale demonstrations of biocontrol based IPM on sugarcane in collaboration with four sugarcane mills of Punjab during 2018

Area covered (acres)	Incidence of *Chiloauricilius*		
	IPM*	Non- Adopted	Reduction over control (%)
8150	2.93	7.00	58.20

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

B) PAU, LUDHIANA

Large-scale demonstrations on the effectiveness of *T. chilonis*against stalk borer, *C. auricilius* were carried out on an area of 1205 acres in Jalandhar, Hoshiarpur, Patiala, Ludhiana, Kapurthala, Fazilka, Fatehgarh Sahib, Amritsar, Gurdaspur, Moga and Sangrur districts in collaboration with KVKs and Regional stations (Gurdaspur, Abohar and Bathinda). The parasitoid, *T. chilonis* was released 10-12 times at 10 days interval from July to October @ 50,000 per ha and was compared with untreated control. The incidence of stalk borer in released fields (3.11%) was significantly lower than untreated control (7.90%). The reduction in incidence over control was 60.6% and the mean parasitism of eggs of *C. auricilius* in released fields was 46.2% as compared to 4.0 % in control **(Table 103)**. It can be concluded that twelve releases of *T. chilonis* at 10 days interval during July to October @ 50,000 per ha were better than untreated control against stalk borer.

Table 103. Demonstrations of *T. chilonis*against *C. auricilius* by PAU, Ludhiana during 2018

Treatments	Incidence (%)	Reduction over control (%)	Parasitism (%)
T. chilonis @ 50,000 per ha*	3.11[a]	60.6	46.2[a]
Control	7.90[b]	-	4.0[b]

* 10-12 releases at 10 days interval

ii. Shoot borer, *Chiloinfuscatellus*

A) In collaboration with sugar mills: Large scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *Chilo infuscatellus* were carried out on an area of 1595 acres in collaboration with four sugar mills of the state i.e. Nawanshahr Co-operative Sugar Mills Ltd. Nawanshahr (SBS Nagar), Morinda Co-operative Sugar Mills Ltd. Morinda (Roop Nagar), Nahar Sugar Mills Pvt. Ltd. Amloh (Fatehgarh Sahib) and Rana Sugar Mills Ltd. Buttar Seviyan (Amritsar). The egg parasitoid, *T. chilonis* was released during mid-April to end-June, at 10 days interval @ 50,000 per ha. The mean incidence of *C. infuscatellus* in released fields was 2.38% as compared to 5.20% in control (non-adopted) fields. It can be concluded that in large-scale demonstrations, eight releases of *T. chilonis* @ 50,000 per ha at 10 days interval during mid-April to end-June reduced the incidence of early shoot borer by 54.3% (**Table 104**).

Table 104. Demonstrations of *T. chilonis*against *Chilo infuscatellus* in collaboration with three sugar mills of Punjab during 2018

Area covered (acres)	Incidence of *Chiloinfuscatellus*		
	IPM*	Non- Adopted	Reduction over control (%)
1562	2.38	5.20	54.3

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

B) PAU, LUDHIANA

Large scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *C. infuscatellus* were carried out on an area of 544 acres in Jalandhar, Hoshiarpur, Patiala, Ludhiana, Kapurthala, Fazilka, Fatehgarh Sahib, Amritsar, Gurdaspur and Sangrur districts in collaboration with KVKs and Regional Stations (Gurdaspur, Abohar and Bathinda). The parasitoid, *T. chilonis* was released 8 times at 10 days interval from mid-April to mid-June @ 50,000 per ha and was compared with chemical control, i.e. chlorantraniliprole (Coragen 18.5 SC) @ 375 ml/ha applied 45 days after planting and untreated control. The incidence of early shoot borer in released fields (2.58%) and chemical control (0.82%) was significantly better than untreated control (5.94%). The reduction in incidence over control was 56.57 and 86.20% in released fields and chemical control, respectively. The mean parasitism of eggs of *C. infuscatellus* in released fields was 45.0% as compared to 4.0% in chemical control and 6.8% in control **(Table 105).** The yield in control (656.0 q/ha) was significantly lower than released fields (711.5 q/ha) and chemical control (838.8 q/ha). It can be concluded that eight releases of *T. chilonis* at 10 days interval during mid-April to mid-June @ 50,000 per ha were better than untreated control, however, these were inferior to chemical control against early shoot borer. However, the cost: benefit ratio (1: 16.21) was high in biocontrol as compared to chemical control (1: 9.07) **(Table 106).**

Table 105. Demonstration of *T. chilonis*against *C. infuscatellus* by PAU, Ludhiana during 2018

Treatments	Incidence (%)	Reduction over control (%)	Parasitism (%)	Yield (q/ha)
T. chilonis @ 50,000 per ha*	2.58^{b}	56.57	45.0^{a}	711.5^{b}
Chlorantraniliprole 18.5 SC @ 375 ml/ ha	0.82^{a}	86.20	4.0^{b}	838.8^{a}
Control	5.94^{c}	-	6.8^{b}	656.0^{c}

* 8 releases at 10 days interval

Table 106. Cost Benefit analysis (2018)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T. chilonis @ 50,000 per ha	711.5	55.5	17205.00	1000.00	16205.00	1:16.21
Chlorantraniliprole 18.5 SC @ 375 ml/ ha	838.8	182.8	56652.50	5625.0	51027.50	1: 9.07
Control	565.0	-	-	-	-	-

Price of sugarcane: Rs. 310/- per quintal during 2018; * includes trichocard/insecticide + labour cost; Price of Coragen (chlorantraniliprole 18.5 SC) @ Rs. 1850/- per 150 ml

iii. Top borer, *Scirpophaga excerptalis*

A) PAU, LUDHIANA

Large-scale demonstrations on the effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 520 acres in Jalandhar, Hoshiarpur, Patiala, Ludhiana, Kapurthala, Fazilka and Sangrur districts. The parasitoid, *T. japonicum* was released 8 times at 10 days interval from mid-April to mid-June @ 50,000 per ha and was compared with chemical control, i.e. chlorantraniliprole (Ferterra 0.4 GR @ 25 kg/ha applied during last week of June). The egg masses of *S. excerptalis* were collected to record per cent parasitization. The incidence of top borer in release and chemical control fields was 3.75 and 1.42 %, respectively. However, both the treatments were significantly better than untreated control (7.80%). The reduction in incidence over control was 54.23 and 81.79% in released fields and chemical control, respectively. The mean parasitism of eggs of *S. excerptalis*in released field was 28.4% as compared to 3.6% in chemical control and 6.8% in control **(Table 107).** The yield in control (648.0 q/ha) was significantly lower than release fields (710.80 q/ha) and chemical control (825.0 q/ha). It can be concluded that eight releases of *T. japonicum* at 10 days interval during mid-April to mid-June @ 50,000 per ha proved as effective as chemical control for the control of top borer. The cost benefit ratio **(Table 108)** was high in biocontrol (1: 17.85) as against chemical control (1: 10.73).

Table 107. Large scale demonstrations of *T. japonicum* against *Scirpophaga excerptalis* during 2018

Treatments	Incidence (%)	Reduction over control (%)	Parasitism (%)	Yield (q/ha)
T. japonicum@ 50,000 per ha	3.75[b]	54.23	28.4[a]	710.80[b]
Chlorantraniliprole 0.4 GR @ 25 kg/ha	1.42[a]	81.79	3.6[b]	825.00[a]
Control	7.80[c]	-	6.8[b]	648.00[c]

*8 releases at 10 days interval

Table 108. Cost Benefit analysis (2018)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T. japonicum@ 50,000 per ha	710.80	60.80	18848.00	1000.00	17848.00	17.85
Chlorantraniliprole 0.4 GR @ 25 kg/ha	825.00	175.00	54250.00	4625.00	49625.00	10.73
Control	648.00	-	-	-	-	-

Price of sugarcane: Rs. 310/- per quintal during 2018; * include trichocard/insecticide + labour cost;
Price of Fetrerra (chlorantraniliprole 0.4 GR) @ Rs 185 per kg

11.2.5: Sun Agro

Methodology: The large block on-farm demonstration (7 hectares) was undertaken in cane variety B.46 in collaboration with Natems Sugars, Chittoor district, Andhra Pradesh. Three treatments were imposed during 6-9 month age of sugarcane crop when internode borer incidence is common .there were three adjacent blocks each of two hectares along with two 0.5ha buffer areas to separate the blocks.

Treatments: 3

T1-Ten releases (weekly) of *T. chilonis* (@ 5cc/ha per release

T2- Ten releases (weekly) of *T. chilonis* (@ 5cc/ha per release concurrently with pheromone trapping (keeping 25 pheromone traps/ha) for the same duration (as optional treatment for local sugar factory)

T3.Untreated control block

Observations: Data on the internode borer incidence on cane basis (distribution) and on internode basis (intensity) were collected at harvest time by sampling in eight sample plots of one cent each per block as perSithanantham et.al. (2017). The cane yield was also recorded in the same sample plots.

Results: The differences among the treatments were found to be significant for both cane basis and internode basis incidence of INB, besides for sugarcane yield **(Table109).**

Table 109. Summary of results on internode borer incidence and sugarcane yield

Treatments	Cane basis incidence (%)	Internode basis incidence (%)	Yield (t/ha)
T1.*Trichogramma* release (5cc/ha10 releases)	48.25	4.04	86.2
T2.T*richogramma* release plus mass trapping (25traps/ha 10 weeks)	19.75	2.17	92.6
T3.No release (control)	70.25	6.04	81.0
Significance	**	**	**
C.D.(p=0.05)	4.17	0.47	2.50

**: Significant at p=0.01

INB incidence (cane basis): The results showed that the INB incidence on cane basis (distribution) was reduced from 70.3% in control block to 48.3% in *Trichogramma* release block, while the block with *Trichogramma* and pheromone trapping together showed the least incidence (19.8%). The respective reduction in borer damage on cane basis due to *Trichogramma* alone was 31%, while when combined with pheromone trapping the reduction in INB was72%.

INB intensity (internode basis): It also showed that while no release plots recorded maximum of 6.04% damage, the block with *Trichogramma* alone recorded 4.04%, whereas when *Trichogramma*release was combined with pheromone trapping it was the least (2.17%)

Sugarcane yield: The yield of sugarcane was 81.0 tons/ha in the no release (control) block, while Tricho release block recorded 86.2 tons/ha, and it was further higher (92.5 tons/ha) in Tricho release plus pheromone trapping block .

Cost-benefit analysis: The costing took into account the current rates and the benefit based on minimum price of cane as Rs.2000/tonne. The cost for *Trichogramma* releases was estimated as Rs. 3000/ha. (10x5xRs.60).The cost of pheromone trapping was also estimated as Rs3,000/ha(25xRs120).Te combined cost was Rs.6,000/ha. The benefit for *Trichogramma* release was Rs.10,400 (5.2 ton xRs.2000),while when combined with pheromone trapping it was Rs.23,000 (11.5tonxRs2000).The respective cost-benefit ratios were1:3.5 and 1:3.8. The benefit for pheromone tapping alone was estimated as Rs.12,600 (6.3tonxRs.2000) the cost benefit ratio working out to 1:4.2.

11.2.6: UAS-Raichur

Treatments Details

T_1 : Releases of *T. chilonis* (temperature tolerant strain)@ 50,000/ha at 10 days intervals 8 releases from mid-45 days old crop to 6 months old crop for early shoot borer.

$T_{2:}$ Farmers' practice (application of chlorpyrifos 20 EC @ 2 ml/lit).

$T_{3:}$ Untreated control

Observations: Pre-release infestation, i.e., per cent dead hearts due to ESB and Post-release count of per cent dead hearts at fortnight interval from initiation of parasitoid release up to 4 months. Total cane yield was recorded and expressed as ton per hectare and the data was analysed statistically.

Results: Before treatment imposition the per cent of dead hearts ranged from 32.50-36.25 in Hampasagar village while in Mudhol it ranged from 18.25 to 20.50% per 10 mrl. Two months after treatment imposition the per cent dead hearts was low in *T. chilonis* (temperature tolerant strain) release plots at both Hampasagar and Mudhol which recorded 2.35 and 1.15% dead hearts per 10 mrl while in farmers practice it was 5.50 and 2.75% dead hearts per 10 mrl and these treatments were significantly superior over untreated control which recorded 7.50 and 4.50% dead hearts per 10 mrl. The highest cane yield of 162.75 t/ha and 181.62 t/ha was recorded in *T. chilonis* (temperature tolerant strain) release plots of Hampasagar and Mudhol, respectively and it was followed by farmers practice plot which recorded 158.50 t/ha and 176.75 t/ha in both Hampasagar and Mudhol, respectively. Untreated control recorded 151.75 t/ha and 171.50 t/ha in both Hampasagar and Mudhol **(Table 110).**

Table 110. Large Scale demonstration of *Trichogramma chilonis* (temperature tolerant strain) against sugarcane early shoot borer

Sl. No	Particulars	Early shoot borer (dead hearts %)*				Cane yield (t/ha)	
		Before treatment		Two months after treatment			
		Hampasagar	Mudhol	Hampasagar	Mudhol	Hampasagar	Mudhol
1	**T_1** : Releases of *T. chilonis* (temperature tolerant strain)	36.25 (37.62)	18.25 (25.29)	2.35 (8.82)	1.15 (6.16)	162.75	181.62
2	**T_2** : Farmers' practice	32.50 (34.76)	20.50 (26.92)	5.50 (13.56)	2.75 (9.55)	158.50	176.75
3	**T_3** : Untreated control	34.85 (36.18)	19.75 (26.39)	7.50 (15.89)	4.50 (12.25)	151.75	171.50
S Em±		**0.31**	**0.06**	**0.08**	**0.03**	**1.63**	**1.41**
CD (P=0.05)		**NS**	**NS**	**0.25**	**0.11**	**4.89**	**4.24**

*****Figures in parentheses are square root transformed values

12. TOBACCO

12.1 Evaluation of bio-pesticides in suppressing tobacco stem borer, *Scrobipalpa heliopa* on tobacco (CTRI, Rajahmundry)

A field experiment was conducted at the experimental farm of BTRC, Kalavacharla of ICAR-CTRI, Rajahmundry during 2018-19 season on burley tobacco with various bio pesticides received from NBAIR, Bengaluru. The bio pesticides were sprayed at 7 days after transplanting (DAT) as a prophylactic spray. Second spray was given at 16 DAT when stem borer infestation was observed in the field and third spray was given at 29 DAT. The results indicated that the infestation of stem borer was low during the season. The treatment Chlorantraniliprole 0.0075% recorded the least stem borer incidence and damage to the seedlings followed by *Bacillus thuringiensis* (*Bt*) formulation 2%, both of which were significantly less than that of untreated control plots. The plant damage was higher in case of *Nomuraea rileyi* NBAIR-Nr1 (2.08% and 4.58%), *Metarhizium anisopliae* NBAIR-Ma4 (2.5% and 4.16%), *Beauveria bassiana* NBAIR-Bb5a (2.06% and 4.16%), and untreated control (2.00% and 4.60%) at 20 DAT and 32 DAT. The other bio pesticide treatments were inferior to the chlortraniliprole and *Bt* formulation **(Table 111).**

Table 111. Effect of biopesticides on tobacco stem borer, *Scrobipalpa heliopa*

Treatment	Stem borer incidence mean no/plot at 16 DAT	Plant damage %/plot at 20 DAT	Stem borer incidence mean no/plot at 28 DAT	Plant damage %/plot at 32 DAT
B. bassiana @5g/lit	1.00	2.08	2.50	4.16
M. anisopliae @5g/lit	1.00	2.50	2.25	4.16
Bt formulation @2ml/lit	0.75	1.66	1.75	3.75
N.rileyi @5g/lit	1.00	2.08	2.25	4.58
Chlorantraniliprole @ 3ml/10 lit	0.50	1.25	1.00	2.08
Untreated Control	1.00	2.50	2.00	4.60
S.Em.±	0.14	0.19	0.18	0.17
C.D. at 5%	0.52	0.60	0.58	0.52

12.2 Impact of contaminated prey (*Myzus nicotianae*) on life parameters of insect predators (*Coccinella* sp.) (CTRI, Rajahmundry).

Experiment on ‘effect of contaminated prey i.e. tobacco aphid *Myzus nicotianae* on mortality and feeding potential of coccinellid predator *Coccinella* sp.was conducted at ICAR-CTRI, Rajahmundry during 2018-19 season with various chemical pesticides. The mortality data was recorded after 24, 48 and 72 hrs of spray (HAS). The lowest in case of pymetrozine and flonicamid treatments i.e. 32.5% and 35% at 72 HAS. While in case of imidacloprid 100% mortality was recorded and where as 47.5% mortality was recorded in thiamethaxam treatment at 72 HAS. Based on laboratory study results as shown by less mortality by pymetrozine and flonicamid are relatively safe to predators.

The feeding potential and fecundity of coccinellids *Coccinella* sp. grubs on insecticide treated aphids were studied. In the all sprayed treatments non-feeding/ cessation behavior of cocccinellids was observed upto 72 hr after spray and it was due to the sprayed chemicals having negative or antagonstic influence on predator feeding potential. In case of untreated control, the feeding potential was observed to be 15.25±2.05, 28.00±2.04 and 40.75±0.75 at 24, 48 and 72 hrs, respectively after spray and no fecundity was observed in all the treatments **(Table 112).**

Table 112. Impact of contaminated prey (Tobacco aphid, *M. nicotianae*) on mortality of insect predator (*Coccinella* sp.)

Treatments	Per cent mortality of Coccinellid		
	After 24h	**After 48h**	**After 72h**
Imidacloprid@2.5ml/10lit	62.5(52.31)	100(90.00)	100(90.00)
Thiamethoxam@3g/10lit	0(0.00)	37.5(36.90)	47.5(43.32)
Pymetrozine@4g/10lit	0(0.00)	27.5(31.38)	32.5(34.48)
Flonicamid@4g/10lit	0(0.00)	32.5(34.48)	35(35.98)
Control	0(0.00)	0(0.00)	0(0.00)
S.Em.±	1.26	3.57	3.87
C.D. at 5%	3.84	10.86	11.77

Figures parenthesis are arc sin transformed values

OIL SEEDS

13. MUSTARD

13.1 Bioefficacy of entomopathogenic fungus against mustard aphid (AAU- J)

13.1.1 AAU-Jorhat

Experimental details:
Location: ICR Farm, AAU, Jorhat
Target pests: *Lipaphiserysimi*
Plot Size: 5m ×5.5 m
Variety: TS-38
Replication: 4 RBD
Treatment: 6
Date of planting: 30-11-2018
Fertilizer dose: 120:60:60 kg N: P: K/ ha
Date of harvesting: 05-03-2019

Treatment details:
Treatments:
T1: *Beauveria bassiana* (AAU-J Culture) @1×10^8 conidia/g – 5 g/lit
T2: *Metarhizium anisopliae* (AAU-J Culture) @1×10^8 conidia/g – 5 g/lit
T3: Lecanicillium lecanii (AAU-J Culture) @1×10^8 conidia/g – 5 g/lit
T4: *Lecanicillium lecanii* (NBAIR Culture) @1×10^8 conidia/g – 5 g/lit
T5: Azadirachtin 1500 ppm @ 2 ml/l
T6: Dimethoate 30EC @ 0.06% (Standard check)
T7: Untreated control

Field experiment was conducted to evaluate the efficacy of entomopathogenic fungus against mustard aphid during *rabi*, 2018-19. Three sprays of entomopathogenic fungus, neem based pesticides (aazadirachtin 1500 ppm) and chemical insecticides (dimethoate 30EC) as standard check were made at 10 days interval starting from 25 DAS. Observations of aphid population on 10 cm apical twigs per plant from 10 randomly selected plants of each treatment were recorded 1 (one) day before and at 3, 7 and 10 days after each spraying. Yield data was recorded per plot basis and converted into quintal/ha.

Table 113. Evaluation of different entomopathogenic fungi against mustard aphid, *Lipaphiserysimi*

Treatments	Pre count	Post treatment count *			Mean of 3 sprays	Reduction over control (%)	Yield (q/ha)
		Ist spray	IInd spray	IIIrd spray			
T1: *B.bassiana* (AAU-J Culture) 10^8 @ 5g/l	23.78	14.73^c	11.85^c	8.60^b	11.73^{bc}	58.56	7.23^{ab}
T2: *M.anisopliae* (AAU-J Culture)10^8 @ 5g/l	23.88	15.35^c	13.38 d	10.73^c	13.15^c	53.54	6.94^{ab}
T3: *L.lecanii* (AAU – J Culture)10^8 @ 5g/l	24.4	13.23^b	10.43^b	9.80^{bc}	11.15^b	60.61	7.19^{ab}
T4: *L.lecanii* (NBAIR Culture)10^8 @ 5g/l	24.67	12.58^b	9.90^b	8.18^b	10.22^b	63.90	7.50^a
T5: Azadirachtin 1500 ppm @ 2 ml/l	24.30	14.03^{bc}	11.90^c	8.25^b	11.39^{bc}	59.76	6.65^b
T6: Dimethoate 30EC @ 2 ml/l	24.03	8.73^a	7.50^a	4.98^a	7.07^a	81.27	7.60^a
T7: Untreated control	23.75	29.68^d	30.85^e	24.40^d	28.31^d	-	5.44^c
CD =0.05	NS	1.89	1.11	2.05	1.84	-	0.74
CV %	-	8.21	5.45	12.89	7.77	-	7.15

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

Results:

The results in the **Table 113** indicated that all the treatments were significantly superior in suppressing the aphid population over untreated control plot. While comparing the mean number of aphid population among the treatments after third spray, it was observed that dimethoate 30EC @ 2ml/lit at 10 days interval was the best in suppressing the aphid population (7.07 per 10 cm apical twig) in comparison to other treatments wi th highest yield of 7.60q/ha. However, amongst the entomopathogenic fungus, *Lecanicillium lecanii*(NBAIR culture) @ 5g/lit was the next best treatment (10.22 per 10 cm apical twig) with next higher yield of 7.50 q/ha and it was, found to be at par with *L.lecanii*(AAU-J Culture)and *Beauveria bassiana* (AAU-J Culture)@ 5g/lit in their efficacy in respect of mean population ofaphid (11.15 and 11.73 per 10 cm of apical twig) and with yield (7.19 and 7.23 q/ha). The minimum yield of mustard (5.44 q/ha) was recorded in untreated control plot with maximum number of aphid population of 28.31 per 10 cm apical twig.

However, the insecticidal check treatment, dimethoate 30 EC @ 2ml/lit brought about maximum per cent reduction of aphid population (81.27) followed by *L. lecanii* (NBAIR culture) and *L. lecanii*(AAU-J culture) @ 5g/lit with 63.90 and 60.61% over untreated control, respectively.

14. GROUNDNUT

14.1 Large scale demonstration of bioagents based IPM module for whitegrub in groundnut (AAU-Anand)

Objectives: To demonstrate bioagents IPM module for whitegrub management in groundnut
Year of commencement: 2018-19
Location: Farmers field of Mahuva and Una taluk, Bhavnagar district
Area: 100 ha
Methodology/module components:
Deep summer ploughing and heavy pruning of trees before onset of monsoon
On the onset of monsoon border trees of the field were sprayed with imidacloprid (7ml/10 lit water) and chlorpyrifos (20 ml/ 10lit water)
Enrichment of FYM with bio-pesticides; *Beauveria bassiana* and *Metarhiziumanisopliae*5 kg each/ha
Seed treatment with chlorpyrifos (20EC) @ 25 ml/ kg of seeds
Bio-pesticides were applied as soil application prior sowing.
Observations recorded:
Larval population/ meter length row near root zone in treated blocks and untreated blocks (entire block was divided into 50 sub blocks and from each block 2 samples were collected)
Yield/ha (collected same as above)
Collaboration:
NGO Gram NirmanSamaj (Devaliya)
TKF (Triveni Kalyan Foundation) Mahuva
APMC, Mahuva. Bhavnagar District, Gujarat

Table 114. Impact of IPM on larval population of whitegrub and yield of groundnut crop

Treatments	Larval count/ meter length row	Yield (kg/acre)
IPM module	0.43 ± 0.53	912.94 ± 30.77
Farmers' practice/ Untreated	1.60 ±0.93	623.46 ± 38.45
z-test	*	*
z-cal	7.5	-28.31
z-table (0.05)	1.96	1.96
P value	<0.0001	<0.0001

Results:

Large scale demonstration was conducted in *kharif* 2018-19. Significant difference was observed between IPM module and farmers' practices. Lower incidence of whitegrub was noticed in IPM module compared to farmers' practice block and similarly the higher yield in IPM module. It can be concluded that adoption of bioagents based IPM module will be useful for the effective management of whitegrub menace in groundnut crop (**Table 114**).

FRUIT CROP

15. BANANA

15.1 Bio-efficacy of entomopathogens against Banana fruit and leaf scarring beetles, *Nodostoma subcostatum* (AAU- Jorhat)

Experimental details:
Location: Farmers' field, Samaguri, Nagaon
Target pests: Banana fruit and leaf scarring beetles, *Nodostoma subcostatum*
Plot size: 1000 m^2
Variety: Cavendis (CV-Jahaji)
Replication: 4 RBD
Plot size: 7m ×7.5 m
Date of planting: Newly planted crop (02.03.2018)
Fertilizer dose: 110:33:330 g N: P: K/ plant

Treatment details:
T1: Four spray of Neem product (azadirachtin, 1500 ppm) @ 5ml/lit
T2: Four time filling of Leaf axil with *Beauveria bassiana* (AAU culture @ 10^8spore), 5 ml/l
T3: Four spray of *Beauveria bassiana* (AAU culture) @ 10^8spore) 5 ml /lit
T4: Bunch covering with plastic bags.
T5: Sprays chlorpyrifos 20EC @ 2.5 ml/lit
T6: Untreated control

Observation:
Observations on mean number of scarring beetle by selecting 5 plants randomly (beetles present on leaves and those hidden inside the crown) was recorded at 3, 7 and 10 days after treatments. Number of infested fingers per bunch was also recorded for per cent finger infestation. Four rounds of entomopathogenic fungi, Neem and chemical insecticides (chlorpyrifos 20EC) were applied at 15 days interval.

Table 115. Bioefficacy of entomopathogen against *Nodostoma subcostatum* (beetles/plant)

Treatments	Pre treatment count	Post treatment count *				Mean of 4 sprays	Reduction over control (%)
		1st spray	2nd spray	3rd spray	4th spray		
T1: Neem product (azadirachtin) @ 5ml/lit	16.25	16.75[bc]	13.75[b]	9.75[b]	6.75[c]	11.75[b]	31.64
T2: Filling leaf axil with *B. bassiana* (AAU Culture) @ 10^8 spore / ml	15.75	15.75[b]	12.75[b]	8.25[b]	5.25[ab]	10.50[b]	38.91
T3: Spray of *B. bassiana* (AAU Culture) @ 10^8 spore / ml	16.25	16.00[b]	13.00[b]	9.00[b]	5.50[ab]	10.88[b]	36.70
T4:Bunch covering with plastic bags	15.50	11.75[a]	8.75[a]	4.75[a]	4.00[ab]	7.31[a]	57.47
T5:Chlorpyrifos 20EC @ 2.5 ml/l	15.75	12.75[a]	9.75 [a]	5.75[a]	3.25[a]	7.88[a]	54.15
T6:Untreated control	16.00	17.75[c]	17.00 c	19.25[c]	14.75[d]	17.19[c]	-
CD =0.05	NS	1.71	1.78	1.66	1.67	2.54	-
CV %		7.50	9.47	11.68	16.87	15.46	-

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

Table 116. Bioefficacy of entomopathogen against *Nodostoma subcostatum*

Treatments	Mean fruit infestation (%)
T1: Neem product (Azadiractin) @ 5ml/lit	15.25[c]
T2: Filling Leaf axil with *Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	13.18[c]
T3: *Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	14.63[c]
T4: Bunch covering with plastic bags	10.53[b]
T5: Chlorpyrifos20Ec @ 2.5 ml/l	6.37[a]
T6: Untreated control	20.52[d]
CD =0.05	2.61
CV %	12.93

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

Results:

The data recorded on mean number of beetles per plant **(Table 115)** revealed that the efficacy of *B.bassiana*, Azadirachtin 1500 ppm, bunch covering with plastic bags and spray of chlorpyrifos 20 EC were equally effective in reducing the leaf scarring beetle / plant after fourth spray in comparison to untreated control plot. However, amongst the different treatments, bunch covering with plastic bag was the best treatment in suppressing the population of beetles (7.31/ plant) followed by spraying of chlorpyrifos 20 EC @ 2.5 ml/lit ,where the beetle population was 7.88/ plant and both the treatments were at par in their efficacy. The highest per cent reduction of 57.47 was also recorded in bunch covering with plastic bags treatment over untreated control plots followed by chlorpyrifos 20 EC @ 2.5ml/lit with 54.15. However, application of *B. bassiana* (AAU culture) as leaf axil filling and spray @ 5ml/lit and azadirachtin 1500 ppm @ 5 ml/lit showed no significant differences amongst them in reducing the population of scarring beetle in both fruit and leaf (10.50 10.88, 11.75 beetles/plant). Highest number of beetles (17.19/ plant) was registered in untreated control plot. The mean fruit infestation by scarring beetle varied significantly in different treatments **(Table 116)** and recorded lower level of fruit infestation (6.37%) treated with chlorpyrifos 20EC @ 2.5 ml/l followed by bunch covering with plastic bag (10.53%). Maximum number of fruit infestation 20.52% was recorded at untreated check.

16. PAPAYA

16.1: Monitoring and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts (AAU- A, TNAU)

16.1.1. AAU- Anand

Objective: To study the incidence and outbreak of papaya mealybug in Gujarat State

Work carried out during current year:

Survey for ascertaining the outbreak of papaya mealybug was carried out in farmers' fields of Anand district during the year 2018-19.

The samples of papaya mealy bug and infested papaya fruits were brought to the laboratory and reared on sprouted potato.

Methodology:

Survey was conducted in randomly selected villages of Anand district to record the infestation of papaya mealybug *P. marginatus*.

Farmers' fields were visited once in a month.

Percentage of plants infested with mealybug was assessed by observing 25plants randomly and intensity of damage was determined.

Observations recorded:

Crop plants infested.

Non hosts crop and weeds infested

Chemical pesticides if any used with dose

Anticipated yield loss / ha (crop - wise)

Existing natural enemies in 25 randomly selected plants

Results:

The intensity of papaya mealybug infestation was ranged between **Nil** to **Low**.

The parasitoid *viz*., *Acerophagus papayae* was noticed parasitizing mealybug.

16.1.2 TNAU, Coimbatore

The infestation of *Paracoccusmarginatus* was noted in crops like papaya, tapioca, mulberry, guava, brinjal and cotton. The incidence of papaya mealybug was recorded in Coimbatore, Erode, Tiruppur, Salem, Karur, Villupuram, Karur, Cuddalore and Namakkal districts of Tamil Nadu. The prevalence was high in Erode, Tiruppur and Coimbatore. The occurrence of this pest was observed from August to December, 2018 in Erode, Tirupur, Coimbatore and Karur districts. It was also observed that the papaya mealy bug parasitoid *Acerophagus papayae*, has widely spread and established in papaya and cassava crops inTamil Nadu. Natural predators like, *Cryptolaemus montrouzieri*, *Spalgiusepius* and *Malladaigorotus* were also noted.

17. MANGO

17.1 Effect of bio pesticides for management of mango hoppers pests *Idioscopus* sp. in field condition (DRYSRUH, CISH)

17.1.1 DRYSRUH, Ambajipeta

Objectives

To evaluate different formulations of biopesticides along with chemical and botanical insecticides against mangohopper, *Idioscopus* sp.

Experimental Details

Orchards with a 50-100 trees are to be selected. The selected blocks were isolated from each other since hoppers are migratory

Treatment details:

Treatments	Dosage	Source/ strain
T1- *Beauveria bassiana*	5 g/l	AnandAgril. University (Source of Strain NBAIR-Bb-5a)
T2- *Metarhizium anisopliae*	5 g/l	AnandAgril. University (Source of Strain NBAIR-Ma-4)
T4- *Lecanicillium lecanii*	5 g/l	ICAR-NBAIR- VI-22
T6- Azadirachtin 10000 ppm	1 ml/l	Commercial
T5- Imidacloprid 17.8 SL	0.4 ml/l	Commercial
T7- *Metarhizium anisopliae*	5 g/l	ICAR-NBAIR (Ma-IIHR)
T8-Untreated control	--	-
T3- *Metarhizium anisopliae*	5 g/l	ICAR-NBAIR (Ma-Shiv)

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

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

Results

The experiment was carried out in mango (cv. Totapuri) 7 years old mango tress planted in Bavojipeta village of Gokavarammandal in East Godavari district. The first spray was done on 18/01/2019 and subsequent two sprays were given at weekly intervals. Data on surviving hopper population was transformed into $\sqrt{x+0.5}$ values before subjecting to analysis of variance. After third spray of *M. anisopliae* (AAU) and *Metarhizium anisopliae* (Ma-Shiv) were effective in suppressing mango hoppers to 0.63 hoppers per tree followed by *B. bassiana* (AAU) (0.75 hoppers per tree). However, conventional insecticide, Imidacloprid and botanical insecticide azadirachtin 10000 ppm were effective than the microbial insecticides with zero hopper population and 0.34 hopper/tree, respectively. Among the biopesticide treatments, *L. lecanii* (VI-22) had a high population of hoppers i.e.0.63/ tree after third spray. In untreated control block a high population of mango hoppers ranging from 11.00 to 28.68/tree was recorded consistently **(Table 117**).

Table 117. Field evaluation of bio pesticide formulations against mango hoppers, *Idioscopus* sp. in Andhra Pradesh

S.No.	Treatments	Dosage	Hopper population/ per tree (for 4 inflorescence) 7 days after spray			
			Pre count	1st spray	2nd spray	3rd spray
1	T1- *B.bassiana* (NBAIR-Bb5a)*	5 g/l	7.06 *(2.75)	3.94 (2.09)	1.18 (1.27)	0.75 (1.08)
2	T2- *M.anisopliae* (NBAIR-Ma-4)	5 g/l	7.88 (2.81)	2.88 (1.79)	0.94 (1.15)	0.63 (1.05)
3	T3- *L.lecanii* (NBAIR-VI-22)	5 g/l	10.45 (3.28)	2.94 (1.84)	2.13 (1.62)	1.16 (1.29)
4	T4- Azadirachtin 10000 ppm	1 ml/l	8.25 (2.96)	1.44 (1.35)	0.88 (1.15)	0.34 (0.92)
5	T5- Imidacloprid 17.8 SL	0.4 ml/l	7.44 (2.82)	1.19 (1.24)	0.0 (0.71)	0.0 (0.71)
6	T6- *M.anisopliae* (Ma-IIHR)	5 g/l	7.63 (2.81)	3.44 (1.96)	1.56 (1.47)	0.94 (1.19)
7	T7-*M. anisopliae* (Ma-Shiv)	5 g/l	11.00 (3.25)	5.13 (2.31)	1.06 (1.16)	0.63 (1.05)
8	T8-Untreated control	--	11.00 (3.30)	16.13 (4.05)	23.75 (4.86)	28.68 (5.38)
9	**SEM**		--	0.22	0.33	0.24
10	**CD (5%)**		--	0.64	0.96	0.70

*Fig in parenthesis are $\sqrt{x+0.5}$ transformed values.
AAU-Anand Agricultural University, Ma-IIHR- *Metarhizium anisopliae*-IIHR strain

17.1.2 Bioefficacy of biopesticides for the management of mango hoppers CISH, Lucknow

Results: ongoing experiment

17.2. Bioefficacy of entomopathogenic fungi formulations in suppression of mango leaf webber (CISH, Lucknow)

Variety	:	Dashehari
No. of trees	:	5 trees per treatment
Layout	:	Randomized Block Design.
Treatments	:	*Beauveria bassiana* (CISH culture) @ 1×10^8 spores/g-5g/lit *Beauveria bassiana* (NBAIR-Bb-5a) @ 1×10^8 spores/g-5g/lit *Metarhizium anisopliae* (NBAIR Ma-4) @1×10^8 spores/g-5g/lit EPN formulation (NBAIR) Lambda-cyahalothrin 0.01% (CISH POP) Untreated control
Replications	:	Each tree to serve as replication
Methodology for imposing treatments	:	Soil application and Spray
Methodology and observations	:	Observation were taken at different intervals after application; No of webs/ tree; Natural enemies, if any

Results:

Entomopathogenic fungi *B. bassiana* and *M. anisopliae* formulations were tested against mango leaf webber. Significant difference was found between the treatments at 7 days after the spray. Among the biocontrol agents low incidence of leaf webber was recorded in *B. bassiana* (CISH formulation) and it was on par with the of *M. anisopliae* (NBAIRMa-4) with 5.65 and 5.90 live webs/tree, respectively. At 21 DAS, *B. bassiana* (CISH formulation) and *B. bassiana* (NBAIR-Bb-5a) were found effective in reducing the leaf webber incidence significantly (**Table 118**).

Table 118. Bioefficacy of entomopathogenic fungi against mango leaf webber during2018

Treatments	Mean number of live webs/tree			
	Before spray	7 DAS	15 DAS	21 DAS
B. bassiana (CISH) 1×10^8 @5g/lit	10.85 (3.77)	5.65[ab] (2.84)	4.15[a] (2.53)	2.35[a] (1.85)
B.bassiana (NBAIR) 1×10^8 @ 5g/lit	14.81 (4.26)	6.75[b] (3.01)	4.43[a] (2.54)	3.56[a] (2.35)
M. anisopliae (NBAIR) 1×10^8 @5g/lit	17.15 (4.57)	5.90[ab] (2.91)	6.50[a] (3.00)	6.02[ab] (2.95)
Lambda-Cyahalothrin @ 0.1%	14.45 (4.26)	1.7[a] (1.79)	3.3[a] (2.29)	1.55[a] (1.27)
Untreated control	14.08 (4.24)	11.91[c] (3.94)	10.83[b] (3.77)	9.58[b] (3.54)
LSD (0.01)	14.47	6.18	5.50	6.10

DAS- Days after spraying; Values in the parenthesis are square root transformed $\sqrt{x+0.5}$; same letters in the column are not significantly different using Tukey's test at $P< 0.05$.

17.3 Habitat manipulation for conservation of bio-agents for management of mango insect pests (CISH, Lucknow).

Results: ongoing experiment

17.4 Field Evaluation of anthocorid predator, *Blaptostethus Pallescens* for mango thrips (CISH, Lucknow).

Results: Experiment will be conducted in current season

17.5 Management studies for inflorescence thrips on mango with biopesticides in field conditions (DRYSRUH, Ambajipeta)

Objectives

To evaluate different formulations of biopesticides along with chemical and botanical insecticides against mangothirps, *Scirtothrips*spp.

Experimental Details

Selection of mango orchard for spraying experiment. Orchards having about 50- 100 trees are to be selected.

Treatment details:

Treatments	Dose	Source/ Strain name
T1- *Beauveria bassiana*	5 ml/l	AnandAgril. University(Source of Strain NBAIR-Bb-5a)
T2- *Metarhizium anisopliae*	5 ml/l	AnandAgril. University(Source of Strain NBAIR-Ma-4)
T3- *Lecanicillium lecanii*	5 ml/l	ICAR-NBAIR (VI-22)
T4- Azadirachtin 10000 ppm	5 ml/l	Commercial
T5- Fipronil 5SC	2 ml/l	Commercial
T6- *Metarhizium anisopliae*	5 g/l	ICAR-NBAIR (Ma-IIHR)
T7- Untreated Control	-	-

Frequency of spray: Weekly (a total of three/ four sprays) (with the incidence of thrips-first generation).

Observations: Thrips population on different time intervals (nymphs and adults) by counting single tap of shoot or panicle on whitepaper on 10 panicles per tree at standing height of tree on a day before spray and 7th, 14th, 21st and 28th day after spray.

Results

The experiment was carried out in 7 year old mango garden (cv. Totapuri) in Bavojipeta village of Gokavarammandal in East Godavari district. The first spray was done on 28/02/2019 and subsequent two sprays were given at weekly intervals. Data on surviving thirps population was transformed into $\sqrt{x+0.5}$ values before subjecting to analysis of variance. After third spray, fipronil treated trees had a low mean thrips population of 2.13

followed by *M. anisopliae* (Ma-IIHR), azadirachtin 10000 ppm, *M. anisopliae* (AAU) and *B. bassiana* (AAU) with 2.75, 3.25, 6.06 and 6.25 thrips per tree, respectively. Among the bio-pesticide treatments, *L. lecanii* (VI-22) had a high thrips population of 7.75 thrips/tree after third spray. In untreated control block a high population of mango thrips ranging from 16.25 to 31.25/ tress was recorded consistently (**Table 119**).

Table 119. Field evaluation of bio pesticide formulations against mango thrips

Treatments	**Dosage**	**Average number of thrips per 10 panicle per tree**			
		Pre count	1st spray	2nd spray	3rd spray
T1- *B.bassiana* (NBAIR-Bb5a)	5 ml/l	11.96 *(3.53)	9.23 (3.12)	7.88 (2.86)	6.25 (2.52)
T2- *M.anisopliae* (NBAIR-Ma4)	5 ml/l	11.00 (3.39)	8.63 (2.94)	7.19 (2.58)	6.06 (2.49)
T3- *L.lecanii*(NBAIR-VI-22)	5 ml/l	10.06 (3.25)	9.00 (3.03)	8.56 (2.97)	7.75 (2.76)
T4- Azadirachtin 10000 ppm	5 ml/l	12.53 (3.61)	7.06 (2.59)	5.31 (2.35)	3.25 (1.88)
T5- Fipronil	2 ml/l	11.19 (3.43)	6.63 (2.66)	3.06 (1.86)	2.13 (1.62)
T6- *M.anisopliae*(Ma-IIHR)	5 g/l	10.99 (3.39)	6.81 (2.62)	4.75 (2.19)	2.75 (1.77)
T7 -Untreated control	-	12.60 (3.62)	18.00 (4.27)	24.00 (4.93)	31.25 (5.61)
SEM	-	-	0.32	0.32	0.33
CD (5%)	-	-	0.96	0.97	0.99

*Fig in parenthesis are √x+0.5 transformed values.AAU- Anand Agricultural University, Ma-IIHR= *Metarhizium anisopliae*-IIHR strain.

18. GUAVA

18.1 Field evaluation of bio-management inputs against root-knot nematode in guava (CISH)

Variety	:	Allahabad Safeda
No. of replicates		10 seedlings per treatment
Layout	:	Randomized Block Design
Treatments	:	Untreated uninoculated Untreated inoculated Inoculated + carbofuran noculated + Neem cake Inoculated + CISH *Trichoderma*
Replications	:	Each seedling to served as replication
Methodology for imposing treatments		Soil application
Methodology and observations	:	Seeds of guava cv. Allahabad Safeda will be raised in sterilized soil: FYM (7:3) mixture. Thirty day old seedlings will be transplanted in sterilized soil FYM (9:1) mixture. Treatments were applied 7 days before transplantation and inoculation of nematode (J2 = 1000/ pot). Observations regarding plant growth parameters and galling on roots were recorded 120 days after inoculation.

Results:

Data indicated that two treatments Neem cake @ 50g/ 2 kg soil and CISH-Biopesticide @ 50g/ 2 kg soil were the best treatments which significantly reduced root-knot index and increased plant growth as compared to controls. Carbofuran applied @ 50 mg/ 2 kg soil was probably much lower dose and was found ineffective (**Table 120**).

Table 120. Efficacy of bioagents against root-knot nematode in guava

Treatments	Shoot Length	Root length	Shoot weight	Root weight	RKI
Untreated uninoculated	10.72^{cd} (3.77)	17.24^{b} (4.63)	0.70^{d} (1.34)	0.30^{ab} (1.05)	0.00^{a} (0.50)
Untreated inoculated	4.88^{a} (2.69)	10.36^{a} (3.70)	0.16^{a} (0.90)	0.20^{a} (0.94)	3.55^{c} (2.38)
Carbofuran inoculated	6.34^{a} (3.01)	11.04^{a} (3.75)	0.24^{ab} (0.99)	0.30^{ab} (1.04)	3.20^{c} (2.29)
Neem cake inoculated	12.42^{d} (4.02)	16.88^{b} (4.59)	1.42^{f} (1.69)	0.82^{d} (1.41)	0.65^{b} (1.24)
CISH-Bioagent inoculated	8.20^{b} (3.36)	9.80^{a} (3.61)	0.40^{bc} (1.13)	0.40^{bc} (1.13)	3.20^{c} (2.29)
CISH-Biopesticide inoculated	9.82^{bc} (3.63)	12.28^{ab} (4.00)	1.02^{e} (1.51)	0.54^{c} (1.23)	0.25^{ab} (0.94)
LSD (0.01)	1.019	8.425	0.012	0.006	0.090

Values in the parenthesis are square root transformed $\sqrt{x+0.5}$; same letters in the column are not significantly different using Tukey's test at $P< 0.05$.

On the basis of this preliminary study, we conclude experiment may be repeated with Neem cake @ 50g/ 2 kg soil, CISH-biopesticide @ 50g/ 2 kg soil, carbofuran @ 100 and 200 mg/ 2 kg soil alongwith few additional treatments (to be decided by PC).

19 APPLE

19.1 Integrated Pest Management of apple codling moth, *Cydia pomonella* (SKUAST, Srinagar)

The present experiment was conducted in Kargil during 2018 with tabulated details of treatment. As the mating disruption pheromone could not be made available from ATGS, Hyderabad, treatment T1 was therefore replaced with twice use of *Heterorhabditis pakistanense* (NBAIR) to study its efficacy against long term overwintering larvae of Codling moth and also its second use coinciding with first generation mature larvae during 2nd week of June. Remaining treatments T2 to T4 were followed as per technical program (2018-19) from NBAIR. Following four locations of Kargil districts were selected to carry out the experiment.

Treatments	Orchards	Details of treatments
T1	Hardas	2.0 spray of *H. pakistanense*
T2	Mingy	Release of *T. cacoeciae* @2.5 lakh/ha. (4 releases/ season) + Trunk banding+ disposal of infested fruits + Pheromone traps+ spray of *Heterorhabditis pakistanense* (NBAIR)
T3	Shanigund	Farmers practice of the region
T4	Slikchey	Untreated Control

Fifty plants each at all the four locations were provided treatments T1-T3 and data was collected from ten randomly selected plants for per cent fruit damage, per cent reduction over control and larval mortality in response to treatments of *H. pakistanense*. Spray of*Heterorhabditis pakistanense* @ 20.0gm/ litwas provided both during 1st week of May and 2nd week of June 2018. For second spray of T1, trunks of twenty apple trees were banded with gunny bags during first week of June and spray of EPN provided on trunk bands during 2nd week of June 2018. Ten randomly selected plants were examined during ending May 2018 for the EPN induced mortality. For this, twenty five pupae/ tree were examined for larval mortality caused by EPN and per cent mortality determined. In order to obtain larval mortality due to second spray of EPN, the gunny bags were untied and dead or morbid larvae counted after 48 hours of the second spray. Percent larval mortality as a result of both sprays of EPN was calculated out of ten replications. Treatment T2 received a comprehensive approach for the management of codling moth. It included four releases of *T. cacoeciae* @ 2.5 lakh/ ha. coinciding with 1st and 2nd generation of the Codling moth, monitored through pheromone traps. Pheromone traps (AG Bios) @ 4.0 traps/ acre used twice, with first installation of traps during 2nd week of May to June 1st week and second installation during ending June to July 1st week. Traps were checked after every 3 days for presence and numerical density of the moth. Spray of *Heterorhabditis pakistanense* was provided during 3rd week of June after trunk banding of the apple tree. Dropped infested fruits in T2 were regularly collected and disposed off. Treatment T3 consisted of use of one spray of chlorpyrifos 20 EC @ 1.0 ml/ lit. provided to about fifty fruit bearing trees at fruitlet stage of apple. Treatment T4 served as untreated control.

Data on fruit damage, both on tree as well as dropped fruits under the trees were taken from ten randomly selected plants and converted to percent. Average fruit damage was calculated for the comparison of different treatments. Percent reduction in damage over control for each treatment was determined.

Overall fruit damage in treated orchards during 2018 **(Table 121)** varied from 40.23 to 67.47% as compared to untreated control (84.24). Differences among treatments in relation to fruit damage on tree (F= 86.64**; d.f.=3,27; p= 0.00), dropped fruits (F=26.23**, d.f.= 3,27; p= 0.00) as well as overall fruit damage (F= 79.19**;d.f.= 3,27; p= 0.00) were found statistically significant, when data was analyzed through one way ANOVA. Per cent reduction in damage over control ranged 19.39 to 52.31, which was also worked out to be statistically significant for treatments (F= 34.85**;d.f.= 2,18; p= 0.00). In present experiment, T1 (2.0 spray of *H. pakistanense*) showed as good result as T3 (one spray of chlorpyrifos 20 EC @ 1.0 ml/ lit. of water) in terms of overall fruit damage and also per cent reduction in damage over control. Per cent larval mortality caused by 1st and 2nd spray of *H. pakistanensis* during May and July' 18 was 13.2 and 53.24 respectively. Difference in per cent larval mortality during both the period was found statistically significant (t= 6.56 P=0.0000, d.f.= 15)when compared through Student's *t*-test.

Higher larval mortality during July is attributed to higher temperature and maximum exposure to IJ whereas during the month of May' 2018 the larvae were well protected under silken covering or pupal cocoon, besides the low temperature during night. Treatment T2 however indicated its supremacy over other treatments and indicated an all-inclusive approach as best for the management of codling moth, *Cydia pomonella* in Kargil.

Table 121. Effect of different treatments on apple fruit damage by codling moth, *Cydia pomonella* in Kargil, during 2018-19

Location	Damage on tree (%)	Dropped fruits (%)	Overall fruit damage (%)	% reduction in damage over control
(T1) Kirkichoo	44.40 (41.82)[c]	90.55 (72.83)[b]	67.47 (55.37)[b]	19.39 (25.16)[a]
(T2) Mingy	9.15 (17.15)[a]	71.31 (57.92)[a]	40.23 (39.33)[a]	52.31 (46.33)[b]
T3 Shanigund	37.81 (37.83)[b]	91.30 (73.54)[b]	64.55 (53.51)[b]	22.80 (27.84)[a]
(T4) Control Slikchey	72.97 (59.10)[d]	95.51 (77.86)[c]	84.24 (66.93)[c]	--
C.D.(0.05)	**4.45**	**4.09**	**3.06**	**4.78**
CV (%)	**60.60**	**13.13**	**26.45**	**55.26**

Values in parentheses are arc sin transformations; similar alphabets in a column indicate values statistically on par; each figure represents mean of 10 replications.

Where T1=Use of *H. pakistanense* during early May and ending June; T2=two sequential releases of *T. cacoeciae* + trunk banding + pheromone trapping, disposal of dropped fruits + use of *H. pakistanense* : T3= one spray of chlorpyrifos 20 EC @1.0 ml/lit.; T4= Untreated Control

19.2 Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite *Panonychus ulmi* and two spotted spider mite, *Tetranychus urticae* on apple (SKUAST, Srinagar)

Weekly observations were made on the field population of European red mite, *Panonychus ulmi* from May' 2018 on red delicious apple variety in the high density apple orchards of the University campus of SKUAST-K. Only motile stages of mites were taken into account for observation. Unlike previous year, population build up necessitating treatments were observed from beginning of August. Four different apple blocks, isolated by about 50 meters each, were selected for four different treatments. Observations were taken from a total of ten plants replicated thrice from each block. Twelve leaves from each plant, four each from top, middle and lower region of the plant were plucked for recording number of motile stages of mites. This included both larval to mature stages of mites. A total of 36 leaves were observed for each treatment both after 3rd day and 7th day of treatments. Two releases of 8-10 days old nymphs of anthocorid bugs, *Blaptostethus pallescens* were made on ten plants@ 200 (T1) and 400 (T2)/ plant. Treatment T3 comprised one spray of University recommended acaricide, fenazaquin 10EC @0.4 ml/lit. Treatment T4 served as untreated Control. Data on number of motile stages of mites was recorded after three and seven days of treatments. Mite count was done in the field itself under binocular. The data was replicated three times and compared with T3 and T4. The culture of anthocorid bugs, *B. pallescens* was received from NBAIR, Bengaluru and mass multiplied in the Bio control laboratory of Division of Entomology, SKUAST-K.

Unlike 2017, insignificant population was observed during the months of June- July during 2018, which increased gradually from August. Average population of European red mite (only the motile stages) *P. ulmi* in untreated check (T4) was 14.33 and 19.66^{-leaf} on 3DAT and 7 DAT respectively, with mean population of 17.0^{-leaf} **(Table 122).** Two releases of bugs @ 200 $^{-plant}$ (T1), indicated average number of mites as 12.83 and 10.94 at 3DAT and 7DAT respectively with mean population of 11.88 mites^{-leaf}. In treatment T2 which involved two release of 400 bugs/plant, average number of mites was recorded as 10.69, and 8.38 at 3DAT and 7DAT respectively, with mean population of 9.54 mites^{-leaf}. One chemical spray of fenazaquin 10 EC @0.4 ml/lit. (T3) showed 1.27, 3.33 and 2.30 mites$^{-leaves}$ on 3DAT, 7DAT and mean population respectively).

Comparison of data indicated a significant difference in mites' population, in response to treatments, both on 3 DAT (F= 470.20**, d.f.= 3(129), p= 0.000), 7 DAT (F= 205.06**, d.f.= 3(129), p= 0.000) and mean of the two periods (F= 839.46**, d.f.= 3(41), p= 0.000), when compared through one way ANOVA. Comparison of data for T1 and T2 through Student's *t*- test indicated non significant difference (t= 1. 18 NS p=0.24 df=284). Mite's population in relation to field releases of anthocorid bugs was worked out as significantly negatively correlated(r= -0.86**). Per cent reduction in mites population^{-leaf} over control for treatments T1, T2 and T3 was worked out as 29.88, 43.67 and 83.44, respectively **(Table 122).**

Field survival ability of anthocorid bug, *Blaptostethus pallescens*

Percent field survival ability of released predator @ 200 and 400 bugs/plant after 24, 48 and 72 hrs. of release was 12.36, 5.64 and 1.0 when released @ 200 nymphs/ plant and 21.41, 8.25 and 2.75% when released @ 400 bugs/plant, respectively **(Table 123).**

Two spotted spider mite *Tetranychus urticae* on apple

Data on impact of field releases of anthocorid bugs, *Blaptostethus pallescens* and one spray of fenazaquin against two spotted spider mite, *Tetranychus urticae* was also taken simultaneously while recording data on European red mite, *Panonychus ulmi*, in response to different treatments.

Average, population of two spotted spider mites (only the motile stages) on 3DAT, 7DAT and mean of the two periods for untreated check (T4) was 8.58, 11.25 and 9.91^{-leaf} respectively. In response to treatments @ 200 bugs/ plant (T1), average population was 6.63, 3.50 and 5.06^{-leaf} on 3DAT, 7DAT and mean of the two periods, respectively. Release of 400 bugs/ plant (T2) showed average population as 4.22, 2.27 and 3.25^{-leaf} on 3DAT, 7DAT and mean of the two periods respectively. One spray of acaricide fenazaquin 10 EC @ 0.4 ml/lit. of water (T3) indicated average population of mites (only motile stages) as 0.38, 1.47 and 0.93 on 3DAT, 7DAT and mean of the two periods respectively **(Table 124).**

Differences in number of mites among in response to treatments were found statistically significant on 3DAT (F= 384.33**, d.f.= 3(129), p= 0.000) 7 DAT(F= 160.70**, d.f.= 3(129), p= 0.000) and mean of the two periods (F= 294.61**, d.f.= 3(129), p= 0.000), when analyzed through one way ANOVA. Data of T1 and T2 when compared through Student's t- test yielded non significant difference (t= 0.90 NS; P=0.37, DF= 285). However cumulative effect of field release of anthocorid bugs indicated a significant negative correlation with decline in population of mites on apple (r= -0.79**). Per cent reduction in mites population^{-leaf} over control, for treatments T1, T2 and T3 was worked out as 48.83, 59.99 and 88.45, respectively. Per cent reduction ranging 29.88 to 43.67 in case of European red mite, *Panonychus ulmi* and 48.83 to 59.99 in case two spotted spider mite, *Tetranychus urticae* in response to releases of anthocorid bugs at above mentioned doses indicated field efficacy of the bugs against both the mites infesting apple in Kashmir.

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Table 122. Impact of field release of *Blaptostethus pallescens* against *P.ulmi* in High density apple in Kashmir during 2018

Treatment	No. of mites/ leaf		Mean population	% reduction in pop. over control
	3rdDAT	7thDAT		
200 bugs/plant(T1)	12.83 (3.57)^{c}	10.94 (3.31)^{c}	11.88 (3.44)^{c}	29.88
400bugs/ plant (T2)	10.69 (3.26)^{b}	8.38 (2.86)^{b}	9.54 (3.08)^{b}	43.67
Fenazaquin @ 0.4 ml/lit. (T3)	1.27 (1.28)^{a}	3.33 (1.88)^{a}	2.30 (1.50)^{a}	83.44
Untreated Control (T4)	14.33 (3.78)^{c}	19.66 (4.42)^{d}	17.00 (4.12)^{d}	0.0
CD(0.05)	**0.21**	**0.28**	**0.15**	
CV (%)	**59.39**	**63.81**	**53.09**	

Figures in 1st and 2nd columns represent mean of 36 observations, whereas third column represents mean of 12 observations; figures in parentheses are$\sqrt{n+0.5}$; different alphabetical superscripts in column indicate values statistically significant

Table 123. Field survival ability of *B. pallescens* after release on apple during 2018 at Shalimar

Bugs/plant	% survival ability after		
	24 hrs.	48 hrs.	72.0 hrs.
@ 200 bugs/ plant	12.36	5.64	1.0
@ 400 bugs/ plant	21.41	8.25	2.75

Table 124. Impact of field release of *B.pallescens* against *T. urticae* in high density apple in Kashmir during 2018

Treatment	No. of mites/ leaf		Mean population	% reduction in pop. Over control
	3rdDAT	**7thDAT**		
200 bugs/plant(T1)	6.63 (2.56)^{c}	3.50 (1.84)^{c}	5.06 (2.24)^{c}	48.83
400bugs/ plant (T2)	4.22 (2.04)^{b}	2.27 (1.49)^{b}	3.25 (1.79)^{b}	59.99
Fenazaquin @ 0.4 ml/lit. (T3)	0.38 (0.52)^{a}	1.47 (1.19)^{a}	0.93 (0.94)^{a}	88.45
Untreated Control (T4)	8.58 (2.92)^{d}	11.25 (3.34)^{d}	9.91 (3.14)^{d}	-
CD(0.05)	**0.19**	**0.27**	**0.22**	
CV (%)	**61.12**	**86.71**	**85.18**	

Figures in 1st and 2nd columns represent mean of 36 observations, whereas third column represents mean of 12 observations; figures in parentheses are$\sqrt{n+0.5}$; different alphabetical superscripts in column indicate values statistically significant

19.3 Evaluation of *Trichogramma* spp against apple fruit moth, *Argyresthia conjugella* under laboratory conditions (YSPUHF, Solan)

Trichogramma spp namely *Trichogramma achaeae, T. pretiosum* (thelytokous strain), *T. chilonis, T. pieridis* and *T.embryophagum* were evaluated against apple fruit moth, *Argyresthia conjugella* under laboratory conditions. Moths of the pest were collected under light and kept in insect rearing cages for egg laying on the developing immature apple fruits. The eggs of the moth were exposed to each *Trichogramma* sp separately in glass tubes at the rate of 30eggs per female for 24h.After 24h, the eggs were transferred to another tube and observed for parasitism and emergence of the parasitoid adults. Observations on per cent parasitism, per cent adult emergence, adult longevity and percentage of females emerged were recorded. The results **(Table 125)** reveal that none of the tested *Trichogramma* spp showed satisfactory efficacy against the pest. Maximum parasitisation obtained was only 26.6% which was resulted by *T. embryophagum.* The parasitism resulted by *T. achaeae, T. pretiosum* and *T.chilonis* was 11.1, 12.2 and 17.7%, respectively. *T. pieridis*, however, failed to parasitize the eggs of apple fruit moth. Adult emergence from the parasitized host eggs was 90.9, 72.7, 87.5 and 85% for *T. achaeae, T. pretiosum, T. chilonis* and *T. embryophagum*, respectively, of which 50, 100, 56.3 and 65% were the females. The developmental period was 12.5, 10.9, 11.8 and 12.1; while, the adult longevity was 4.4, 3.9, 3.4 and 4.1 days for the respective species.

Table 125. Evaluation of *Trichogramma* spp against apple fruit moth, *Argyresthia conjugella* under laboratory conditions

***Trichogramma* sp**	**% Parasitism**	**% Adult emergence**	**Adult longevity (days)**	**Developme nt period (days)**	**% females**
T. achaeae	11.1 (19.4)c	90.9 (72.4)a	4.4	12.5	50 (44.9)c
T. pretiosum	12.2 (20.3)c	72.7 (58.5)b	3.9	10.9	100 (90.0)a
T. chilonis	17.7 (24.8)b	87.5 (69.2)a	3.4	11.8	56.3 (48.6)bc
T. embryophagum	26.6 (31.1)a	85.0 (67.2)a	4.1	12.1	65.0 (53.7)b
T. pieridis	0.0 (0.0)	-	-	-	-
CD (p=0.05)	(3.8)	(7.6)	NS	NS	(9.7)

19.4. Management of apple root borer using *Metarhizium anisopliae* (YSPUHF, Solan)

A large scale demonstration on the management of apple root borer, *Dorysthenes hugelii* by using *Metarhizium anisopliae* was laid in apple (cv. Royal Delicious) in Shimla, Sirmaur and Mandi districts covering an area of 5h and 15 orchards. *Metarhizium anisopliae* (10^8 conidia/g) was applied @ 30g/ tree basin mixed in well rotten farm yard manure (FYM) during July- August i.e. at the time of egg hatching and emergence of new/young grubs. Chemical treatment comprising of chlorpyrifos (0.06%) was also applied maintained for comparison. The details of the locations where the demonstrations were laid are given below:

S.No	**Location**	**Number of orchards**
1	Rohru, district Shimla	4
2	Chaupal, district Shimla	2
3	Kotkhai, district Shimla	3
3	Shilai, district Sirmaur	1
4	Rajgarh, district Sirmaur	1
5	Gohar district Mandi	4
	Total	**15**

The observations on the grub mortality and feedback from the farmers were collected during November-December, 2018 at the time of basic preparation.*Metarhizium anisopliae* treatment resulted in 67.8 to 78.4% mortality of the apple root borer grubs in different orchards, while in chlorpyrifos (0.06%) treated plants the grub mortality was 76.4 to 88.6%. It can therefore be concluded that *M. anisopliae* can be used as a substitute for chlorpyrifos for the control of apple root borer, *D.hugelii* in apple.

PLANTATION CROPS

20. COCONUT

20.1 Surveillance of rugose whitefly in coconut and assessing the population of natural biocontrol agents (CPCRI, DRYSRUH, KAU Kumarakom, KAU Thrissur, TNAU, NBAIR)

20.1.1 CPCRI, Kayamkulam

Observations on rugose spiralling whitefly (RSW) incidence was made at monthly intervals from two pest infested gardens at Kayamkulam and one garden at Kasaragod. Five palms were selected at random in each garden for observation. Percentage of leaf and leaflet infested by RSW was recorded *In-situ* from the plot. Detailed data on pest stages and natural enemies was recorded from 20 leaflets collected/plot @ 4 infested leaflets /sample palm.

Kayamkulam

In 10 year old Malayan Green dwarf plantation, about 72% palms were infested with RSW with 29.9% leaf infestation. Percentage leaflet damage/leaf was 27-41% during June-July 2018 and 23.7 to 53.7 during September 2018 to March 2019.
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RSW population ranged from 58-60/leaflet during June and July 2018 with percentage parasitism ranging from 63-68%. RSW were totally wiped out by heavy rains and flood in Alappuzha District, Kerala during August 2018 and build up was observed from September 2018 with 7.3% leaflet damage and 18.46% parasitism by *E. guadeloupae.* Parasitism by *Encarsia guadeloupae* steadily increased from 42-50% during October – November along with increase in pest population **(Table 126& Fig. 20).**

Table 126. Life stages of RSW and parasitism by *E.guadeloupae*

Month	Average Population of RSW (number ± SE/leaflet)				Parasitism by *E.guadeloupae* (%)
	Colony	adult	egg	Nymphs	
June 2018	8.9 ± 1.05	3.1 ± 0.83	41.9±3.35	10.8±1.27	69.5±1.86
July	8.4± 0.77	2.2±0.71	48.4±4.48	7.4±0.66	64.6±1.68
August	0.00	0.00	0.00	0.00	0.00
September	3.3±0.64	1.7±0.69	45.6±4.8	3.1±0.83	18.5±4.69
October	4.4±0.67	2.4±0.74	59.4±5.39	21.5±2.82	42.1±2.66
November	4.2±0.69	2.2±0.69	50.8±3.93	11.5±2.73	50.7±3.50
December	8.7±1.16	3.1±0.67	8.4±3.70	41.9±5.73	23.9±7.54
January 2019	5.3±0.77	1.7±0.54	34.3±6.44	11.0±5.41	47.4±7.69
February	3.9±0.43	7.0±0.84	26.6±2.23	23.2±2.89	38.5±5.20
March	10.9±1.96	2.9±1.99	12.9±3.77	11.1±1.54	40.8 ± 3.84

During December 2018, incidence of nesting whiteflies, *Paraleyrodes bondari* and *Paraleyrodes minei* were observed co-existing along with RSW. The parasitism by *E. guadeloupe* was dropped to 23.8% during December 2018 due to displacement of RSW by nesting whiteflies, which didn't register effective parasitism by aphelinid parasitoids in the field. The nesting whiteflies co-existed with spiralling whitefly and outnumbered RSW during January to March 2019.

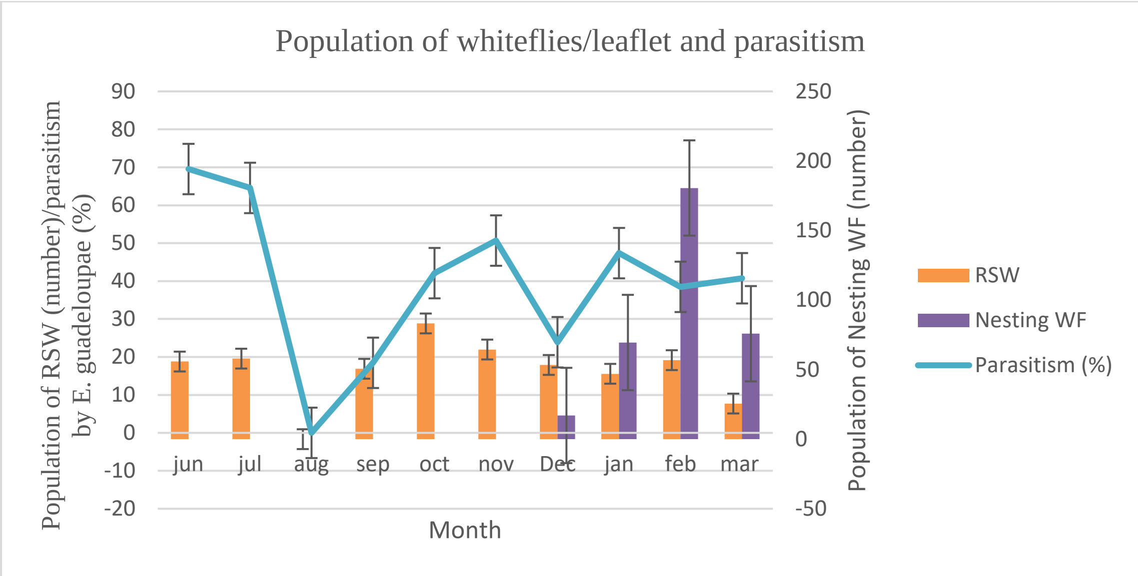
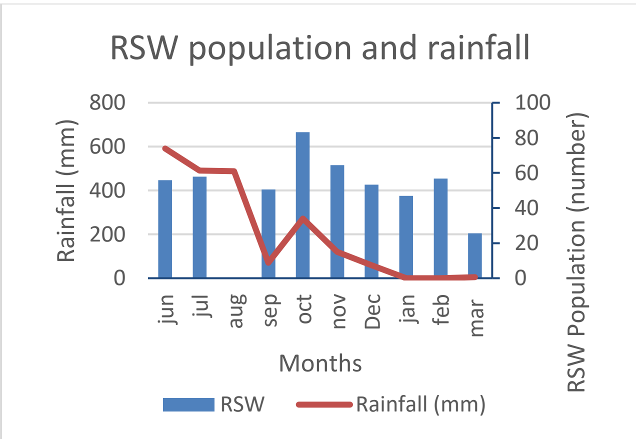


Fig. 20 Seasonal incidence of various whiteflies on coconut palm 2018-2019 and parasitism (%) on RSW

Population of whiteflies showed a decreasing trend with rainy days and total rainfall received per month during 2018-19 at Kayamkulam **(Fig. 21 & 22)**



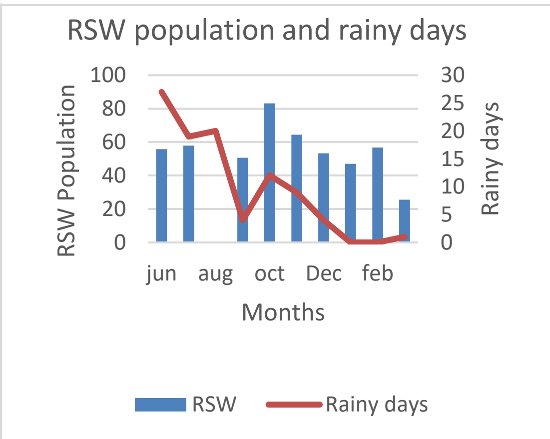


Fig. 21 RSW population and rainfall during 2018-19

Fig. 22 RSW population and rainy days Kasaragod

At monthly intervals, the population of rugose spiralling whitefly was recorded from randomly selected ten leaflets in an unsprayed coconut gardens during October 2017 - December 2018. High nymphal population (164 nymphs/ leaflet) was recorded during March 2018 while low population (7 nymphs / leaflet) was recorded during September 2018. Natural parasitism by *Encarsia guadeloupae* (%) was recorded and it ranged from 15.1 to 72.6 % during this period **(Table 127).**

A low to moderate incidence of new invasive nesting whitefly, *Paraleyrodes minei* was noted on coconut during October 2018 at Kasaragod, Kerala. Biology of *P. minei* was attempted and their survival was found to be of 46.01%. The total life cycle was completed in 23.2±0.83 days. Different host plants recorded are coconut, teak, banyan, mango, jamun and *Terminalia* during January 2019.

Table 127. Population dynamics of RSW on coconut in an unsprayed garden during October 2017- December 2018

Months	Active nymphal population of rugose spiralling whitefly / 10 leaflets (Mean Numbers ± SEM)	Parasitization by *Encarsia guadeloupae* (%)
Oct – 17	76.4 ± 12.7	42.9
Nov -17	100.8 ± 16.8	48.0
Dec -17	118.2 ± 23.4	66.1
Jan – 18	131.6 ± 21.3	65.2
Feb – 18	133.7 ± 31.2	60.8
March - 18	163.7 ± 28.3	58.5
April -18	102.1 ± 28.0	72.5
May - 18	96.9 ±14.0	63.9
June -18	39.3 ± 16.8	52.8
July -18	16.6 ± 6.8	46.7
Aug -18	10.1± 3.8	28.6
Sep -18	7.8± 2.8	33.3
Oct -18	47.1 ± 19.2	11.3
Nov -18	80.3 ± 12.1	17.3
Dec - 18	110.3 ± 17.2	57.4

20.1.2 KAU-Thrissur

Monitoring of rugose whitefly population and their natural enemies was carried out in Thrissur and Palghat districts from October 2018 onwards. Observations were recorded at fortnightly intervals as per approved technical programme. The results on mean whitefly population as well as mean parasitism are presented in **Tables 128 & 129**.

Incidence of rugose whitefly on coconut was more widespread in Thrissur and Palghat districts during 2018-19 compared to previous year. The severity of infestation was high during the early stages but gradually declined towards the end of the study period.

Mean parasitism by *Encarsia guadeloupae*, however, remained relatively low till January 2019 when it crossed 80% in both the locations. Mean parasitism was highest in March 2019.

It can be seen that the RSW infestation broadly followed the pattern observed in 2017-18 as well. However, parasitic activity appeared to be much lower in 2018-2019 taking longer time to reach significant levels, while in 2017-18, 92% parasitism was observed as early as November. Whether the unprecedented floods in Kerala could have had any .bearing on parasitism remain to be investigated.

Another reason that could have contributed to lower values for parasitism could be the presence of one or probably two more species of whiteflies, namely *Paraleurodes bondari* and *P. minei* (reported by CPCRI, Kayamkulam) which are hardly parasitized by *Encarsia guadeloupae.*

Table 128. Severity of infestation and extent of parasitism of rugose whitefly at KVK campus in Thrissur District

Palms	16-10-18		5-11-18		19-11-18		3-12-18		18-12-18		29-1-18		26-2-18		11-3-19		25-3-19	
	Severity	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**
P1	S	28.67	S	30.47	S	4.12	M	61.18	L	66.16	L	81	L	83.33	L	89.2	L	89
P2	H	5.26	S	27.64	H	71.33	L	20.34	L	66.38	L	79.54	L	81.05	L	90	L	91.33
P3	H	0	S	34.56	H	0	M	0	L	11.94	L	80	L	84.12	L	91	L	93.14
P4	H	2.4%	S	0	S	84.07	M	9	L	0	L	89.3	L	91	L	94	L	95
P5	S	14.43%	S	54.27	H	28.83	L	47.77	L	56.81	L	91.12	L	94	L	93.25	L	92.05
Mean parasitism		**10.15**		**29.38**		**37.67**		**27.65**		**40.25**		**84.19**		**86.70**		**91.49**		**92.10**

L: Low (3 infested leaflets /frond); M: Medium (4 to 7 infested leaflets /frond) H: High (>10 infested leaflets/ frond); S (>10 infested leaflets /frond with sooty mould)

Table 129. Severity of infestation and extent of parasitism of rugose whiteflyat Alathur in Palakkad District

Palms	24-10-18		8-11-18		23-11-18		6-12-18		20-12-18		10-1-19		1-2-19		12-2-19		27-2-19		13-3-19	
	Severity	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**	**Severity**	**Mean parasitism (%)**
P1	S	29.11	S	58	S	23.32	M	31.94	L	55.29	L	87	L	89.23	L	89.44	L	90.33	L	86.10
P2	H	14.29	S	53.30	H	32.76	L	33.06	L	48.83	L	88	L	90.33	L	92.15	L	90.20	L	94.33
P3	H	19.08	S	53.86	H	81.03	M	62.41	L	76.37	L	85	L	92	L	92.45	L	87.57	L	90
P4	H	27.07	S	41.05	S	65	M	49.15	L	34.08	L	90	L	94	L	93.37	L	86.15	L	88.15
P5	S	7.12	S	83.55	H	67.68	L	44.77	L	38.30	L	90.15	L	95	L	89.33	L	89	L	94.35
Mean parasitism		**19.33**		**57.89**		**53.95**		**44.26**		**50.57**		**88.03**		**92.11**		**91.34**		**88.65**		**90.58**

Low (3 infested leaflets /frond); M (4 to 7 infested leaflets /frond) H (>10 infested leaflets/ frond); S (>10 infested leaflets /frond with sooty mould)

20.1.3: KAU-Kumarakom

Survey on infestation by rugose spiraling whitefly and parasitism by *E. guadalopae* was conducted at monthly intervals from September 2018 to March 2019 at three locations spread out in three districts (Kottayam, Alapuzha and Ernakulam) of Kerala. High infestation ranging from 53 -73% was observed at Kumarakom **(Table 130).** The highest infestation was during the month of September (73.54%) which later decreased up to 53.60% in December and further increased up to 61.91% during March. At Kumarakom, infestation was seen on the nuts and base of the fronds (Plates 1,2,3,4). Percentage of parasitism by *Encarsia guadalopae* was found to be high in the month of March (42.1%). At Moncompu (Alapuzha district), low to medium infestation ranging from 37 to 51% was observed with percentage of parasitism ranging from 12-58%. At Vyttila percent medium to high infestation which ranged from 44-57% and parasitism by *E. guadalopae* of 27-47% was observed. The infestation of new invasive was observed at Vyttila during November 2018 and in the months it was also observed at Kumarakom and Moncompu also.

Table 130. Severity of infestation and extent of parasitism of rugose whitefly at three different locations (Kumarakom, Moncompu, Vyttila)

Places surveyed	Month	Percentage of infestation	Intensity of damage (%)	Live colonies /leaflet	Severity of infestation	Mean parasitism by *E. guadalopae* (%)
Kumarakom	Sep-18	73.54	64.76	40.63	High	-
	Oct-18	54.34	46.71	31.02	High	-
	Nov-18	57.40	56.61	33.67	High	37.10
	Dec-18	53.61	59.08	29.51	High	19.90
	Jan-19	54.73	67.63	35.50	High	40.39
	Feb-19	57.63	52.23	35.04	High	34.51
	Mar-19	61.91	50.81	31.10	High	42.10
Moncompu	Oct-18	40.43	24.39	12.25	Medium	-
	Nov-18	51.94	31.40	11.45	Medium	-
	Dec-18	40.60	27.15	9.20	Low	12.65
	Jan-19	37.72	48.57	14.45	Medium	57.93
	Feb-19	41.83	32.97	9.05	Low	36.05
	Mar-19	44.37	37.13	12.50	Medium	-
Vytilla	Oct-18	44.41	25.56	17.35	Medium	-
	Nov-18	53.15	42.25	21.00	High	46.10
	Dec-18	52.43	45.70	19.55	Medium	27.25
	Jan-19	56.69	65.04	15.45	Medium	47.50
	Feb-19	55.58	44.26	13.85	Medium	44.70

20.1.4: KAU-Vellayani

The population was monitored in the Vellayani ecosystem from three different blocks at fortnightly intervals for a period of one year. Observations revealed that the population just reappeared after the flood, in September 2018. It started gradually increasing thereafter and is rated as moderate during January- February 2019. More than 70% of the pupal colonies were found parasitized by *Encarsia guadeloupae.*

20.1.5 DRYSRUH, Ambajipeta

Observations on the whitefly incidence were made at monthly intervals from three gardens. Five palms were selected at random in each garden.The infestation was graded by the following methodology.

Methodology

The estimation of damage level caused by RSW was assessed by scoring the presence of live egg spirals on each coconut leaflet. It is categorized as Low <10 egg spirals/ leaflet),Medium (10-20 egg spirals/leaflet)and High (>20 egg spirals/ leaflet).Five leaflets were collected per garden and brought to laboratory for assessment of natural enemies and pest stages.Information on the management practices followed by the farmer was also be collected.Information on alternate hosts were documented.

Mean number of spirals per 4 leaflets was ranged from 11.13 to 54.24. During April, the mean number of spirals were 28.53 and 40.73 and the corresponding mean number of adult whiteflies were 71.36 and 38.58 in East Godavari and West Godavari districts, respectively. During May, the mean whitefly population per 4 leaflets was observed to be higher than the previous month and the population increase was continued till July. The adult population was 63.79 and 40.18 insects per 4 leaflets during May at East Godavari and West Godavari, respectively. Number of spirals and adults per 4 leaflets increased till July. During August, the whitefly population was observed to be 4.12 per four leaflets in East Godavari while no whitefly adults, nymphal and pupal stages were recorded in August. A very low whitefly population was recorded during September in both districts. The whitefly population was observed to increase from October with 22.16 and 24.02 spirals per 4 leaflets and the corresponding adult insect population was 21.22 and 21.38 per 4 leaflets at East Godavari and West Godavari districts, respectively. This increasing trend of population was continued till December **(Table 131).**

Table 131: Population fluctuation of rugose spiralling whitefly, *A. rugioperculatus* in Andhra Pradesh (From April 2018 to December 2018)

Month & Year	District	Mean no .of spirals per 4 leaflets	Mean no .of adults per 4 leaflets	Mean no .of nymphs per 4 leaflets	Mean no .of pupae per 4 leaflets
April 2018	East Godavari Mean	28.53	71.36	52.48	62.64
	West Godavari Mean	40.73	38.58	42.22	44.96
May 2018	East Godavari Mean	37.98	63.79	56.47	60.00
	West Godavari Mean	44.77	40.18	46.65	45.12
June 2018	East Godavari Mean	45.49	58.82	53.87	55.85
	West Godavari Mean	54.24	45.80	47.03	46.72
July 2018	East Godavari Mean	52.70	61.29	49.49	49.51
	West Godavari Mean	50.39	51.54	52.91	50.53
August 2018	East Godavari Mean	17.76	4.12	-	-
	West Godavari Mean	12.45	-	-	-
September 2018	East Godavari Mean	11.13	10.67	9.51	12.37
	West Godavari Mean	11.29	12.84	11.67	13.67
October 2018	East Godavari Mean	22.16	21.22	13.26	16.81
	West Godavari Mean	24.02	21.38	15.96	18.59
November 2018	East Godavari Mean	44.19	21.33	16.61	25.62
	West Godavari Mean	50.58	29.23	23.46	25.14
December 2018	East Godavari Mean	51.11	24.20	23.92	26.24
	West Godavari Mean	49.94	26.84	21.97	25.49

The rugose piralling whitefly population was recorded at weekly intervals from Jan 2019 at Pulletikurru village, Ambajipeta mandal. High mean number of 77.25 adults per four leaflets was recorded during 6th standard week and the adult population started decreasing from 7th standard week and a low adult population was recorded during 14th standard week (32.25) and the corresponding number of nymphs and pupae per 4 leaflets was 17.75 and 11.5, respectively **(Table 132).**

Table 132. Incidence of rugose spiralling whitefly, *A. rugioperculatus* at East Godavari district during 2019

Std. Week No	Month (2019)	Std. Week	Mean number of spirals per 4 leaflets	Mean number of adults per 4 leaflets	Mean number of nymphs per 4 leaflets	Mean number of pupae per 4 leaflets
1	Jan	01-07	55.50	36.50	59.50	30.25
2	Jan	08-14	58.50	41.25	63.50	33.25
3	Jan	15-21	60.75	56.75	69.25	44.25
4	Jan	22-28	66.75	58.75	72.25	49.25
5	Jan	29-04	69.50	75.50	76.75	50.75
6	Feb	05-11	62.75	77.25	77.75	54.75
7	Feb	12-18	60.50	76.25	65.75	44.25
8	Feb	19-25	67.50	69.50	57.25	41.25
9	Feb	26-04	58.75	57.75	47.50	37.50
10	Mar	05-11	46.25	55.75	39.50	35.25
11	Mar	12-18	43.50	52.75	26.75	28.50
12	Mar	19-25	41.50	40.50	21.50	25.50
13	Apr	26-01	32.75	37.75	19.50	16.75
14	Apr	02-08	24.75	32.25	17.75	11.50

20.1.6 TNAU

Rugose whitefly and their natural enemies on coconut were monitored during 2018-19. The pest population escalated from July to November, 2018 and declined from December 2018 to March 2019 **(Table 133).**The occurrence of rugose whitefly *Aleurodicus rugioperculatus* was recorded in various Districts in Tamil Nadu *viz.*, Coimbatore, Tirupur Theni, Tanjore, Cuddalore, Kanyakumari, Tiruvarur, Tirunelveli Dindigul and Erode. The infestation index ranged between 1.00 and 3.00 in various Districts in Tamil Nadu. The parasitisation by *Encarsia* sp.ranged between 10.00 and 100.00% on coconut gardens. A diverse array of predators *viz*., *Chilocorus nigrita*, *Coccinella transversalis*, *Mallada desjardinsi*, *Cheilomenes sexmaculatus*, *Propylea dissecta*, *Scymnus nubilis, Scymnus saciformis; Chrysoperla zastrowi sillemi* are present in the coconut gardens.

Table 133. Incidence of rugose whitefly (*Aleurodicus rugioperculatus*) and its natural enemies

Places surveyed	Period	*A.rugioperculatus* (No. of nymphs /15 cm leaflet)	*A.rugioperculatus* affected trees (%) Total no. of trees - 70	Natural Enemy/5 leaflet			
				Encarsia sp.	*Cryptolaemus*	*Mallada sp.*	*Chrysoperla*
Coimbatore	April 18	80	34	8	-	-	-
	May 18	114	34	10	-	-	-
	June 18	125	34	8	-	-	-
	July 18	132	34	9	-	1	-
	Aug 18	145	34	10	-	-	-
	Sep 18	156	34	14	-	1	-
	Oct 18	150	34	11	-	-	-
	Nov18	137	34	10	1	1	-
	Dec 18	118	34	18	2	2	-
	Jan 19	80	28	16	2	-	-
	Feb19	75	28	24	-	3	-
	Mar 19	63	28	20	-	1	-
Tirupur	Dec 18	109	25	20	-	-	-
	Jan 19	96	34	18	1	2	-
	Feb19	85	24	14	-	-	1
	Mar 19	50	44	21	-	2	-
Erode	Dec 18	95	48	17	-	-	-
	Jan 19	102	42	13	1	1	-
	Feb19	80	38	20	-	1	-
	Mar 19	78	39	21	-	-	-

20.1.7 NBAIR

About 3 trips were made to Dakshina Kannada, Udupi and Uttar Kannada districts and 3 trips in Ramanagara, Mandya, Mysuru districts 4 trips to Bengaluru rural district in Karnataka for survey on incidence and infestation of rugose spiralling whitefly *Aleurodicus rugioperculatus* Martin on coconut and other host plants during 2018-19. Survey route was Mangalore to Bhatkal (*via* Udupi and Brahmavar, Kundapura, Hemmadi, Marvanthe, Byndoor, Shiroor); Bengaluru to Malavalli (via Ramanagara, Channapatna, Madduru, KM Doddi) and Malavalli to Bengaluru (*via*, Lakshmipura, Bannur, Mysuru, Srirangapatna and Mandya). Incidence and infestation of rugose spiralling on coconut was recorded to the extent of 5-30% in different locations with maximum incidence was observed in younger and dwarf hybrid palms. The incidence noticed on banana, Indian almond, *Callophyllum*, Indian ficus and many other ornamental plants. RSW incidence drastically reduced in the locations where severe infestation noticed in previous year 2017-18. This is due to enhancement in natural enemies population over the period of time and weather factors. The pest population continue to spread newer areas along coastal tracts in Karnataka and incidence was even more serious in Goa. As per the natural parasitism as concern, the predominant natural enemies were *Encarsia guadeloupae* which parasitism was recorded to extent of 24-62%.

Besides, RSW infestation of three invasive whiteflies such as Bondar's nesting whitefly, *Paraleyrodes bondari* and *P. minei* to the extent of 15-28% on coconut was noticed. In few location, it was observed that this nesting whiteflies co-existence with RSW on coconut. Similarly, yet another whitefly, highly invasive coconut whitefly was found to cause sextensive damage in South India and its identification is under progress.

20.2 Per cent Parasitization of *E. guadeloupae* on rugose spiralling whitefly in coconut and oil palm (DRYSRUH, Ambajipeta)

The parasitisation by *E. guadeloupae* was not observed in the whitefly infested gardens and nurseries up to December 2017 in A.P. As *E. guadeloupae* parasitoid is effective against the whitefly and was yet to establish in Andhra Pradesh, in December 2017 the parasitoids consignment were obtained from Coconut Research station, Aliyarnagar, TNAU. The first consignment of 150 numbers of *E. guadeloupae* parasitized pupae were released in coconut gardens in Kalavalapalli village of West Godavari district on 18-12-2017. Further on 08-1-2018 a second consignment of 250 numbers of *E. guadeloupae* parasitized pupae were released in Oil palm and Coconut gardens in Kalavalapalli and Chikkala villages in West Godavari district. The third consignment of *E. guadelopae* parasitoid in higher numbers (3000 nos) were obtained and distributed for release in Kalavalapalli, Chikkala, Neeladripuram, Korumamidi and Chagallu villages in West Godavari and Kadiyapulanka and Pottilanka villages in East Godavari on 20.01.2018. The data on parasitisation of rugose whitefly by *E. guadeloupae* was recordedto ascertain establishment of parasitoid in the released gardens.

During January, 20.01±1.69% parasitized pupae were observed per 10 palms. Later the per cent parasitisation was increased to 72.06±3.15 during February which later decreased to zero during April till August. However, per cent parasitisation of 29.34±3.56, 42.38±5.48, 69.49±4.94 and 68.83±3.61 was observed during moths of September, October, November and December, respectively. Similarly on oilpalm, the per cent parasitization was 9.92±2.90 during January which declined to zero in April and no parasitisation was observed till August. During September, per cent parasitisation was 25.62±1.84 which was observed to slowly increase to 49.16±2.93 by December **(Table 134).**

Table 134. Per cent parasitized whitefly pupae observed after parasitoid release on oil palm and coconut in Kalavalapalli village

Month/Year	Per cent parasitized whitefly pupae observed (For 10 palms at random)	
	Coconut (5 years old)	OilPalm (15 years old)
January 2018	20.01±1.69	9.92±2.90
February 2018	72.06±3.15	59.97±3.65
March 2018	52.81±3.07	33.01±4.09
April 2018	Nil	Nil
May 2018	Nil	Nil
June 2018	Nil	Nil
July 2018	Nil	Nil
August 2018	Nil	Nil
September 2018	29.34±3.56	25.62 ±1.84
October 2018	42.38±5.48	33.87+2.26
November 2018	69.49±4.97	46.71+2.48
December 2018	68.83±3.61	49.16+2.93
January 2019	71.35±4.31	-
February 2019	65.44±2.63	-
March 2019	28.68±1.78	-

20.3 Effect of cassava leaf extracts on rugose spiralling whitefly (CPCRI)

Cassava leaf based formulations *viz.,* Nanma and Shreya developed by ICAR-CTCRI@ 2% concentration and 0.5% neem oil were evaluated on RSW infected juvenile coconut palms. Observations were also recorded from non-sprayed palms as control. Five replicates were maintained for each treatment. Observation on RSW population was recorded from 4 leaflets/palm. There was 68 to 75% reduction in adult population and 69 to 82% reduction in egg numbers when the leaves were sprayed with Nanma and Shreya respectively. Neem oil @ 0.5% effected 72.5% reduction in adult whitefly population and 72.6% reduction in egg numbers at 20 DAT. There was a natural reduction of 23% adult population and 36% egg numbers in control palms (**Table 135)**.

Table 135. Effect of spraying botanical formulations on RSW

Treatments	Average Population of RSW adult /leaflet (numbers)				RSW eggs /leaflet (numbers)			
	Precount	**2 DAT**	**20 DAT**	**% reduction**	**Precount**	**2 DAT**	**20 DAT**	**% reduction**
Nanma @20 ml/L	14.53	8.2	4.6	68.3	156.8	65.6	48.4	69.13
Shreya @20 ml/L	18.49	10.3	4.45	75.9	192.6	61	34	82.34
Neem oil @0.5%	15.14	6.2	4.15	72.5	160.8	52.8	44	72.6
Control	15.45	11.8	7.8	23.6	149.2	55.4	95	36.3

20.4 Management of coconut rugose spiraling whitefly using entomopathogenic fungus, *Isaria fumosorosea* (Pfu-5) (ANGRAU, KAU-K, NBAIR)

20.4.1: ANGRAU-Anakapalle

On farm trial on management of coconut spiraling whitefly using entomopathogenic fungi, *Isaria fumosorosea* (Pfu-5) @ 5 g/L with Sticker @ 10 g/lt conducted at two locations (Patharlapalli, Srikakulam dist. and Chollangipeta ,Vizianagaram dist.) as two sprayings at 15 day interval. Reduction in whitefly population at 15 days after first spraying with mummifield nymphs and malformed adullts noticed in February, 2019 due to favourable weather (Temparature below 28°C and humidity above 90%). Whitefly damage as new egg spirals was not noticed at 15 days after first spraying in February, 2019 **(Table 136).** Mummified nymphs were very low at one month after second spraying in March, 2019 may be due to sudden increase in temperatures (above 35°C and decrease in humidity below 75%). Rugose whitefly adults and whitefly damage on new leaflet (egg spirals) noticed at one month after second spraying due to aerial spread of the pest.

Table 136. Coconut spiraling whitefly in entomopathogenic fungus, *Isaria fumosorosea* (Pfu-5) sprayed coconut palms

Location	Before spray			After first spray		After second spray			% reduction in intensity at 15 days after spraying	% reduction in intensity at 45 days after spraying
	% Infestation	% Intensity	Live colonies /leaflet	% Intensity	Live colonies	% Infestation	% Intensity	Live colonies		
Patarlapalli Srikakulam Dt	29.34	30.32	45.7	0.9	<10 (9.0)	7.14	20.09	>20 (26.4) as egg spirals 6.53 Adults / fresh leaflet	97.03	33.74
Chollangipeta Vizianagaram Dt	68.14	87.94	53.2	36.31	>20 (25.1)	7.55	64.4	>20 (32.3) as egg spirals 9.75 Adults / fresh leaflet	58.71	26.77

20.4.2: KAU Kumarakom(March 2019)

Dose: 5 g of rice grain based formulation per liter of water along with Tween 20 as sticker

Number of palms: 20 palms/treatment

Observations:

Pretreatment count on number of live colonies from 10 leaflets per palm
Post treatment count on number of live colonies from 10 leaflets per palm on 3, 7 and 10 days after treatment
After first spray: Percentage reduction live colonies ranged from 4.3 to 53% (3rd DAT). An increasing trend in percent reduction was observed which ranged from 3.4 to 59% on 10th DAT **(Table 137).**

After second spray: Percentage reduction live colonies ranged from 6.49 to 78.79% (3rd DAT) when compared with initial count. At 7th day it ranged from 8.78 to 75%. Up to a maximum of 75% reduction was observed in the number of live colonies when compared with pre-treatment count.

Table 137. Per cent reduction of coconut rugose whitefly infestation on spraying of *Isaria fumosorosea* (ICAR-NBAIR Pfu-5)

Number of live colonies per leaflet*														
Treated palms													Control palms	
Palm Number	First spray							Second spray					Before first spray	Before second spray
	Pretreatment	3rd day	% redun.	7th day	% redun.	10th day	% redun.	Pretreatment	3rd day	% redun.	7th day	% redun.		
1	18.50	17.70	**4.32**	16.00	**13.51**	15.40	**16.76**	15.40	15.70	**15.14**	13.70	**25.95**	23.60	25.40
2	25.10	17.90	**28.69**	14.30	**43.03**	16.00	**36.25**	19.50	18.40	**26.69**	16.60	**33.86**	17.60	21.80
3	12.50	12.80	**-2.40**	11.10	**11.20**	6.80	**45.60**	8.50	7.00	**44.00**	6.60	**47.20**	26.50	25.30
4	28.60	18.40	**35.66**	15.50	**45.80**	19.60	**31.47**	19.00	18.40	**35.66**	16.50	**42.31**	25.50	29.00
5	24.20	18.50	**23.55**	19.60	**19.01**	17.50	**27.69**	18.50	18.10	**25.21**	14.10	**41.74**	24.50	18.70
6	21.80	10.10	**53.67**	14.80	**32.11**	13.30	**38.99**	18.30	16.60	**23.85**	16.40	**24.77**	33.60	26.50
7	26.50	19.40	**26.79**	16.70	**36.98**	17.00	**35.85**	19.00	14.40	**45.66**	12.60	**52.45**	23.00	21.30
8	16.30	12.90	**20.86**	12.40	**23.93**	13.50	**17.18**	16.50	13.20	**19.02**	16.80	**-3.07**	19.10	14.60
9	26.20	22.20	**15.27**	25.90	**1.15**	25.30	**3.44**	27.30	24.50	**6.49**	23.90	**8.78**	22.20	24.70
10	18.20	15.20	**16.48**	13.50	**25.82**	15.30	**15.93**	14.20	14.80	**18.68**	14.00	**23.08**	28.40	27.00
11	19.40	17.90	**7.73**	13.10	**32.47**	13.90	**28.35**	13.30	14.20	**26.80**	12.00	**38.14**	25.00	26.30
12	9.30	7.90	**15.05**	3.20	**65.59**	8.80	**5.38**	8.80	2.10	**77.42**	4.90	**47.31**	28.10	32.50
13	7.70	7.60	**1.30**	6.60	**14.29**	5.60	**27.27**	6.20	5.10	**33.77**	4.20	**45.45**	19.80	18.00
14	23.50	19.00	**19.15**	13.60	**42.13**	14.90	**36.60**	14.40	13.00	**44.68**	12.10	**48.51**	26.80	29.80
15	8.70	7.40	**14.94**	5.70	**34.48**	5.90	**32.18**	6.70	4.10	**52.87**	4.80	**44.83**	15.60	15.50
16	16.50	9.70	**41.21**	6.90	**58.18**	6.70	**59.39**	5.70	3.50	**78.79**	4.10	**75.15**	22.60	25.00
17	18.50	16.40	**11.35**	13.10	**29.19**	11.60	**37.30**	14.60	13.20	**28.65**	12.80	**30.81**	19.80	18.40
18	21.70	18.90	**12.90**	17.20	**20.74**	16.20	**25.35**	15.60	13.50	**37.79**	16.50	**23.96**	19.80	20.10
19	28.30	24.10	**14.84**	21.80	**22.97**	22.50	**20.49**	21.60	15.20	**46.29**	7.20	**74.56**	12.30	12.00
20	10.40	8.80	**15.38**	7.10	**31.73**	6.10	**41.35**	7.10	7.60	**26.92**	7.20	**30.77**	19.80	19.90

*Per cent reduction is calculated in comparison with the pretreatment count before the start of the experiment

20.4.3: NBAIR

Field evaluation was carried out with ICAR-NBAIR Pfu-5 strain at Nelamangala (Bengaluru Rural district, Karnataka) in coconut and coconut & oil palm at Kalavalapalli, Pullerukuttu & Madhavaraya palyam in West and East Godavari districts of Andhra Pradesh by spraying at the dose of $1x10^8$ spores/ml on ten randomly selected infested palms in each location using power operated high volume sprayer on all fronds of the palm. Two sprays were given at 15 days interval. Results revealed that *I. fumosorosea* (Pfu-5), reduced 51.60-78.58% of egg hatching, causing 47.25-68.30% mortality of early nymphal instars and 42.70-63.41% mortality of late nymphal instars across the locations. Besides, adult's malformation also observed from population emerging from the sprayed palms.

20.5. Management of coconut black headed caterpillar using *Goniozus nephantidis* and *Bracon brevicornis* in endemic areas of Kerala (CPCRI)

Regular monitoring on the incidence of black headed caterpillar, *Opisina arenosella* was undertaken in Kannur and Kasaragod districts, Kerala as well as Dakshina Kannada and Udupi districts, Karnataka. Mild incidence was observed in a coconut garden at Kanhangad, Kasaragod district during February 2019. Larval population ranged from 1.1 to 7.8 per leaflet during the survey. Adequate pest population was not available for taking up statistically laid out experiments. Various natural enemies recorded from field are pupal parasitoids, *Brachymeria* sp., larval parasitoid, *Bracon* sp. and predator *Cybocephalus* sp. Timely augmentative release of *Goniozus nephantidis* and *Bracon brevicornis* @20 parasitoid/palm significantly subdued the pest population. A fresh incidence of *O. arenosella* was reported from Kumarakom, Kerala during April 2019. Release of larval parasitoids will be undertaken after assessing pest population.

20.6 Screening of coleopteran specific *Bt* formulation (NBAIR/CPCRI strains) against rhinoceros beetle (*Oryctes rhinoceros*) (CPCRI)

Two distinct spore-forming entomopathogenic bacteria were isolated by ICAR-CPCRI, Kasaragod. The isolates were purified and used for bioassays on second-instar grubs of *O. rhinoceros. In vitro* bioassays showed that the isolates 1 and 2 infected second instar *O. rhinoceros* grubs and caused 98% and 90% mortality, respectively ($F=10.03$; $p<0.0001$). Infected larvae exhibited bacterial septicemia like symptoms and mortality noticed between 2 - 8 weeks after inoculation. Based on morphology and sequencing of the 16S rRNA gene, the isolates 1 and 2 were identified as *Bacillus cereus* and *Bacillus thuringiensis*.

About 20 bacterial isolates were collected at ICAR-CPCRI, Kayamkulam from naturally infected field collected rhinoceros grubs. Promising two isolates were subjected to bioassay. Isolate 1 (*Bacillus* sp.) induced 80% mortality of 3^{rd} instar grubs within 15 days after treatment. However, it showed non- specific symptoms than the field collected grubs. Isolate 2 (*Proteus* sp.) showed non-specific symptoms as that of field collected grubs and induced 70% mortality of grubs in 15DAT. Further studies with Isolate 2 was discontinued as some of the *Proteus* sp. may be human pathogenic.

The *Bt* formulation of ICAR-NBAIR, *Bt*AN4, was tested on third instar grubs of rhinoceros beetle (average weight of grubs 7g) at concentrations 2% and 4% along with control with 10 grubs per treatment. No mortality was observed on 3^{rd} instar grubs.

20.7. Screening of coleopteran specific *Bt* formulation (NBAIR strains) against red palm weevil (*Rhynchophorus ferrugineus*) (CPCRI)

The *Bt* strain of ICAR-NBAIR, *Bt*AN4 was tested on grubs of red palm weevil at two concentrations viz., 2% an 4% along with control by food poisoning technique. The required quantity of *Bt* formulations were incorporated into the meridic diet of red palm weevil. Grubs weighing 4-5 g were introduced individually in falcon tubes containing respective diets and observations were recorded at daily interval. Equal numbers of control treatments were maintained with the same diet devoid of *Bt* formulation. Each treatment was replicated 10 times with single grub /replicate. The *Bt* strain, *Bt*AN4, induced mortality of *R. ferrugineus* grubs from 4th day after treatment and there was doze dependant mortality. 100% mortality of grubs was effected at 14 DAT with 4% concentration. 2% concentration of *Bt* formulation induced 80% mortality at 15 days after treatment **(Fig23).**

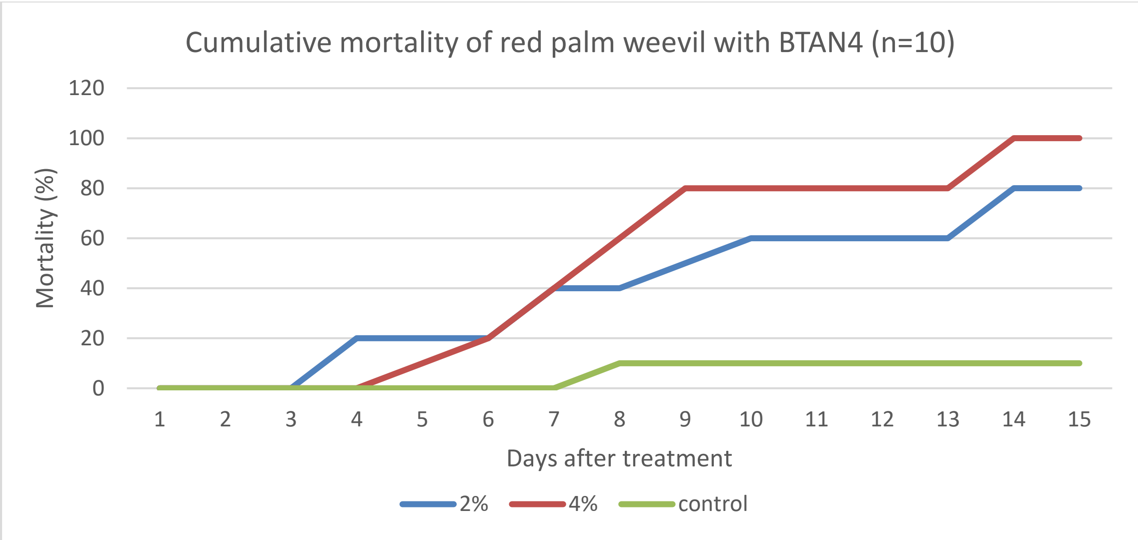


Fig. 23 Mortality of red palm weevil with *Bt* formulations

*Bt*AN4 @ 4% formulation (1 litre per palm) was tested in the field on red palm weevil infested palms for curative treatment. Out of 6 palms tested in field, 3 palms with early infestation completely recovered with fresh spear leaf emergence and one palm died **(Table 138).** Second treatment at the same dose was given to the two palms which did not indicate any recovery and the palm are being monitored. As red palm weevil is an internal tissue borer, and coconut being monocot with single meristem, actual assessment of pest population inside the palm trunk is not possible. Hence, field evaluation has to be conducted with more number of palms to confirm and validate field efficacy of the formulation.

Table 138. Effect of *Bt*AN4 formulation on red palm weevil infested palms

Palm No	Stage of infestation	Pest entry	Symptoms	Variety& Age of palm	Post data at 14 DAT	Post data at 21 DAT
1	Middle	Crown entry	Spindle drying Yellowing of inner whorl of fronds	CGD, 20 years	No visible change, 2nd treatment given	No visible change
2	Early	Crown entry	Spindle drying& Yellowing of fronds	WCT 20 years	Spindle leaf emerging	Spindle leaf unfurled
3	Early	Crown entry	Spindle drying& Yellowing of fronds	CGD 20 years	Spindle leaf emerging	Spindle leaf emerged
4	Medium	Crown entry	Spindle drying & yellowing	CGD X MGD 7 years	dead	--
5	Early	Crown entry	Spindle drying & yellowing	CGD X MGD 7 years	Spindle leaf emerging	New spear leaf unfurled
6	Middle	Crown entry	Spindle drying & yellowing	WCT	No change, 2nd treatment given	No change

21. COCOA

21.1 Evaluation of microbial insecticides against bagworm, *Pteroma plagiophelps* in cocoa (DRYSRUH, Ambajipeta)

This experiment was not executed due to lack of bagworm population.

21.2.: *In vivo* evaluation of effective bio control agents against *Phytophthora* Pod rot management in cocoa (DRYSRUH, Ambajipeta)

Random Surveys were conducted in different cocoa growing areas of East and West Godavari districts and the soil samples were collected for isolation of native biocontrol agents. Eight isolates of *Trichoderma* spp. representing varied geographical locations were collected and their variations with respect to morphological and cultural characters were documented.

22. TEA

22.1 Field evaluation of biopesticides against tea red spider mite, *Oligonychus coffeae* (UBKV)

Location: Tea garden, UBKV, Pundibari.

Plot size: 8×5 m; **Variety:** Akashi; **Layout**: RBD

Replication: Four blocks were selected in the tea garden and each block was divided into 5 equal sized units (each block= one replication and each unit = one treatment).

Treatment details:

T1: *Lecanicillium lecanii* (NBAIR Vl-8 strain) 1×10^{8}cfu @ 10g/lit
T2: *Beauveria bassiana* (NBAIRBb-5a strain) 1×10^{8}cfu @ 10g/lit
T3: Azadirachtin 10000 ppm @ 1ml/lit
T4: Spiromesifen 240 SC @1.0ml/lit
T5: Control

Spray schedule: Two sprays at 15 days interval; First: 15.10.2018; Second: 30.10.2018

All the treatment performed statistically better than the control treatment in managing the red spider mites of tea **(Table 139).** Best management was recorded in the plots treated with spiromesifen 240SC. Among the tested bio-pesticides, *B. bassiana*, NBAIR-Bb5a reduced the mite population better which is statistically at par with azadirachtin 10000 ppm. Significantly highest yield of tea leaves was also recorded in the treatment Spiromesifen 240 SC (6.57qt/ha) followed by *B. bassiana* NBAIR-Bb5a (4.57qt/ha) and azadirachtin 10000 ppm (3.92qt/ha).

Table 139. Bioefficacy of some biopesticides against tea red spider mite

Treatment	Population of tea red spider mite/ leaf								Green tea leaf yield (q/ha) of single plucking after the sprayings
	First spray				Second spray				
	Pre-treatment	1DAS	3DAS	7DAS	Pre-treatment	1DAS	3DAS	7DAS	
T1-*L. lecanii* (NBAIR-Vl-8 strain) @ 10 gm/lit.	6.20 (2.44)*	5.33 (2.31)	3.00 (1.72)	3.61 (1.77)	3.16 (1.77)	3.20 (1.77)	1.62 (1.26)	1.87 (1.36)	3.70 (1.92)*
T2-*B. bassiana* (NBAIR Bb-5a strain) @ 10 gm/lit.	4.58 (2.13)	4.20 (2.40)	2.41 (1.54)	3.08 (1.74)	3.08 (1.74)	3.00 (1.73)	1.20 (1.09)	1.33 (1.11)	4.57 (2.14)
T3- Azadirachtin 10000 ppm @ 1ml/lit.	6.08 (2.46)	5.54 (2.35)	2.58 (1.60)	3.00 (1.71)	3.00 (1.71)	3.20 (1.78)	1.95 (1.38)	2.33 (1.51)	3.92 (1.98)
T4- Spiromesifen 240SC @ 1ml/lit.	4.08 (2.02)	0.50 (0.69)	0.33 (0.55)	0.58 (0.73)	0.62 (0.78)	0.20 (0.45)	0.37 (0.58)	0.33 (0.57)	6.57 (2.56)
T5- Control	7.12 (2.66)	8.12 (2.84)	9.08 (2.99)	9.00 (2.99)	9.00 (2.99)	7.79 (2.76)	8.12 (2.85)	5.45 (2.32)	1.97 (1.40)
SEm (±)	0.10	0.10	0.12	0.14	0.13	0.15	0.10	0.10	0.04
CD (at 5%)	0.32	0.32	0.38	0.45	0.42	0.49	0.32	0.31	0.13
CV (%)	8.76	10.16	14.87	16.19	15.23	18.83	14.59	14.83	4.19

DAS- Days after spray * Figures in the parenthesis are square root transformed values.

VEGETABLE CROPS

23. TOMATO

23.1 Bio-intensive pest management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato (AAU- Anand, MPKV, PAU, TNAU, YSPUHF, IIVR, IIHR)

23.1.1 AAU- Anand

Objectives: To demonstrate BIPM module in tomato
Year of commencement: 2017-18 - *rabi* season
Location: Farmer field, Runaj, Sojitra taluk, Anand district
Methodology and treatments:

Variety	Alankar –Hybrid (F1)
Plot size	8×5 m
Spacing	60×30 cm
Layout	Randomized Block Design (RBD)
Treatments	**T1 = BIPM package** Seed bio-priming with *Trichoderma harzianum* @ 10 g/kg of seeds. Raising marigold as trap crop Use of NBAIR pheromone traps @ 1 trap per plot. *T. achaeae / T. chilonis* @ 50,000 per release (6 releases) Azadirachtin 1500 ppm @ 2 ml/lit *B. thuringiensis* (PDBC *Bt*G-1)1%WP (1×10^8) @ 5g/lit *L. lecanii* (Vl-8) 1%WP ($1x10^8$) @ 5g/lit for sucking pests **T2 = Chemical control** Chlorantraniliprole 18.5%SC for *Tutaabsoluta* and indoxacarb 14.5SC for other pests **T3 = Untreated Control**
Replications	Five
Methodology and observations	The treatment application was started at initial occurrence of pests. Six releases of parasitoids at weekly interval and three sprays of biopesticides were given during evening hours at fortnightly interval. Ten plants were randomly selected in $40m^2$ crop area and observed all the leaves for presence of leaf mine / sucking pests caused by the larva. Ten plants were randomly selected in $40m^2$ crop area and observed all the fruits for presence of holes/ damage caused by the larva. Observations were recorded at fortnightly interval from fruit formation to last harvest. Fruit damage (%) and yield was recorded **(Table 140)**

Table 140. Effect of different modules on incidence of *H. armigera* and yield of tomato

Modules/Treatments	*H. armigera* larvae / plant*	Fruit damage* (%)	Fruit yield (t/ha)
BIPM Package	1.21 (1.46)	19.70 (11.36)	16.25
Chemical Control	1.19 (1.42)	19.68 (11.34)	16.43
Untreated Control	1.70 (2.89)	29.62 (24.43)	10.89
S. Em. ±	0.07	0.76	0.68
C. D. at 5 %	0.20	2.30	2.06
C. V. %	13.76	9.31	13.24

Mean of five observations
* √x + 0.5 transformed values,
** Arc sin transformed values, Figures in parentheses are retransformed values

Results: Demonstration experiment was conducted in *rabi* 2017-18. During the experimental period, incidence of *H. armigera* incidence was recorded and there was no incidence of *Tuta absoluta* and sucking pests. No significant difference was observed between BIPM package and chemical control with regard to the parameters *viz*., number of *H. armigera* larvae/plant and fruit damage. BIPM package found equally effective as chemical control against *H. armigera*. Chemical control module recorded the highest yield (16.43 t/ha) which was at par with the yield recorded in BIPM package (16.25 t/ha). However, low yield was recorded in untreated control (10.89 t/ha). It can be concluded that BIPM package is promising in minimizing the pest damage with higher yield.

23.1.2 MPKV, PUNE

The experiment was laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. Tomato var. Namdhari 501 planting is done on 28/02/2019 with 4.5 x 4.5 m plot size and, 90 x 45 cm spacing in Randomized Block Design replicated thrice with eight treatments.

Results: The incidence of American pinworm, *Tuta absoluta* on tomato is generally observed in summer months. Hence, the trial is in progress.

23.1.3 PAU, Ludhiana

The experiment on bio-intensive pest management of *Helicoverpa armigera* and sucking pests of tomato was conducted at Entomological Research Farm, PAU, Ludhiana on tomato during 2017-18. There were three treatments with six replications each. The treatments were

T1: BIPM

Seed treatment with *Trichoderma harzianum* @ 10g/kg of seed
Raising marigold as trap crop
Use of pheromone traps @ 1 trap per plot
Trichogramma pretiosum @ 50,000 per release (6 releases)

Azadirachtin 1500 ppm @ 2 ml/liter water.
Lecanicillium lecanii (NBAIR) 1×10^8 spores/ g @ 5g/lt for sucking pests
T2: Chemical control - Indoxacarb 14.5SC @ 500ml/ha
T3: Untreated Control

The pooled per cent fruit damage in BIPM (12.86%) was significantly lower than untreated control (18.79%). However, chemical control recorded minimum per cent fruit damage (10.80%).The per cent reduction in fruit damage over control was 47.63 and 31.55% in chemical control and BIPM plot, respectively. The fruit yield in BIPM (28.32q/ha) was at par with chemical control (32.83q/ha), However, both the treatments were significantly better than untreated control (20.62/ha) **(Table 141).**

Table 141.BIPM module for management of pests of Tomato

Treatment	Per cent fruit damage	Yield (q/ha)
BIPM	12.86 [b] (20.74)	28..32 [a]
Chemical control (Indoxacarb 14.5 SC @ 500 ml/ha)	10.80 [a] (19.00)	32.83[a]
Untreated control	18.79 [c] (25.44)	20.62[b]
CD (p=0.05)	1.80	6.99

23.1.4 TNAU, Coimbatore

The details of the experiment are given below

Name of the Farmer	: Mr. Gunasekeran
Location	: Narasingapuram, Tirupur Dt.
Date of sowing African Marigold	: 13.11.18
Tomato Hybrid	: Surya
Spacing	: 60 x 45 cm
Date of Transplanting	: 13.11.2018

Treatments

$T_{1:}$ BIPM package
Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds.
Raising marigold as trap crop
Use of NBAIR pheromone traps @ 1 trap per plot.
Trichogramma pretiosum @ 50,000 per release (6 releases)
Azadirachtin 1500 ppm @ 2 ml/lit.
Lecanicillium lecanii (NBAIR) 1×10^8 spores/ g @ 5g/lt for sucking pests
T2: Chemical control
Chlorantraniliprole 18.5% SC for *T. absoluta* and indoxacarb 14.5SC for other pests
T3: Untreated Control
Plot size: 10 cents/treatment

Observations:

Damage by *Helicoverpa armigera* and *Tuta absoluta* were recorded at 15 days interval and Yield data were recorded at harvest

Results: The results indicated that in the BIPM field, on 60 days after transplanting (DAT), the leaf damage caused by *T. absoluta* (6.70%) was significantly lesser than farmers practice and control plot **(Table 142)**. At 105 DAT, the fruit damage caused by *T. absoluta* (10.90%) was significantly lesser in BIPM plots when compared to chemical treatment (13.20%) and control (18.90%). Moreover, the fruit damage caused by *H. armigera* (11.30%) was significantly lesser in BIPM when compared to chemical treatment (16.10%) and control (25.30%). The fruit yield (24t/ha) was significantly higher in BIPM plot as compared to insecticide treated plot (21.5t/ha) and control plot (18.25/ha).

Table 142. Bio-intensive pest management of *Helicoverpa armigera* and *Tuta absoluta* in tomato

Treatments	Per cent fruit damage by *H. armigera*			% reduction over control	Per cent leaf damage by leafminer			% reduction over control	Per cent fruit damage by leaf miner			% reduction over control	Fruit yield (Kg/ha)	CB Ratio
	75 DAT	90 DAT	105 DAT		30 DAT	45 DAT	60 DAT		75 DAT	90 DAT	105 DAT			
BIPM	21.6[a]	17.5[a]	11.3[a]	43.4	2.5[a]	4.2 [a]	6.7 [a]	44.4	7.3 [a]	7.8 [a]	10.9 [a]	45.3	24000[a]	3.96
Farmers practice	25.2[b]	25.3[b]	16.1[b]	25.3	2.9[b]	5.9 [b]	9.2 [b]	25.2	10.9[b]	9.8 [a]	13.2[b]	28.7	21500[b]	2.71
Control	34.9[c]	28.9[c]	25.3[c]		3.7[c]	8.1 [c]	12.3 [c]		15.6[c]	13.1 [b]	18.9 [c]		18250[c]	
SEm CD	4.0 9.2	1.8 4.2	2.0 4.7		0.802. 2	0.24 0.7	0.8 2.2		1.0 2.3	1.0 2.3	1.1 2.5		0.008 0.022	

DAT – Days after transplanting; Means followed by a common letter in a column are not significantly different by DMRT, Figures in parentheses are arcsine transformed values (Damage), Figures in parentheses are logarithmic transformed values (Yield), Values are mean of five replications

23.1.5. YSPUHF, Solan

Experiment for bio-intensive management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato was conducted at the experimental farm of the Department of Entomology, YSP University of Horticulture and Forestry Nauni, Solan (HP). Bio-intensive Integrated Pest Management (BIPM) module comprising of pheromone trap (PCI), marigold as trap crop, six releases of *Trichogramma achaeae* @ 50000/ha, two sprays of azadirachtin 1500ppm @ 2ml/L, one spray of *Lecanicillium lecanii* (5g/L of 10^8 conidia/g) was evaluated for the control of*H. armigera*, *T. absoluta* and sucking pests of tomato. Chemical control where the crop was sprayed with chlorantraniliprole 18.5EC and indoxacarb 14.5 EC, and untreated control were also maintained. The treatment applications were started from the June end with the initiation of the attack of *T. absoluta*. *T. achaeae* was released six times at weekly intervals and azadirachtin was applied twice at 15 days interval, while, only one spray of *L. lecanii* was given towards the end of the cropping season. In chemical plot need based two sprays of chlorantraniliprole 18.5EC and one of indoxacarb 14.5 EC were given. Observations on the number of mines per leaf, number of fruits infested by *T. absoluta* and *H. armigera* were recorded separately on 10 randomly selected plants per plot. The observations were recorded at fortnight interval starting from mid-July till the final harvest of the crop i.e. mid-September. Yield data from each plot were recorded at each picking and were pooled to get the total yield. The data were subjected to analysis of variance using RBD and the results of the experiment are presented in **Tables 143 and 144** and described as under.

Incidence of *T. absoluta* on leaves: The number of mines by *T. absoluta* as recorded during July to August and Mines/leaf were given in **Table 143**. Both the BIPM module and the chemical insecticides were statistically equally effective in managing the pest.

Table 143.*Tuta* infestation on tomato leaves

Treatment	Mines/leaf on indicated dates			
	July 15	July 30	August 14	August 29
BIPM	2.8 ± 0.8	2.3 ± 0.9	1.7 ± 0.3	1.6 ± 0.4
Chemical control	2.9 ± 0.7	2.5 ±0.8	1.2 ± 0.4	1.8 ± 0.3
Untreated control	2.6 ± 0.6	3.6 ± 0.7	4.1 ± 0.6	5.2 ± 1.1
CD (0.05)	NS	0.8	1.7	2.1
CV (%)	18.9	28.1	33.7	43.2

Incidence of *T. absoluta* on fruits:

The average fruit infestation recorded on 15th of Julywas statistically same in all the plots and varied from 0.57% in untreated control to 0.62% in BIPM plots. With the passage of time the incidence increased in all the plots **(Table 144**). Thereafter, the percentage of infested fruits decreased in the BIPM plot and chemical plot, whereas, it went on to increase gradually in untreated control plots. Both the BIPM and chemical insecticides were statistically equally effective in reducing the fruit infestation by *T. absoluta* in tomato. The yield was maximum (22t/ha) in BIPM plots, but, statistically on par (21.3t/ha) with that recorded in chemical treated plots.

Table 144. *Tuta absoluta* infestation on fruits

Treatment	Infested fruits (%) on indicated date					Yield (t/ha)
	July 15	July 30	August 14	August 29	Sept 14	
BIPM	0.62 ± 0.20 (4.58 ± 0.54)	1.13 ± 0.12 (5.73 ± 0.67)	1.26 ± 0.15 (6.31 ± 0.85)	1.34 ± 0.17 (6.89 ± 1.04)	1.12 ± 0.16 (5.74 ± 1.13)	22.8 ± 4.6
Chemical control	0.58 ± 0.05 (4.51 ± 0.52	1.01 ± 0.09 (5.68 ± 1.03)	1.31 ± 0.11 (6.38 ± 1.12)	1.26 ± 0.18 (6.71 ± 0.98)	1.24 ± 0.19 (6.25 ± 1.49)	21.3 ± 3.8
Untreated control	0.57 ± 0.15 (4.49 ± 0.64	1.55 ± 0.62 (6.91 ± 1.01)	3.93 ± 0.83 (11.51 ± 2.02)	3.49 ± 0.54 (10.8 ± 2.12)	4.57 ± 0.77 (12.3 ± 2.23)	13.6 ± 4.1
CD (0.05)	NS	(0.79)	(1.38)	(1.99)	(2.44)	5.3
CV (%)	5.3	11.4	15.6	23.1	19.6	39.2

Incidence of *H. armigera* and aphids:

The incidence of *Helicoverpa armigera* was very low throughout the cropping seasonvaried from 0.53 to 2.67 throughout the season in different plots. Similarly towards the end of the cropping season, the incidence of tomato aphid, *Macrosiphum euphorbiae* was also recorded on the tender shoots of the plants. The aphid population recorded on top 10 cm length of the shoot on 14th of September was lowest (8.4) on chemically treated plants, followed by on par population (11.6) in BIPM plots. In untreated control plots the aphid population was 18.2.

23.1.6 IIVR, Varanasi

Variety	:	Kashi Aman
Plot size	:	8×5 m^2
Layout	:	Randomized Block Design.
Replication	:	Five

Bio-intensive pest management module (BIPM) comprising seed treatment with *Trichoderma harzianum*@ 10g/kg of seeds; raising marigold as trap crop; inoculative six-release of *T. pretiosum*@ 50,000 / release and spraying of azadirachtin 1500 ppm @ 2 ml/lit; and *L. lecanii* (NBAIR) 1×10^8 spores/ g @ 5g/lit for sucking pests was compared with chemical control (chlorantraniliprole 18.5%SC for *Tuta* and Indoxacarb 14.5 SC for other pests) and untreated control against insect pests complex of tomato. The major insect pests encountered during the observation were whitefly (*Bemisiatabaci*), Aphid (*Aphisgossypii*), Jassid (*Amrasca* spp.), leafminer (*Liriomyzatrifolii*) and tomato fruit borer (*H.armigera* and *T.absoluta*) along with the predatory mirid bug (*N.tenuis*) during January to April, 2019 at the experimental plots of ICAR-IIVR, Varanasi, Uttar Pradesh. From the table, it is evident that lowest whitefly (0.27), aphid (0.20), jassid (0.23) and leaf miner (0.97) populations per leaf were recorded in the BIPM module followed by chemical module with 0.43, 0.40, 1.30 and 0.30 pest population per leaf, respectively. In contrast, untreated control plots harboured maximum whitefly (1.77), aphid (1.31), jassid (2.89) and leaf miner (1.48) population per leaf. However, lowest fruit damage by its borer complex was recorded in chemical control module (1.57%) followed by BIPM module (3.33%) where maximum fruit damage (11.50%) was recorded in untreated control **(Table 145).** Similarly, occurrence of predatory mirid bug (*Nesidiocoristenius*) was recorded maximum in untreated control plots (2.58 bugs/leaf) followed by BIPM module (2.13) treated plots and lowest predator population (0.47) was in plots treated with chemical insecticides

.

Table 145. Effect of different pest management module of tomato

Treatments	**Whitefly/ leaf**	**PROC#**	**Aphid /leaf**	**PROC#**	**Jassid / leaf**	**PROC#**	**Leaf miner / leaf**	**PROC#**	**Fruit damage (%)**	**PROC#**	**Predatory mirid bug /leaf**
BIPM	0.35	80.23	0.35	73.28	1.06	63.32	0.83	43.92	3.33	71.04	2.13
Chemical control	0.59	66.67	0.51	61.07	1.52	47.41	0.68	54.05	1.57	86.35	0.47
Untreated control	1.77	--	1.31	--	2.89	--	1.48	--	11.50	--	2.58
CD (5%)	0.38		0.47		0.83		0.65		2.89		1.13

#PROC = Per cent reduction over control

23.1.7 IIHR

In the first trial, no incidence of *Tuta absoluta* was recorded on the plants and only 3 adults were caught in the trap during the crop period which was abandoned due to heavy rains and flooding in the field. The percent borer damage was minimal (10.82-13.77%) and was on par in all treatments **(Table 146).** In the second trial, six releases of *T. pretiosum* (50,000 per release) were done on 24.02.2019, 02.03.2019, 08.03.2019, 15.03.2019, 22.03.2019 and 29.03.2019. NBAIR pheromone traps @ 1 trap per plot were erected to monitor *T. absoluta*. Alternate application of Azadirachtin 1500 ppm @ 2 ml/lit, *L. lecanii*(NBAIR) 1x 10^8 spores/ g @ 5g/lt were carried out for sucking pests and soilapplication of *Pochonia chlamydosporia* was done for root-knot nematode. The incidence of *H. armigera* and *T. absoluta* were very minimal and fruit borer damage percentage damage was very low in all treatments **(Table 148)** hence no conclusive inference could be made. Adults of *T.absoluta* were trapped in the pheromone traps in small numbers occasionally **(Table 147).** No other stage of the pest was observed on the plant or fruits during the entire season. Incidence of *H. armigera* was insignificant across the treatments.

Table 146. Biointensive management of *Helicoverpa armigera, Tuta absoluta*and sucking pests of tomato (Var. Arka Rakshak and date of transplanting 07.08.2018)

Sl. No.	**Treatment**	**Total Yield (Kg)**	***H. armigera* Damage (Kg)**	**Percentage damage**
1	T1 BIPM	74.33	9.62	13.77
2	T2 Spinetoram 11.7% SC 0.25ml/L	74.7	8.62	11.96
3	T3 Control	75.88	8.28	10.82

Table 147. Biointensive management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato (Var. Arka Rakshak and date of transplanting 23.12.2018)

Treatments	Marketable yield (Kg)				*H. armigera* damaged fruits (kg)				Percentage damage
	Harvest 1	Harvest 2	Harvest 3	Total	Harvest 1	Harvest 2	Harvest 3	Total	
T1 BIPM	128.32	138.65	172	438.97	3.80	16.50	6.25	26.55	5.70
T2 Spinetoram 11.7% SC 0.25ml/L	105.10	159.50	182.52	447.12	2.85	2.53	6.80	12.18	2.65
T3 Control	169.55	126.60	131.25	427.40	5.70	3.75	4.7	14.15	3.20
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

T1 BIPM: Seed treatment with *T.harzianum* @ 10g/kg of seeds, Raising marigold as trap crop,Use of NBAIR pheromone traps @ 1 trap per plot, *T. pretiosum* @ 50,000 per release (6 releases), Azadirachtin 1500 ppm @ 2 ml/lit, *L. lecanii*(NBAIR) 1x 10^8 spores/ g @ 5g/lt for sucking pests and *P. chlamydosporia* for root knot nematode
T2=Spinetoram 11.7% SC 0.25ml/L
T3 = Untreated Control.

Table 148. Catches of *Tuta absoluta* in NBAIR pheromone traps (Var. Arka Rakshak and date of transplanting 23.12.2018)

S. No	Treatment	No. of adult *Tuta absoluta* in NBAIR pheromone traps (Average of 3 traps)						
		22/1/19	02/2/19	12/2/19	21/2/19	01/3/19	12/3/19	22/3/19
1.	NBAIR pheromone trap	3.66	8.33	6.66	8.33	4.66	8.33	8.33

23.1.7 Bio-intensive pest management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato (PJTSAU, Hyderabad)

Results: The trial is recently harvested in April, 2019. The outcome of the experiment will be submitted within week after processing and analyzing of data recorded.

23.2 Large scale field trials for the management *Helicoverpa armigera* (Hubner) on tomato (MPUAT – 2 ha)

Variety: Location specific popular variety
Plot Size: 2.0 ha
Location: Farmer’s field at Pilader and Veerpura (Jaisamand)
Year: 2018-19
Treatments: 3
Treatment details:
T1 = BIPM
Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds.
Azadirachtin 1500 ppm @ 2 ml/lit.

Beauveria bassiana @ 1×10^{8} conidia /gm, @ 5g/lt – 2 sprays at 15 days interval
Spray of HearNPV (1.5×10^{12} POBS/ha) twice during the peak flowering and at fruit setting stage at 15 days interval.
Bacillus thuringiensis @ 1kg/ha-1 two times during season at 15 days interval

T2 = Chemical control

Spinosad 45SC @ 0.25 ml/***l***

T3 = Untreated Control

Observations:

The treatment applications were started at initial occurrence of *H. armigera* infestation and biopesticides were applied during evening hours at fortnightly interval.
Randomly select 10 plants/ 40 m^{2} crop area were observed for presence of holes/ damage caused by the larva.
Observations were recorded at fortnightly interval from fruit formation to last harvest.
Fruit damage percentage and yield were recorded

Table 149. Effect of different modules on incidence of *H. armigera* and yield of tomato during *rabi*, 2018-19

Modules/Treatments	*H. armigera* larvae /plant*	Fruit damage* (%)	Fruit yield (t/ha)
BIPM Package	2.11	21.67	15.10
Chemical Control	1.83	20.91	15.90
Untreated Control	2.70	33.07	9.75

Results: Demonstration experiment was conducted in *rabi,* 2018-19. During the experimental period, incidence of *H. armigera* incidence was recorded. No significant difference was observed between BIPM package and chemical control with regard to the parameters *viz.*, number of *H. armigera* larvae/plant and fruit damage. BIPM package was equally effective as chemical control against *H. armigera*. Chemical control module recorded the highest yield (15.90 t/ha) which was at par with the yield recorded in BIPM package (15.10 t/ha). Significantly, low yield was recorded in untreated control (9.75 t/ha). It could be concluded that BIPM package had promising results in minimizing the pest damage with higher yield **(Table 149).**

24. BRINJAL

24.1. Role of habitat manipulation for insect pests, nematodes and natural enemies in brinjal (AAU-J)

Location: Organic plot, Experimental Farm, Department of Horticulture, AAU, Jorhat
Plot size: 5 × 5.5 sq.m.
Replication: 5, Design: RBD
Date of planting: 10.11.2018
Treatments: 4

Treatment details:

T1: Brinjal intercropped with coriander and carrot as border crop.
T2: Brinjal intercropped with carrot and cowpea as border crop.
T3: Brinjal intercropped with cowpea and coriander as border crop.
T4: Brinjal as sole crop.

Population of aphids and leafhopper per leaf were recorded from randomly selected 5 plants throughout the cropping season starting from 25 DAT at 15 days interval from each plot at 3 leaves (top, middle and lower). Similarly, per cent infestation of shoots and fruits was also recorded from different stages of the crop starting from 25 DAT. The natural enemy population (coccinellids) was recorded from per plant at 15 days interval. Moreover, to collect the parasitoids from sucking and lepidopteran larvae, the insects were kept in the laboratory for emergence of parasitoids, if any. Marketable yield at each harvest was recorded.

Table 150. Effect of different treatments for insect pests and natural enemies in brinjal

Treatment	Aphids/ leaf	Leaf Hopper/ leaf	BSFB		No of predator /plant	Yield (q/ha)
			Shoot (%)	Fruit (%)		
T1	4.60[b]	2.12 [a]	13.97 [c]	13.77 [b]	1.87 [a]	202.00 [b]
T2	2.65 [a]	2.32 [a]	11.37 [a]	10.08 [a]	1.91 [a]	210.67 [b]
T3	5.95 [c]	3.44 [b]	12.64 [b]	14.05 [c]	1.15 [c]	184.40 [c]
T4	8.20 [d]	4.60 [c]	14.70 [c]	18.45 [d]	1.60 [b]	152.37 [d]
CD=0.05	0.88	0.64	0.87	0.45	0.20	7.68
CV%	11.9	14.8	16.21	8.72	9.15	2.98

*Data based on mean of five replications. Column mean followed by same letter do not differ significantly at 5% level of probability

Results:

The population of aphids and leafhopper/ leaf and *Leucinodesorbonalis* in different treatments indicated that in Treatment-2, the lowest population of aphid (2.65/leaf), leaf hopper (2.32/leaf) and shoot(11.37%) and fruit damage(10.08%) was recorded with a maximum yield of 210.67 q/ha. Higher number of coccinellids predator population of 1.91/ plant was recorded in Treatment-2 and lowest in Treatment-4, 1.60coccinellids/ plant **(Table 150).**

24.2Biointensive insect pest management in brinjal (AAU-Jorhat, KAU, Thrissur, MPKV, TNAU, CAU, Pasighat, OUAT, NBAIR)

23.2.1 AAU- Jorhat

Location: Farmes' field, NeulGaon, Alengmora, Jorhat
Plot size: 200sqm
N:P:K: 50:50:50
Variety: PusaPuple Long
Date of Planting: 27.10.2018
Replication: 8
Treatments: 3
Treatment details:
T1 = BIPM
For sucking pests
Azadirachtin 1500 ppm @ 2ml/lt
Lecanicillium lecanii (NBAIR strain) 1x 10^8 spores/ml @ 5g/lt
For BSFB
Release of *Trichogramma chilonis* multiple insecticide tolerant strain @100,000/ha, 8-10 releases at weekly interval from initiation of flowering.
T2 = Chemical Control
Profenophos 50 EC @ 2 ml/l at 10 days interval
T3: Untreated control

Observations on pretreatment incidence on shoots infestation and catches of *Leucinodesorbanalis* from pheromone traps were recorded. Traps were erected in the field from 25 DAT to 55 DAT@ 15 traps/ha. On an average 21.75 adult of *L. orbonalis* was trapped per pheromone traps. Post treatment counts of infestation of shoots and fruit stages of the crop were recorded at fortnightly interval from 10 randomly selected plants in each treatment block after imposition the treatments. Per cent fruit damage and weight of the marketable brinjal per treatment block were recorded at the time of each harvesting. Nine releases of *T. chilonis* (MITS) were made @ 1,00,000 in BIPM plots. Six rounds of profenophos 50 EC @ 0.05% was sprayed at fortnightly interval staring from 35 DAT in farmer's practice. Egg parasitism by *T. chilonis*were also recorded through retrieval by placing sentinel egg cards of *Corcyra* at five spots in each treatments block. Hand collection and destruction of infested shoots along with larval stages of *L. orbonalis* was also done prior to flowering in all the treatments plots. The yield of marketable fruit per plot at each picking was summed up and converted into q/ha

Table 151.Effect of BIPM package against*Leucinodesorbanalis* of brinjal

Treatment	% shoot damage*		%fruit damage**	Parasitism (%) (*Trichogramma* spp.)	Yield(q/ha)
	Pre treatment	Post treatment			
BIPM	14.25 (3.76)	11.43 ^{b} (3.37)	13.24^{b} (3.62)	6.8	236.61^{b}
Chemical control	15.03 (3.86)	8.68 ^{a} (2.94)	9.77 ^{a} (3.11)	2.4	261.72 ^{a}
Untreated check	14.58 (3.81)	18.67 ^{c} (4.31)	23.88 ^{c} (4.88)	3.7	135.25^{c}
CD	NS	1.35	0.27	-	6.12
CV (%)		5.54	6.35	-	2.69

*Mean of three observations

**Mean of six observations

Figures in parenthesis are transformed angular values

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

Results: Farmer's practice withsix round sprays ofprofenofos 50EC @ 2 ml/l at fortnightly interval contributed maximum protection with average per cent shoot and fruit infestation of 8.68 and 9.77, respectively with maximum yield of 261.72 q/ha **(Table 151).** It was, however significantly different from those of BIPM. The incidence of shoot and fruit infestation in BIPM plot was 11.43 and 13.24%, as against 18.67 and 23.88% in untreated control plots, respectively. The yield of BIPM package was 236.61q/ha, as against 135.25q/ha in untreated control plot. The per cent parasitisation on *Corcyra* sentinel cards by trichogrammatids species in BIPM plots was 6.8 as against 2.4% in chemical control plots.

24.2.2 KAU, Thrissur

An experiment on validation of biointensive integrated pest management (BIPM) in brinjal was carried out at College of Horticulture, Vellanikkara from September 2018 to March 2019, as per the details given below.

Design: RBD Variety: Haritha

Plot size: 40 m^2/ replication.

T1 = BIPM

For sucking pests

Beauveria bassiana @ 10^8 conidia/ ml

NSKE5%

Lecanicillium lecanii (NBAIR strain) 10^8 spores/ml

Bacillus thuringiensis NBAII *Bt*G42%

For mealybug

T1: *Cryptolaemus montrouzieri* @ 5 grubs / plants, twice at 15 days interval.

T2: BSFB- Flubendiamide 25 g a.i ha^{-1}

Mealybug- Imidacloprid 30 g a.i ha^{-1}

T3: Untreated control

Results: The results of mean shoot damage, mean fruit damage and mean mealy bug count are given in **Table 152, 153 and 154**, respectively.

Table 152. Comparison between BIPM and chemical control for the management of shoot damage by brinjal shoot and fruit borer *Leucinodesorbonalis*

	Mean shoot damage (%)				
Treatment	**Pre count**	**5 DAS1**	**10 DAS1**	**5 DAS2**	**10 DAS2**
T1: BIPM	14.664(3.88)	20.97(4.66)	17.63(4.25)	15.94(4.051)	10.30(3.28)
T2:Flubendiamide	16.09(4.02)	18.80(4.39)	17.75(4.27)	13.73(3.770)	9.01((3.07)
T3: Control	17.66(4.22)	22.7(4.812)	22.93(4.83)	23.41(4.887)	21.10(4.64)
CD @ 5%	NS	0.33	0.18	0.19	0.37

Values in parentheses are square root transformed values

Table 153. Comparison between BIPM and chemical control for the management of fruit damage by brinjal shoot and fruit borer *Leucinodesorbonalis*

Treatment	Mean fruit damage (%)			
	5 DAS3	**5 DAS4**	**5 DAS5**	**Yield**
T1: BIPM	34.07(34.928)	38.00(37.9)	32.04(34.07)	8.61
T2:Flubendiamide	26.15(27.692)	35.23(36.14)	33.15(35.03)	9.76
T3: Control	51.84(46.037)	38.13(38.03)	57.09(49.56)	5.42
CD @ 5%	11.98	NS	14.16	2.48

Values in parentheses are arc sine transformed values

Table 154. Comparison between BIPM and chemical control for the management of mealybug by brinjal mealybug

	Mean number of mealybugs per plant				
Treatments	**5 DAS4**	**10 DAS4**	**5 DAS5**	**10 DAS5**	**5 DAS6**
T1: BIPM	16.55(2.14)	18.12(2.21)	16.15(2.21)	0(0.707)	0(0.707)
T2:Imidacloprid	0(0.707)	0(0.707)	0(0.707)	10.61(1.84)	3.46(1.31)
T3: Control	53.71(5.86)	57.20(6.03)	53.89(5.86)	64.67(6.39)	69.07(6.59)
CD @ 5%	3.76	3.89	3.73	4.50	4.17

Results: Shoot damage was observed only during the early stages of the experiment.Five days after second round of spray, the BIPM and chemical control treatments were significantly superior to untreated control in terms of shoot damage. Chemical control was also superior to BIPM with mean shoot damage of 13.73% as against 15.94% in case of BIPM plots. Ten days after second spray, plots sprayed with insecticide (9.01% shoot damage) was on par with those where BIPM was followed (10.3% mean shoot damage), both being significantly superior to untreated control. Both BIPM and insecticide treated plots had significantly fewer fruits damaged (34.07% and 26.15%, respectively) as compared to untreated control. When BIPM treatment recorded 32.04% fruit damage as compared to 33.15 in flubendiamide treated plots, both treatments were on par with each other and significantly superior to control (57.04%).Mealy bug infestation was observed from January 2019 onwards. Plots treated with imidacloprid were free of mealy bug infestation till the final stages of the crop. BIPM plots also constantly recorded fewer mealy bugs as compared to the untreated control.Both BIPM and insecticide treated plots recorded yields of 8.61 and 9.76 Kg per plot, respectively, which were significantly superior to untreated plots with mean yield of 5.42 Kg/plot. Both the treatments were on par with each other.

24.2.3 MPKV, Pune

The experiment was laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune, brinjalcv. Panchganga was sown on 05/07/2018 in 4.5 x 4.5 m plot size with 90 x 90 cm. Experiment was laid ina RBD with eight treatments with three replications. Three sprays of biopesticides and chemical insecticide were given at fortnightly interval, whereas 6 releases of *T. chilonis*were done at weekly interval. The observations were recorded on five randomly selected plants per plot. The yield of healthy marketable fruits per plot was registered at each picking. The shoot and fruit damage caused by *L. orbonalis*were recorded at weekly interval from initiation of treatment application and post counts are presented in **Table 155.**

Treatments details:

BIPM	**Pests**	1:Azadiractin 1500 @2 ml/lit
		2:*L.lecanii*(NBAIR strain) 1x 10^8spores/ml@ 5 gm/lit
	BSFB	1: *T. chilonis*@ 100,000/ ha, 8-10 releases at weekly interval (6 releases)
		2: *B. thuringiensis* (NBAIR strain) *Bt* G4 @ 20ml/ lit
	Ash weevil	EPN (NBAIR) strain @ 2 billion IJs/ ha
	Mealy bug	*C.montrouzieri* @ 5 grub /plants or 1500/ ha
	Tutaabsoluta	chlorantraniliprole 18.5 % SC @ 0.4 ml /lit
		untreated control

Table 155. Efficacy of bioagents for management of shoot and fruit borer, *L. orbonalis*on brinjal

Treatment	Shoot damage (%)		Fruit damage (%)		Yield (q/ha)
	Pre-count	Post count	No. basis	Wt. basis	
T1 : BIPM Azadiractin 1500 @2 ml/lit *L. lecanii*(NBAIR strain) 1x 10^8spores/ml@ 5 gm/lit *T.chilonis*@ 100,000/ ha, 8-10 releases at weekly interval *B. thuringiensis* (NBAIR strain) *Bt* G4 @ 20ml/ lit EPN (NBAIR) strain @ 2 billion IJs/ ha *C.montrouzieri* @ 5 grub /plants or 1500/ ha	16.52[a] (23.94)	8.12 [a] (16.55)	10.04 [a] (18.48)	5.68 [a] (13.78)	208.40 [a]
T2: Chlorpyrifos0.04%	16.42 [a] (23.86)	6.56 [a] (14.84)	5.58 [a] (17.03)	4.74 [a] (12.57)	226.34 [a]
T3: Untreated control	16.36 [a] (23.83)	26.80 [b] (31.18)	40.26 [b] (39.38)	42.50 [b] (40.69)	140.38 [b]
SE	**0.70**	**0.74**	**0.80**	**0.79**	**9.90**
CD at 5%	**NS**	**2.24**	**2.41**	**2.40**	**30.04**
CV	**18.32**	**16.07**	**17.04**	**15.03**	**13.69**

Figures in parenthesis are arc sin transformed values.

Results: The results in **Table 155** indicated that the treatments with chlorpyrifos0.04% and BIPM were found at par with each other by recording shoot infestation (6.56% and 8.12%), fruit damage on number basis (5.58% and 10.04%) and on weight basis (4.74% and 5.68%), respectively.The highest marketable fruit yield (226.34 q/ha) was recorded in chlorpyrifos0.04% treated plots which was at par with BIPM treated plot (208.40 q/ha).

24.2.4 TNAU, Coimbator

Name of the Farmer : Mr.Dileep
Location : Vattmalapalayam, Coimbatore
Brinjal Variety : Varikathiri
Plot size : 8 × 5 m
Replications : 8

Treatments:

T1: BIPM
Azadirachtin 1500 ppm @ 2ml/lt.
Lecanicillium lecanii (NBAIR strain) 1× 10^8 spores/ml @ 5g/lt.
Cowpea as border crop
Mass trapping of fruit borer with pheromone traps
Release of *Trichogramma pretiosum* @100,000/ha, 8-10 releases at weekly interval from initiation of flowering.
T2: Chemical Control

T3: Untreated control

Results: The fruit damage in brinjal was significantly low (10.45%) in plots sprayed with pesticides followed by 14.65% fruit damage in BIPM plots (Azadirachtin 1500 ppm @2ml/lit (one round of spray) + *L. lecanii* (one round of spray) + *T.pretiosum*(8 releases) + Pheromone traps @20/ha + cowpea as bund crop) **(Table 156).**In the control plot fruit damage was 31.28%. The fruit damage in BIPM and insecticides treated plots was significantly lower than the fruit damage in the control plot. The cost benefit ratio realized in BIPM was 1:3.58 as against 1:4.57 in insecticides treated plots.

Table 156.Biointensive insect management in brinjal

Treatments	Fruit damage %	% decrease over control	Yield Kg/ha (marketable fruits)	% increase over control	CB ratio
T1: BIPM- Azadirachtin 1500 ppm @2ml/lit (one round of spray) + *T. pretiosum*(8 releases) + Pheromone traps @20/ha + Cowpea as bund crop	14.65 (22.3)[b]	46.84	11624[a]	26.57	4.60
T2: Spraying of imidacloprid (0.5 ml/lt), flubendiamide (0.5 ml/ lt) and Dimethoate (2ml/lt)	10.45 (18.7)[a]	33.40	12152[a]	32.32	5.49
T3: Control	31.28 (33.9)[c]		9184[b]		
SEd	1.1586		594.26		
CD(P=0.05)	2.4852		1274.71		

Means followed by a common letter in a column are not significantly different by DMRT
Values are mean of six replications

24.2.5 CAU, Pasighat

On farm trial was conducted in the field of department of plant protection, Collage of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh to manage the insects and root-knot nematodes in brinjal. The experimental field of an area 24 x 9 m in size and it was further divided into three treatments and was replicated eight times. The experiment was carried out during *kharif* season, 2018-19. The Brinjal variety ‘PusaUttam’ was used for the experiment and transplanted at 75 x 60cm. The first treatment is the biocontrol based component, second treatment was chemical control compare and untreated control. The experiment was laid out in randomized complete block design.

In the BIPM module, *Paecilomyces lilacinus* @ 20 g/m^2 (root-knot nematode management), Azadirachtin 1500ppm@2ml/L, *Lecanicillium lecanii* (NBAIR Strain) 1x10^8 spores/ml @ 5g/L (for sucking pests) and mass trapping, release of *Trichogrammachilonis*@ 100,000/ha. 8-10 release at weekly interval from initiation of flowering, *Bacillus thuringiensis* NBAIR *Bt*G4 2% spray (Brinjal Fruit and Shoot Borer) were used. Soil application of *P.lilacinus*, @ 20 g/m^2 wasdonealong with FYM 15 days prior to transplanting. Dimethoate 200 a.i./ha. @ 660 ml dissolve in 700 L/ha sprayed as chemical control and observations were recorded on pre and post count of insects, initial and final nematode populations, percent shoot and fruit damage, insect population in three terminal leaves such as aphids, jassids and white flies. Data on per cent shoot and fruit damage and yield of marketable fruits per plot was summed and converted into quintals per ha was recorded.

Results

The data in **Table 157** indicated that spray of dimethoate 0.05% was effective by causing lowest shoot (6.90%) and fruit (8.40%) damage and gave maximum yield (224.40 q/ha). However, the BIPM module were the next best treatment showing 10.3% shoot and 12.40% fruit infestation and gave 213.60 q/ha yield. The percent reduction over the control was max chemical control (53.33%) compared to the BIPM module (31.11%).

Table 157. Effect of different BIPM modules against infestation of *Leucinodesorbonalis* and brinjal yield

Treatments	% Shoot Damage		% Fruit Damage	% reduction over control	Yield (q/ha)
	Pre-count	Post-count			
T1	18.10±0.25	10.30	12.40	31.11	213.60
T2	18.70±0.67	6.90	8.40	53.33	224.40
T3	19.10±0.45	13.10	18.00	-	167.30

T1 = BIPM, T2= Chemical control, T3= untreated control

.

Table 158. Effect of different IBPM modules against infestation of sucking pests and brinjal yield

Treatments	Average no. of sucking pests population/3 leaves						
	Aphids		Jassids		Whiteflies		Yield (q/ha)
	Pre-Count	Post-Count	Pre-Count	Post-Count	Pre-Count	Post-Count	
T1	20.86	6.60	5.89	1.66	5.60	1.60	213.60
T2	20.74	5.12	6.54	1.28	6.00	1.10	224.40
T3	20.11	27.45	5.83	8.68	4.80	11.40	167.30

T1 = BIPM, T2= Chemical control, T3= untreated control

The sucking pests were recorded from randomly selected 5 plants per plot and tagged as replicate before treatment and 10 days after each treatment. The pest population was recorded from three leaves (terminal shoots)/plant. The treatments with dimethoate and BIPM were superior over the untreated control in reducing sucking pests, *viz.*, aphids, jassids and whiteflies population. The highest yield (224.40 q/ha) was recorded in dimethoate compare to BIPM module (213.6 Q/ha**) (Table 158).**

Table 159. Effect of different IBPM modules against root knot nematode, *Meloidogyne incognita* race-2and brinjal yield

Treatments	Initial nematode population	Final nematode population	Decline in RKN Population (%)	Yield (q/ha)
T1	248.5	149.00	39.91	213.60
T2	281.80	158.00	43.93	224.40
T3	315.00	460.00	0.00	167.30

T1 = BIPM, T2= Chemical control, T3= untreated control

The average initial root-knot nematode population in the field ranged from 248.5 to 315 nematode/200 cm^3 of soil. It could be seen from **Table 159** that all the treatments were significantly superior over untreated control in reducing the root-knot nematode population with increase in the yield. However, soil application of *P.lilacinus,* @ 20 g/m^2 wasdonealong with FYM 15 days prior to transplanting was found effective in reducing the root-knot nematode population (39.91 %) and increasing the yield. However, the treatment with dimethoate was found most effective compare to other treatments with reduction in root-knot nematode population (43.93%).

24.2.6 OUAT, Bhubaneswar

Variety: VNR -B5
Plot size: 8x5m
Design: RBD
TREATMENTS
T1: BIPM
For sucking pests
Azadirachtin 1500ppm @ 2ml /l-3 sprays
Lecanicillium lecanii (NBAIR strain) 1×10^8 spores /g @5g/l- 2 sprays
For BSFB
Mass trapping by PCI traps
Release of *T.chilonis* multiple insecticide tolerant strain @
1, 00,000/ha, 12 releases were made at weekly interval from initiation of flowering
For epilachna beetle and ash weevil
Entomopathogenic nematode (NBAIR strain) @ 2 billion IJs/ha -2 sprays
T2: Chemical control
Lambda cyhalothrin 5 EC @ 1ml /l-6 sprays at 15-20 days interval
Coragen- 5 sprays at 15-20 days interval
T3: Untreated control
No. of replications: 8
Date of transplanting: 31.08.2018
Date of last harvesting: 25.01.2019

Observations: The pheromone trap against BSFB was installed on 15.10.2018 in BIPM plots and weekly moth catches were recorded. Pre treatment incidence one day before spraying and post treatment incidence 10 days after spraying were recorded against BSFB both at vegetative and reproductive stages of the crop. Finally, fruit yield and cost benefit ratios were determined.

Results: It is evident from **Table 160** that, there was significant reduction in BSFB damage in BIPM plots as compared to untreated control. Although, there was marked reduction in shoot damage in chemical control as compared to control plots, but the fruit damage in chemical control remained at par with control. Highest yield (9.5 t/ha) and C: B ratio (1:1.54) were noted in BIPM plots followed by chemical control. Lowest yield (6.9 t/ha) was recorded in untreated control

Table 160. Effect of bio-intensive insect management in brinjal

Treatments	**Shoot damage (%)**	**Fruit damage (%)**		**Fruit yield (t/ha)**	**Increased yield over control (t/ha)**	**Avoidable loss (%)**	**Cost of increased yield over control (Rs/ha)**	**Cost of control (Rs.)**	**Net profit (Rs.)**	**C:B ratio**
		No. basis	**Wt. basis**							
BIPM	15.12* (3.94)	60.06	60.77	9.500	2.525	-	50,500	19,874	30,626	1:1.54
Chemical control	18.75 (4.38)	62.08	63.38	8.430	1.463	11.26	29,260	20,130	9130	1:0.45
Untreated check	24.95 (5.04)	62.92	64.33	6.975	-	26.58	-	-	-	-
S.E. (m) ±	- (0.11)	0.67	0.84	0.317	-	-	-	-	-	-
C.D. (0.05)	- (0.33)	2.03	2.54	0.957	-	-	-	-	-	-

*Figure in parentheses are $\sqrt{(x+0.5)}$ transformed values

24.2.7 NBAIR, Bengaluru

A field trial was conducted to manage brinjal fruit and shoot borer through release of *Trichogramma chilonis* (HQS strain).

Results: The trial was conducted at farmer field in village Thalahalli, Chikballapur. Twelve release of *Trichogramma chilonis* (HQS) @ 1, 00,000/ release were made against fruit and shoot borer. The observation on fruit damage, shoot damage and per cent fruit damage was recorded after 15 days of application of Trichocards. In the present study, results indicated that the percent fruit and shoot damage was less compared to the farmer practice. The percent fruit damage was recorded significantly lower in the biocontrol agent applied field in comparison to farmer practices (F= 105.65; df =1,119, P<0.0001). Similarly the percent shoot damage was also significantly lower in the biocontrol agent applied field in comparison to farmer practices (F= 98.73; df= 1,119, P<0.0001) **(Table 161).**

Table 161. Effect of biocontrol based management practice on brinjal fruit and shoot borer

Treatment	% Shoot damage*	%Fruit damage (%)*
T_1	5.11±0.29	10.00±1.03[a]
T_2	16.391±0.37	31.61±1.30[b]
P value	*P*<0.0001	*P*<0.0001

*Mean of four observations at 15 days interval

24.3 Bioefficacy of microbial agents against *Myllocerous subfasciatus* on brinjal (IIHR)

Variety	Variety will be selected as per the institute recommendation
Plot size	8x5 m
Layout	Randomized Block Design.
Treatments	Treatments T1: *M. anisopliae* (IIHR Strain) oil formulation @ 1ml/l T2:*B.bassiana* (IIHR Strain) WP formulation 10g/l T2: *M. anisopliae* (Biometa, AAU strain) (1x108 spores /g) @ 5g/ litre T3: *B.bassiana* (Biosona, AAU strain) (1x108 spores /g) @ 5g/ litre T4: *M.anisopliae* (Ma-4) NBAIR strain (1x108 spores /g) @ 5g/ litre T5: *B. bassiana* (Bb-5a) NBAIR strain (1x108 spores /g) @ 5g/ litre T6: *Heterorhabditis indica* @ 2.5 10^9 IJs ha^{-1} T7: Imidacloprid @ 20 g ai/ha T8: Untreated control

In the first trial, incidence of *Myllocerous subfasciatus* was minimal in the field during the season **(Table 162).** Wilting of plants was not observed in the field for destructive sampling to look for grubs. The trial was abandoned after the second observation post imposition of treatments due to heavy rains and flooding in the field.

In the second trial, incidence of *M.subfasciatus* was very scarce. Along with the six treatments, one round of Azadirachtin 1500ppm @2ml/L spray , one spray of *Lecanicillium lecanii*(NBAIR)1×10^8 spore/ g @ 5g/lt and six releases of *Trichogramma chilonis*(50,000 per release) were done except in T7 where imidacloprid was sprayed and unsprayed control. Observations were recorded on yield and percentage damage caused by brinjal shoot and fruit borer **(Table 163).** The percentage borer damage ranged from 2.41% to 7.90% in the treatments against 8.31% in imidacloprid treated plots and 15.03% in untreated control.

Table 162. Bioefficacy of microbial agents against shoot and fruit borer on brinjal (Var. ArkaAnand; date of transplanting 07.08.2018)

Treatment	Leaf damage percentage		
	Pre treatment	**Post treatment-I**	**Post treatment-II**
T1: *M. anisopliae* (IIHR Strain) oil formulation @ 1ml/l	6.19	3.10	4.23
T2:*B. bassiana* (IIHR Strain) WP formulation 10g/l	7.92	3.31	5.31
T3: *M.anisopliae* (Biometa, AAU strain) (1x108 spores /g) @ 5g/ litre	6.40	3.38	3.02
T4: *B. bassiana* (Biosona, AAU strain) (1x108 spores /g) @ 5g/ litre	8.15	4.17	4.00
T5: *M. anisopliae* (Ma-4) NBAIR strain (1x108 spores /g) @ 5g/ litre	7.00	3.85	3.15
T6: *B. bassiana* (Bb-5a) NBAIR strain (1x108 spores /g) @ 5g/ litre	7.27	3.65	3.63
T7: *Heterorhabditis indica* @ 2.5 10^9 IJs ha^{-1}	6.63	3.67	3.58
T8: Imidacloprid @ 20 g ai/ha	6.27	4.31	1.96
T9: Untreated control	6.19	3.10	4.23

The trial was abandoned due to heavy rains and flooding in the field.

Table 163. Bio-intensive management of shoot and fruit borer on brinjal (Var. ArkaAnand; date of transplanting 23.12.2018)

Treatment	**No. leaf with feeding marks**							**Percentage Fruit and shoot borer damage**
	22/1/19	02/2/19	12/2/19	21/2/19	01/3/19	12/3/19	22/3/19	
T1: *M.anisopliae* (IIHR Strain) oil formulation @ 1ml/l	0	2	0	0	0	0	2	7.90
T2:*B. bassiana* (IIHR Strain) WP formulation 10g/l	0	0	1	1	0	0	0	6.60
T3: *M. anisopliae* (Biometa, AAU strain) ($1x10^8$ spores /g) @ 5g/ litre	2	2	2	0	0	0	0	4.85
T4: *B.bassiana* (Biosona, AAU strain) (1x108 spores /g) @ 5g/ litre	2	0	0	0	1	1	1	2.37
T5: *M. anisopliae* (Ma-4) NBAIR strain (1×10^8 spores /g) @ 5g/ litre	0	2	1	0	0	0	0	2.41
T6: *B. bassiana* (Bb-5a) NBAIR strain (1×108 spores /g) @ 5g/ litre	1	0	0	0	2	2	2	5.08
T7: *Heterorhabditis indica* @ 2.5×10^9 IJs ha^{-1}	0	2	0	1	0	0	0	6.32
T8: Imidacloprid @ 20 g ai/ha	0	1	1	0	0	0	1	8.31
T9: Untreated control	0	0	1	1	1	1	0	15.03

T1 to T6 included one spray of Azadirachtin 1500ppm @2ml/L, one spray of *Lecanicillium lecanii*(NBAIR)$1X10^8$ spore/ g @ 5g/lt and six releases of *Trichogramma chilonis* (50,000 per release).

25. OKRA

25.1 Efficacy biocontrol agents for management of fruit borer *Eariasvittella*on okra (AAU-Anand, and TNAU)

25.1.1 AAU-Anand

Objectives: To evaluate the efficacy of different biocontrol agents on fruit borer *Eariasvittella*infesting okra.
Year of commencement: 2017-18 – *kharif*
Location: Agronomy farm, AAU, Anand

Variety	:	GAO 5
Spacing	:	60 x 30 cm
Plot size	:	8 x 5 m
Net Plot	:	7.6 x 4.8 m
Layout	:	Randomized Block Design (RBD)
Treatments	:	T1: *Lecanicillium lecanii* @ 5 g/ litre (2×10^8cfu/g) 1% WP T2: *Metarhizium anisopliae*@ 5 g/ litre (2×10^8cfu/g) 1% WP T3: *Beauveria bassiana*@ 5 g/ litre (2×10^8cfu/g) 1% WP T4: *Trichogramma chilonis*@ 50,000 parasitoids/ha, 6 releases at weekly interval starting from initiation of fruit ripening T5: *Bacillus thuringiensis* @ 5 g/ litre ($2x10^8$cfu/g) 1% WP T6: NSKE 5% suspension T7: Emamectin benzoate 5 SG @ 0.0025% (12.5 g.a.i./ha) (5g/10 litre water) T8: Untreated control
Replications	:	Three
Methodology	:	Six releases of parasitoid*T. Chilonis* were made at weekly interval and three sprays of entomopathogens, NSKE and chemical insecticide were carried out at fortnightly interval with the initiation of pest.

Observations:
The observations were recorded on five randomly selected plants/ plot.

1. **Pre and post- treatment counts on fruit infestation.**
The observations on larval population of *E. vittella* were recorded from five randomly selected plants per treatment before spray and at 5th, 10th and 15th day after each spray. The observations on fruit damage on number and weight basis was recorded from net plot area from each treatment at each picking **(Table 165)**
2. **Yield of healthy marketable fruits at each picking.**

Results:
Among different biocontrol agents tested, significantly lowest number of *E. vittella* larvae/plant was recorded in the treatment T_5 – *B. thuringiensis* @ 5 g/litre (0.99) which was followed by treatments T_4 – *T. chilonis*@50,000 parasitoids/ha (1.06), T_6 - NSKE 5% suspension (1.09) and T_3 - *B. bassiana* @ 5 g/litre (1.10). Similar trend was observed with regard to yield parameter and the efficacy of bioagents *B. thuringiensis* was nearly equal to that of chemical insecticide used **(Table 164).**

Table164. Bio-efficacy of different biocontrol agents against *Eariasvittella* on okra

Treatments		BS	No. of larvae / plant												Pooled over periods over sprays
			1st spray				2nd spray					3rd spray			
			5 DAS	10 DAS	15 DAS	Pooled	5 DAS	10 DAS	15 DAS	Pooled	5 DAS	10 DAS	15 DAS	Pooled	
T1	*L. lecanii* @ 5 g/ litre	1.55a	1.34a	1.37c	1.44d	1.38d	1.53d	1.39d	1.44d	1.45e	1.54d	1.39d	1.39d	1.44e	1.43e
T2	*M. anisopliae*@ 5 g/ litre	1.54a	1.35a	1.22bc	1.12c	1.22c	1.37c	1.25cd	1.22c	1.28d	1.25c	1.15c	1.13c	1.18d	1.23d
T3	*B.bassiana*@ 5 g/ litre	1.55a	1.30a	1.16b	1.03bc	1.16bc	1.24bc	1.11bc	1.03bc	1.12c	1.11bc	1.01bc	0.94bc	1.02c	1.10c
T4	*T.chilonis* @ 50,000 parasitoids/ha	1.54a	1.32a	1.16b	1.00bc	1.16bc	1.17bc	1.07bc	0.98b	1.07bc	1.00ab	0.94bc	0.90b	0.95bc	1.06c
T5	*Bacillus thuringiensis* @ 5 g/ litre	1.49a	1.20a	1.07ab	0.87ab	1.06ab	1.13b	1.04b	0.87ab	1.01b	0.98ab	0.87ab	0.83ab	0.89b	0.99b
T6	NSKE 5%	1.54a	1.34a	1.17b	1.01bc	1.17bc	1.25bc	1.11bc	0.96b	1.10bc	1.02abc	1.00bc	0.94bc	0.99bc	1.09c
T7	Emamectin benzoate 5 SG @ 0.0025%	1.59a	1.19a	0.98a	0.70a	0.96a	0.90a	0.78a	0.70a	0.79a	0.78a	0.70a	0.70a	0.73a	0.83a
T8	Untreated control	1.56a	1.56a	1.64d	1.77e	1.65e	1.79e	1.85e	1.85e	1.83f	1.81e	1.85e	1.85e	1.83f	1.77f
S. Em. ±	**Treatment(T)**	**0.09**	**0.08**	**0.05**	**0.08**	**0.04**	**0.07**	**0.06**	**0.07**	**0.04**	**0.08**	**0.07**	**0.06**	**0.04**	**0.02**
	Period (P)	**-**	**-**	**-**	**-**	**0.02**	**-**	**-**	**-**	**0.02**	**-**	**-**	**-**	**0.02**	**0.01**
	Spray (S)	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.01**
	T x P	**-**	**-**	**-**	**-**	**0.07**	**-**	**-**	**-**	**0.06**	**-**	**-**	**-**	**0.07**	**0.04**

T x S	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.04**
S x P	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.02**
T x S x P	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.07**
C. D. at 5% T	**NS**	**NS**	**0.16**	**0.23**	**0.12**	**0.22**	**0.18**	**0.21**	**0.11**	**0.24**	**0.21**	**0.19**	**0.11**	**0.06**
P	**-**	**-**	**-**	**-**	**0.07**	**-**	**-**	**-**	**0.06**	**-**	**-**	**-**	**0.07**	**0.04**
S	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.04**
T x P	**-**	**-**	**-**	**-**	**0.22**	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**	**0.00**
T x S	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.00**
S x P	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**NS**
T x S x P	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**NS**
C. V. (%)	**9.91**	**10.34**	**7.44**	**11.68**	**11.08**	**9.70**	**8.70**	**10.81**	**9.82**	**11.52**	**10.88**	**10.03**	**10.84**	**10.57**

BS: Before Spray, DAS: Days after spray

Table 165. Influence of different biocontrol agents on fruit damage of yield of okra

Treatments		Fruit damage (%)		Yield (q/ha)
		Number basis	Weight basis	
T1	*Lecanicillium lecanii* @ 5 g/ litre	24.07d	24.77d	80.50d
T2	*Metarhiziumanisopliae*@ 5 g/ litre	21.80cd	21.83cd	90.92cd
T3	*Beauveriabassiana*@ 5 g/ litre	18.64bc	20.45c	101.33bc
T4	*Trichogrammachilonis* @ 50,000 parasitoids/ha	16.72b	18.70bc	104.55b
T5	*Bacillus thuringiensis* @ 5 g/ litre	15.67ab	16.98b	109.10b
T6	NSKE 5%	17.28bc	18.56bc	104.14b
T7	Emamectin benzoate 5 SG @ 0.0025%	11.30a	12.02a	122.45a
T8	Untreated control	32.94e	34.40e	59.44e
S. Em. ±		1.51	1.13	4.13
C. D. at 5%		4.57	3.44	12.54

25.1.2 TNAU, Coimbatore

Name of the Farmer : Mrs.SushilRajan
Location : Mettupalayam, Coimbatore.
Bhendi Hybrid : CoH
Plot size : 8 X 5 m
D.O.P : 05.12.18
T1: *Metarhizium anisopliae* (NBAIR)1×10^8 spores/ g @ 5g/lt
T2: *Beauveria bassiana* (NBAIR)1×10^8 spores/ g @ 5g/lt
T3: *Trichogrammachilonis*@50,000 parasitoids/ha, 6 releases at weekly interval.
T4: *Bacillus thuringiensis* @ 1 kg/ha
T5: Azadirachtin 1500 ppm@ 2 ml/lit
T6: Flubendiamide @ 0.3 ml/lit
T7: Untreated control
Replications: Three

Observations:

Releases of parasitoids at weekly interval and three sprays of entomopathogens and azadirachtin done at fortnightly interval.

The observations were recorded on five randomly selected plants/ plot.

1. Pre and post- treatment counts on fruit infestation at weekly interval.
2. Yield of healthy marketable fruits at each picking.

Results: we found that 87.27% reduction in the fruit damage due to *E. vitella* was observed in insecticide sprayed plots. Among the biocontrol treatments, maximum reduction in fruit damage (83.43%) was registered in release of *Trichogrammachilonis*@50,000 parasitoids/ha, 6 releases at weekly interval followed by *Bacillus thuringiensis* @ 1 kg/ha (70.82%). The fruit yield was also significantly high (9978Kg/ha) in *T.chilonis*@50,000 parasitoids/ha, 6 releases at weekly interval while in control, the fruit yield was 8266Kg/ha (**Table 166**).

Table 166. Biological control of fruit borer, *Eariasvitella* on bhendi

Treatments	Pre Treatment	15 days after I release/spray	15 days after II release /spray	15days after III release/spray	Per cent reduction over control	Yield Kg/ha	CB ratio
	Per cent fruit damage	Per cent fruit damage	Per cent fruit damage	Per cent fruit damage			
*Metarhiziumanisopliae*1x10^8 spores/ g @ 5g/lt	51.83	36.7 (37.3)^e	26.2 (30.7)^d	16.2 (23.6)^d	50.38	8766.66^c	2.08
Beauveriabassiana(NBAIR)1x10^8 spores/ g @ 5g/lt	53.43	31.4 (34.0)^d	25.7 (30.5)^d	14.5 (22.3)^d	55.09	8800.00^c	2.22
Trichogrammachilonis@50,000 parasitoids/ha, 6 releases	44.73	21.1 (27.4)^b	4.3 (11.8)^a	1.0 (5.7)^a	83.43	9780.50^a	3.56
Bacillus thuringiensis @ 1 kg/ha	53.02	24.3 (29.5)^c	11.2 (19.5)^b	11.0 (19.3)^c	70.82	9115.00^b	3.39
Azadirachtin 1500 ppm@ 2 ml/lit	51.83	34.4 (35.9)^e	19.5 (26.2)^c	11.1 (19.4)^c	59.23	8525.25^d	2.05
Flubendiamide@ 0.3 ml/l	51.63	13.7 (21.6)^a	4.4 (12.0)^a	2.2 (8.4)^b	87.27	9785.55^a	1.70
Control	51.99	50.6 (45.6)^f	54.4 (47.5)^e	54.4 (47.5)^e	0.00	8266.61^e	-
SEd	-	0.7214	0.9631	2.2683		368.09	
CD	-	1.5718	2.0984	16.2 (23.6)^d		802.01	

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

Figures in parentheses are arcsine transformed values (Fruit damage), Figures in parentheses are logarithmic transformed values (Yield)

Values are mean of three replication

26. CABBAGE

26.1 Evaluation of *Steinernemacarpocapsae, Heterorhabditis indica* (NBAIR strain) and *H. pakistanense* against lepidopteran pest complex on cabbage (SKUAST)

EPN species namely NBAIR strain *Heterorhabditis indica, H. pakistanense* and *Steinernema carpocapsae* received from NBAIR were evaluated against Cabbage butter fly, *Pieris brassicae* and diamondback moth, *Plutella xylostella* infesting kale in the plot of Biological control unit of the Division of Entomology, SKUAST-K during the month of July-August' 2018.

The experiment was conducted on forty five days old seedlings of kale in a plot of 10 x 10 m^2 area split in five sub plots (2 x 1 m^2). Twenty five laboratory reared 3rd instar larvae of *Pieris brassicae* and *Plutella xylostella* were released separately on each plant replicated five times, for five different treatments. Each treatment was provided with 2.5 lakh IJs/m^2 with the help of rose water can. Two such sprays with a gap of three days were provided to each treatment receiving EPN. Treatments were provided during evening hours. These included *S. carpocapsae* (T1), *H. indica* (T2) *H. pakistanense* (T3), University recommended chlorpyrifos 20EC @ 1.0 ml/ litre of water (T4) and untreated check (T5). Close monitoring of the treated plants for larval mortality was done. Per cent larval mortality was recorded after 72 and 96 hrs of the treatments. Larvae killed by chemical were collected and disposed beyond the reach of birds, after recording data.

In order to determine active juveniles/24 hrs. after spray, three plants treated with EPN were cut from stem after 24 hrs., brought to laboratory and dipped in glass jar with one litre of water. The plant material after 24 hrs. in water was taken out and number of active/moving EPNs in one drop of water was counted with the help of nematode counting dish. The experiment was replicated thrice and average number of EPNs were taken. Number of EPN/ ml of water was then multiplied by 1000 to determine actual number of IJS/ plant. Dead/ morbid larvae, both of *P. brassicae* and *P. xylostella* were collected and kept separately in petridish for harvesting the IJs/ larvae.

Laboratory experiment was also conducted to determine average yield of IJs from 2nd, 3rd and 4th and 5th larval instar of the above mentioned pests. For this, cadaver were collected from the experimental plot and brought to laboratory in order to confirm that the larva has been killed by EPN and also to record the IJs yield. For each species of EPN six dead larvae were taken. Six White trap set were prepared and one cadaver was placed on each white trap and kept in BOD at 23 ± 2°C. After 3-8 days. Emergence of IJS from dead larva was checked on regular basis to record the data. IJs that emerged from the cadaver were collected in water reservoir of white trap. These IJs were harvested in a beaker. The yield of IJs thus collected was counted on daily basis by diluting the suspension. 0.1 ml was taken with the help of micro-pipette and poured in counting dish. The process of harvesting of IJs and counting was performed until the cadaver was exhausted and only the integument was left with no further emergence of IJs. Finally, the number of all IJs collected on different days were added total number of IJs from a single cadaver was calculated. Average of six cadavers from six white trap was taken.

Among EPNs *H. pakistanense*caused highest larval mortality, both of *P. brassicae* and *P. xylostella* followed by *H. indica* and *S. carpocapsae*. Although per cent mortality caused to larvae of *P. brassicae* by *H. pakistanense* on 72 hrs. (40.8) was statistically different from *H. indica* (29.6) but statistically on par with the latter at 96 hrs. (13.6) and total average (54.4). All the treatments provided to 3rd instar larvae of *P. brassicae* showed statistically significant difference in per cent larval mortality at 72 hrs (F= 89.93**; d.f.= 4(16); p= 0.000), 96 hrs. (F= 14.64**; d.f.= 4(16); p= 0.000) and total mortality (F= 59.78**; d.f.= 4(16); p= 0.000), when compared through one way ANOVA. Total mortality caused by Chlorpyrifos 20 EC @ 1.0 ml/lit. of water was 73.6% as compared to 2.4% in untreated control. Per cent mortality in *P. brassicae* during 72 hrs. and 96 hrs. when compared through Student's *t*- test exhibited significant difference (t= 4.41* P=0.0001 d.f.= 33).

H. pakistanensis was found to be superior over *H. indica* and *S. carpocapsae* in terms of larval mortality of diamondback moth (*P. xylostella*). Difference in mortality for all the treatments was found statistically significant after 72 (F= 75.58**; d.f.= 4(16); p= 0.000)hrs. 96 hrs. (F= 5.44**; d.f.= 4(16); p= 0.000)and also the total mean (F= 85.22**; d.f.= 4(16); p= 0.000). Larval mortality of *P. xylostella* after 72 and 96 hrs. when compared using Student's t- test was found statistically significant (t= 5.08* P=0.0001 d.f.= 32) **(Table 167).**

Active Juvenile stage (IJS/ plant) after 24 hrs on kale was found maximum in case of *H. pakistanense* (7000.00) followed by *H. indica* (5333.33) and *S. carpocapsae* (4666.67). Comparison of data through one way ANOVA indicated non significant difference among the three EPNs in terms of their survival ability after 24 hrs.(F= 3.4 NS; d.f.= 2(4); P= 0.136) **(Table 168).**

Laboratory experiment revealed harvesting of IJS/ cadaver of both *P. brassicae* and *P. xylostella* as maximum from 5th instar larvae. On an average 3.12 lakh IJS/ cadaver and 6375 thousand IJS/ cadaver was obtained from 5th instar larvae of *P. brassicae* and *P. xylostella* **(Table 169).**

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Table 167. Field efficacy of some entomopathogenic nematodes against cabbage butterfly, *Pieris brassicae* and diamondback moth, *Plutella xylostella* on kale in Kashmir, during 2018

Treatments (IJs/ 4 sq.m. plot)	After 72 hrs.	After 96 hrs.	Total mortality	After 72 hrs.	After 96 hrs.	Total mortality
	% mortality of *P. brassicae*			**% mortality of *Plutella xylostella***		
T1 *S. carpocapsae*	13.6 (21.84)^{b}	4.0 (10.85)^{b}	17.6 (24.81)^{b}	17.6 (25.08)^{b}	4.0 (10.85)^{a}	21.6 (27.94)^{a}
T2 *H. indica*	29.6 (33.01)^{c}	14.4 (22.60)^{c}	44.0 (41.74)^{c}	35.2 (36.46)^{c}	6.4 (14.18)^{a}	41.6 (40.38)^{b}
T3 *H. pakistanense*	40.8 (39.96)^{d}	13.6 (21.64)^{c}	54.4 (47.84)^{c}	40.00 (39.45)^{c}	18.4 (25.30)^{b}	58.4 (50.31)^{c}
T4 Chlorpyrifos 20 EC @ 1.0 ml./lit. of water	68.0 (55.90)^{e}	5.6 (14.12)^{b}	73.6 (59.55)^{d}	84.0 (67.17)^{d}	10.4 (18.91)^{ab}	94.4 (77.17)^{d}
T5 Untreated control	1.6 (7.33)^{a}	0.8 (5.69)^{a}	2.4 (8.97)^{a}	10.4 (19.20)^{a}	13.6 (21.84)^{b}	24.00 (29.51)^{a}
CD (0.05)	**4.77**	**4.63**	**6.35**	**5.26**	**6.13**	**5.37**
CV (%)	78.19	86.26	70.32	72.25	68.18	59.21

Each figure in column represents mean of 5 observations; figures in parentheses represent arc sin transformation n+0.5; different alphabetical superscripts in column indicate values statistically significant.

Table 168. Active IJs/ plant after 24 hrs. on kale after foliar application: 2 lakh IJs/ sq. m. in Kashmir, during 2018

EPN species	Active IJs/plant
S. carpocapsae	4666.67 (68.22)[a]
H. indica	5333.33 (72.72)[a]
H. pakistanense	7000.00 (83.52)[ab]
CD= 12.81	

Figures in column represent mean of three replications; figures in parentheses are sqrt transformation; similar superscripts indicate values statistically on par

Table 169. Yield (Average yield of IJs from 1st, 2nd, 3rd and 4th larva of *P. brassicae* and DBM on Kale in Kashmir, during 2018

	Pieris brassicae		**DBM**
EPN species	**Larval instar**	**IJs/ Larva (in lakh)**	**IJs/ Larva**
S. carpocapsae	2nd	0.22	0.00640
	3rd	0.84	0.01790
	4th	1.30	0.03250
	5th	2.10	0.05565
H. indica	2nd	0.29	0.00653
	3rd	0.92	0.01910
	4th	1.75	0.03665
	5th	2.77	0.05930
H. pakistanense	2nd	0.34	0.00689
	3rd	1.09	0.02040
	4th	2.10	0.03950
	5th	3.12	0.06375

26.2 Biointensive pest management in cabbage (TNAU)

Name of the Farmer : Mr.V.Kulandaivelu
Location : Narasipuram
Cabbage Variety : Ganesa local
Date of Planting : 21.10.18

Treatments

T1: Raising of mustard as intercrop, 5 releases of *Trichogrammachilonis*@ 100,000/release against *Plutella xylostella*, at 30 days after transplanting, release of *Chrysoperla zastrowi sillemi* @ 2000/ release, 2 releases at 15 days interval against cabbage aphid, *L. lecanii*-1×10^8 spore/ ml @ 5ml/lt and three sprays NBAII *Bt*G4 2%.

T2: Farmers practices

Replications: Five

Methodology and observation

Pre- release observation –No. of larvae/plant (10 plants/ each spot)

100 eggs collected and parasitisation rate observed during 4 times.

Aphid – observation recorded in 5 random spots including 10 plant each spot for aphid infestation and counted total number of infested plant. Five observation taken on the aphid colony infesting leaves by using the 1cm window

Yield data

The results revealed that the efficacy of BIPM practices was significantly superior in reducing the population of DBM by recording 0.46 larvae/plant after three rounds of spray while it was 1.62 and 7.66 larvae /plant in chemical treatment and control plot respectively. Inundative release of *Trichogramma* worked out effectively and parasitoids were recovered from cabbage plants at the level of 3.5 to 10.2/5 leaves in BIPM plot. In control plots also, 1.0 to 4.02 parasitoids/5 leaves were recorded indicating the movement of the wasp. A highest yield of 44.25 t/ha was recorded in BIPM plot which was on a par with chemical treatment (43.2 t/ha) **(Table 170).** Yield from control plot was 38.7 t/ha. The CB ratio was 3.53 in BIPM plot while it was 2.84 in chemical treatment.

Table 170. Field demonstration of biointensive pest management in cabbage

Treatments	Pre Treatment	45 – DAT- 15 days after I release/spray	60- DAT- 15 days after II release /spray		75- DAT -15days after III release/spray		90 - DAT -30days after IV release/spray		Yield Kg/ha	CB ratio
	No. of larvae/plant	No. of larvae/plant	No. of larvae/ plant	Parasitoid emergence/ 5 Leaves	No. of larvae / plant	Parasitoid emergence/ 5 Leaves	No. of larvae / plant	Parasitoid emergence/ 5 Leaves		
Mustard + *Trichogrammachilonis*@ 100,000/release + *Chrysoperla* @ 2000/ release, *L. lecani* @ 5ml/lt and *Bt*G4 2%.	0.89	1.22 (1.15)^{a}	0.86 (0.96)^{a}	5.8 (2.35)^{a}	0.46 (0.72)^{a}	10.2 (3.28)^{a}	0.26 (0.51)^{a}	16.4 (4.02)^{a}	44245 (210.34)^{a}	3.53
Chlorpyrifos @ 0.04% + imidacloprid	0.82	1.78 (1.35)^{b}	1.7 (1.34)^{b}	0 (0.00)^{c}	1.62 (1.27)^{b}	0 (0.00)^{c}	1.4 (1.18)^{b}	0 (0.00)^{c}	43200 (207.84)^{a}	2.84
Control	0.88	3.96 (1.94)^{c}	6.24 (2.35)^{c}	1 (1.00)^{b}	7.66 (2.76)^{c}	3.5 (1.86)^{b}	8.22 (2.79)^{c}	4 (1.99)^{b}	38700 (196.72)^{b}	-
SE d	0.0277	0.0332	0.0978	0.9601	0.0511	3.9506	0.1499	0.8588	1.4656	-
CD(0.05)	0.0639	0.0765	0.2256	2.2139	0.1179	9.1102	0.3457	1.9803	4.0692	-

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

Figures in parentheses are square root transformed values (Larvae/Parasitoid), Figures in parentheses are logarithmic transformed values (Yield)

Values are mean of five replications

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

Plot size 8x5m=40 m^2;   Replication = 04;   Design: RBD;   Variety = Golden Acre

Treatments

1. Bb-5a isolate of *Beauveria bassiana*
2. Bb-45 isolate of *Beauveria bassiana*
3. Ma-4 isolate of *Metarhizium anisopliae*
4. Vl-8 isolate of *Lecanicillium lecanii*
5. Recommended Insecticide application (Indoxacarb 14.5 SC @ 0.75 ml/lit)
6. Control (Untreated)

Table 171. Bioefficacy of different EPF against DBM and aphids infesting cabbage

Treatments	DBM / plant			Aphid/leaf			Spider / plant
	Before spray	After spray	PROC#	Before spray	After spray	PROC	
T1	8.57	6.30^b	24.28	3.12	1.80^a	39.60	0.18
T2	8.11	5.90^b	29.07	3.08	1.48^a	50.34	0.24
T3	8.36	5.51^b	33.77	2.94	1.64^a	44.97	0.24
T4	8.47	5.71^b	31.37	2.34	1.46^a	51.01	0.26
T5	7.98	3.54^a	57.45	3.16	1.26^a	57.72	0.08
T6	8.69	8.32^c	--	3.02	2.98^b	--	0.46
SEm(±)	--	0.63	--	--	0.47	--	
LSD (5%)	--	1.32	--	--	1.03	--	

#PROC= Per cent reduction over control; Means followed by same letters in a column are not significantly different at P<0.05

Effect of different biopesticides on major insect pests of cabbage was studied during the *rabi* season 2018-19 at the experimental farm of ICAR-IIVR, Varanasi. From the **Table 171** it is evident that among the biopesticides tested, *Metarhizium anisopliae* (Ma-4 strain) most promising with 33.77% reduction over control (PROC) against DBM followed by *Lecanicillium lecanii* (Vl-8 strain). In case of aphid (*Myzus persicae*), maximum reduction (51.01 PROC) was recorded with *Lecanicillium lecanii* (Vl-8) followed by *Beauveria bassiana* (Bb-45 strain) with 50.34 PROC and these are statistically at par with each other. However, amongst the all treatments, indoxacarb 14.5 SC was the best both in reducing DBM and aphids. Amongst the spider population, lowest population (0.08 per plant) was noted with indoxacarb treated plots, whereas, all the entomopathogens treated plots had harboured higher spiders per plant.

26.4 Trial using Bracocards against DBM on cabbage (IGKV)

This experiment was conducted in the field behind Bio-control laboratory on cabbage (var.) Bracocards were applied as one of the treatments along with other biopesticides tested.

Table 172. Showing number of dead larvae of DBM due to *Bracon hebetor*

S.No.	Treatment	Mean number of dead larva of DBM		
		3 DAT	7 DAT	14 DAT
1.	*B. hebetor* in the form of Bracocards	3.33	5.33	7.66

Result: Application of *B. hebetor* under caged condition was effective in managing the population of DBM in cabbage crop. Initially after 3 days of application it showed 3.33 number of dead larvae which increased to 5.33 and 7.66 after 7 and 14 days of treatment (**Table 172**).

27. CHILLI

27.1 Screening of promising isolates of entomopathogenic fungi for management of white flies in chillies (KAU, Kumarakom)

Variety	Ujjwala (KAU variety)
Layout	Randomized Block Design.
Plot size	8×5 M
Treatments	T1: Bb-5a isolate of *Beauveriabassiana* T2: Ma-4 isolate of *Metarhiziumanisopliae* T3: Ma-6 isolate of *Metarhiziumanisopliae* T4: Vl-8 isolate of *Lecanicilliumlecanii* T5: Spiromesifen 22.9SC@ 96 g ai ha^{-1} T6: Untreated control
Replications	Four
Mode of application	Four rounds of foliar sprays of oil formulations of entomopathogenic fungi at the spore dose of $1x10^8$cfu/ml (5ml/liter) to be given at 15 days interval
Observations	➢ Pre and post count of whiteflies ➢ Yield

Inference: The whitefly count was very low during the period of experiment **(Table 173, 174).** Hence significant results were not obtained.

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Table 173. Efficacy of isolates of entomopathogenic fungi for management of whiteflies in chillies (RARS, Kumarakom, December 2018)

Treatment	**Mean number of whiteflies***																	
	First spray						**Second Spray**						**Third Spray**					
	Preco unt	**1st day**	**3rd day**	**5th day**	**7 th day**	**9 th day**	**Preco unt**	**1st day**	**3rd day**	**5th day**	**7 th day**	**9 th day**	**Preco unt**	**1st day**	**3rd day**	**5th day**	**7 th day**	**9 th day**
T1	0.25 (0.85)	0.13 (0.78)	0.25 (0.78)	0.19 (0.82)	0.19 (0.82)	0.13 (0.79)	1.38 (1.30)	0.19 (0.82)	0.13 (0.78)	0.13 (1.01)	0.63 (1.01)	0.25 (0.85)	1.06 (1.24)	0.63 (1.03)	0.31 (0.86)	0.06 (0.75)	0.13 (0.78)	0.19 (0.83)
T2	0.31 (0.89)	0.06 (0.75)	0.50 (0.75)	0.00 (0.71)	0.31 (0.89)	0.38 (0.92)	0.19 (0.81)	0.00 (0.71)	0.19 (0.83)	0.06 (0.78)	0.13 (0.79)	0.69 (1.04)	2.44 (1.47)	0.06 (0.75)	0.00 (0.71)	0.19 (0.82)	0.06 (0.75)	0.13 (0.79)
T3	0.38 (0.93)	0.06 (0.75)	0.06 (0.75)	0.25 (0.85)	0.38 (0.92)	0.19 (0.81)	0.13 (0.79)	0.19 (0.81)	0.50 (0.96)	0.31 (0.85)	0.25 (0.85)	0.38 (0.90)	0.75 (1.09)	0.13 (0.78)	0.06 (0.75)	0.06 (0.75)	0.13 (0.78)	0.25 (0.84)
T4	0.25 (0.85)	0.00 (0.71)	0.63 (0.71)	0.63 (1.03)	0.38 (0.93)	0.13 (0.78)	0.50 (0.96)	0.13 (0.78)	0.56 (0.97)	0.06 (0.94)	0.44 (0.94)	0.38 (0.91)	0.76 (1.08)	1.94 (1.25)	0.56 (0.99)	0.25 (0.85)	0.19 (0.82)	0.06 (0.75)
T5	0.38 (0.91)	0.00 (0.78)	0.13 (0.78)	0.13 (0.78)	0.31 (0.89)	0.25 (0.86)	0.56 (1.03)	0.00(0 .71)	0.19 (0.81)	0.50 (0.85)	0.25 (0.85)	0.38 (0.91)	0.13 (0.78)	0.13 (0.78)	0.31 (0.88)	0.19 (0.82)	0.19 (0.82)	0.25 (0.86)
T6	0.63 (1.05)	0.25 (0.71)	0.380(0(0.71)	0.31 (0.88)	0.32 (0.89)	0.06 (0.75)	0.13 (0.78)	0.00 (0.71)	0.56 (0.99)	0.25 (1.25)	1.31 (1.25)	0.88 (1.14)	0.50 (0.97)	0.06 (0.75)	0.50 (0.96)	0.25 (0.86)	0.13 (0.79)	0.31 (0.89)
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Values in parantheses are square root transformed.

T1: Bb-5a isolate of *Beauveria bassiana*
T2: Ma-4 isolate of *Metarhizium anisopliae*
T3: Ma-6 isolate of *Metarhizium anisopliae*
T4: Vl-8 isolate of *Lecanicillium lecanii*
T5: Spiromesifen 22.9SC@ 96 g ai ha^{-1}
T6: Untreated control

Table 174. Efficacy of isolates of entomopathogenic fungi for management of whiteflies in chillies (RARS, Kumarakom, December 2018)

	Percentage of infestation*																	
	First spray						Second Spray						Third Spray					
	Precount	**1st day**	**3rd day**	**5th day**	**7 th day**	**9 th day**	**Precount**	**1st day**	**3rd day**	**5th day**	**7 th day**	**9 th day**	**Precount**	**1st day**	**3rd day**	**5th day**	**7 th day**	**9 th day**
T1	4.38 (9.30)	0.94 (3.87)	2.44 (7.09)	2.50 (7.18)	2.19 (6.74)	1.88 (6.22)	9.69 (16.11)	1.88 (6.22)	2.50 (5.68)	2.50 (7.18)	7.69 (12.24)	1.88 (6.22)	12.81 (20.75)	6.75 (12.88)	3.75 (6.77)	0.63 (3.35)	1.25 (4.31)	1.8 (7.18)
T2	5.31 (11.82)	1.25 (4.31)	5.00 (9.64)	0.00 (1.43)	3.56 (9.43)	4.06 (10.73)	2.50 (5.88)	0.00 (1.43)	3.13 (9.09)	1.25 (4.31)	1.25 (5.27)	6.88 (12.50)	10.50 (14.35)	1.25 (4.31)	0.00 (1.43)	1.88 (6.22)	0.63 (3.35)	1.25 (5.27)
T3	6.25 (4.30)	1.25 (4.31)	1.25 (4.31)	3.75 (8.56)	5.25 (11.8)	1.88 (5.05)	1.25 (5.7)	2.19 (5.38)	7.50 (12.11)	5.50 (10.40)	2.88 (7.36)	4.06 (8.43)	8.81 (15.37)	1.25 (4.31)	1.25 (4.31)	0.63 (3.35)	1.25 (4.31)	2.50 (5.68)
T4	5.00 (9.64)	0.00 (1.43)	4.69 (7.49)	6.88 (13.15)	5.50 (12.03)	1.25 (4.31)	4.38 (9.12)	1.25 (4.31)	4.13 (8.48)	1.25 (4.31)	3.75 (9.52)	3.31 (8.12)	8.13 (13.98)	4.75 (7.53)	4.13 (9.06)	2.63 (7.1)	1.88 (6.22)	0.63 (3.35)
T5	7.50 (11.7)	0.00 (1.43)	1.88 (5.05)	2.50 (5.68)	4.31 (10.72)	2.81 (8.65)	5.00 (12.12)	0.00 (1.43)	2.50 (5.68)	7.25 (11.91)	3.88 (8.27)	5.69 (11.81)	2.00 (5.18)	3.75 (6.77)	3.75 (8.56)	1.88 (6.22)	1.88 (6.22	2.50 (8.14)
T6	11.25 (19.09)	2.50 (5.68)	4.69 (7.49)	5.00 (9.93)	5.06 (11.12)	0.63 (3.35)	1.25 (4.31)	0.00 (1.43)	7.25 (11.91)	5.25 (9.84)	8.88 (15.27)	9.50 (15.85)	5.00 (9.93)	0.63 (3.35)	7.50 (11.97)	2.50 (8.14)	1.25 (5.27)	3.75 (9.52)
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Values in parantheses are arcsine transformed.

T1: Bb-5a isolate of *Beauveria bassiana*
T2: Ma-4 isolate of *Metarhizium anisopliae*
T3: Ma-6 isolate of *Metarhizium anisopliae*
T4: Vl-8 isolate of *Lecanicillium lecanii*
T5: Spiromesifen 22.9SC@ 96 g ai ha^{-1}
T6: Untreated control

27.2 Evaluation of Fungal pathogens against chilli yellow mite, *Polyphagotarsonemuslatus* (UBKV, Pundibari)

Location: Instructional Farm, UBKV, Pundibari
Target pest: Chilli yellow mite
Plot size: 6×5 m
Variety: Akashi
Layout: RBD
Replication: 4
Date of transplanting: 03.09.2018
Fertilizer dose: as per State recommendation
Treatment details:
T1: *Metarhizium anisopliae* (NBAIR strain) 1×10^8cfu @ 6g/lit
T2: *Beauveri abassiana* (NBAIR strain) 1×10^8cfu @ 6g/lit
T3: *Lecanicillium lecanii* (NBAIR strain) 1×10^8cfu @ 6g/lit
T4: Spiromesifen 240SC @1ml/lit
T5: Control
Spray schedule: Two sprays at 15 days interval (First: 01.10.2018 and Second: 15.10.2018)

Results:
The population of chilli yellow mite was recorded from upper, middle and lower leaf of chilli plants. Totally five plants and 15 leaves from each plot were considered for observation and expressed mites per leaf and presented in the **Table 175**.The treatment with Spiromesifen 240SC performed better in controlling the mite in both the spray. Among the tested fungal biopesticides, *Metarhizium anisopliae* (NBAIR strain) significantly reduced the mite population as compared to the other two cultures. Significantly highest yield of green chilli was registered in the treatment spiromesifen 240 SC (168 qt/ha) followed by *Metarhizium anisopliae* (NBAIR strain).

Table 175. Bioefficacy of some biopesticides against chilli mite

Treatment	Population of chilli mite/ leaf								Yield (q/ha)
	First spray				Second spray				
	Pre-treatment	**1DAS**	**3DAS**	**7DAS**	**Pre-treatment**	**1DAS**	**3DAS**	**7DAS**	
T1- *Metarhiziumanisopliae* (NBAIR strain) 1×10^8cfu @ 10g/lit	8.0 (2.79)*	7.20 (2.65)	4.0 (1.98)	4.54 (2.11)	4.79 (2.16)	4.54 (2.10)	3.29 (1.81)	2.75 (1.65)	83.75 (4.43)**
T2-*Beauveria bassiana* (NBAIR strain) @ 10 gm/lit.	8.45 (2.89)	8.79 (2.95)	5.12 (2.25)	5.41 (2.32)	5.62 (2.37)	5.54 (2.33)	5.25 (1.27)	4.37 (2.07)	79.50 (4.37)
T3- *Lecanicilliumlecanii* (NBAIR strain) 1×10^8cfu @ 10g/lit	8.62 (2.92)	8.20 (2.86)	4.54 (2.12)	4.50 (2.10)	4.62 (2.12)	4.54 (2.10)	4.45 (2.10)	3.87 (1.95)	85.75 (4.45)
T4- Spiromesifen 240SC @ 1 ml/lit.	7.83 (2.79)	0.04 (0.10)	0.08 (0.20)	0.29 (0.53)	1.16 (1.08)	0.41 (0.63)	0.25 (0.49)	0.25 (0.49)	168.0 (5.12)
T5- Control	6.52 (2.55)	7.95 (2.81)	7.95 (2.81)	8.45 (2.89)	8.87 (2.97)	9.16 (3.02)	9.83 (3.13)	9.54 (3.09)	44.0 (3.78)
SEm (±)	0.16	0.17	0.15	0.15	0.14	0.17	0.12	0.13	0.03
CD (at 5%)	NS	0.53	0.47	0.48	0.44	0.54	0.38	0.40	0.08
CV (%)	0.51	15.24	16.35	15.73	13.49	17.26	12.51	13.86	1.19

DAS- Days after spray * Figures in the parenthesis are square root transformed values.** Figures in the parenthesis are Log transformed values.

28. CUCUMBER

28.1 Bioefficacy of some biopesticides against whitefly (*Bemisiatabaci*) and jassids (*Empoascaflavescens*) in cucumber (UBKV, Pundibari)

Location: Instructional Farm, UBKV, Pundibari
Plot size: 6×5 m
Variety: Malini
Layout: RBD
Replication: 4
Date of transplanting: 07.09.2018
Fertilizer dose: as per State recommendation
Treatment details:
T1-*Lecanicillium lecanii* (NBAIR strain) @ 10gm/lit. (10^8 spores/ml)
T2- *Beauveria bassiana* (NBAIR strain) @ 10gm/lit. (10^8 spores/ml)
T3- Azadirachtin 10000 ppm @ 1ml/lit.
T5- Buprofezin 25 SC @ 1.5 ml/lit.
T5- Control
Spray schedule: Two sprays at 15 days interval (First: 07.10.2018 and second: 22.10.2018)

Results:

The trial was conducted only against whitefly because jassids population was very low. The treatment with buprofezin 25SC ranked best in controlling the whitefly followed by *Lecanicillium lecanii* (NBAIR strain) in both the spray. Among the tested fungal biopesticides, *L. lecanii* (NBAIR strain) significantly reduced the whitefly population as compared to the other culture. The treatment *L. lecanii* (NBAIR strain) was almost at par with the effect of azadirachtin 10000 ppm. Significantly highest yield of cucumber was obtained in the treatment buprofezin 25SC (241.25qt/ha) followed by *L. lecanii* (NBAIR strain) **(Table 176).**

Table 176. Bioefficacy of some biopesticides against whitefly in Cucumber

Treatment	Population of whitefly/ leaf								Yield (q/ha)
	First spray				Second spray				
	Pre-treatment	1DAS	3DAS	7DAS	Pre-treatment	1DAS	3DAS	7DAS	
T1-*Lecanicillium lecanii* (NBAIR strain) @ 10 gm/lit.	3.95 (1.97)*	3.10 (1.76)	2.90 (1.70)	1.92 (1.38)	3.79 (1.95)	3.04 (1.74)	2.83 (1.68)	1.83 (1.35)	155.25 (5.05)**
T2-*Beauveria bassiana* (NBAIR strain) @ 10 gm/lit.	4.10 (2.02)	3.67 (1.91)	3.42 (1.85)	2.15 (1.46)	4.5 (2.12)	3.5 (1.87)	3.08 (1.76)	2.08 (1.44)	129.5 (4.86)
T3- Azadirachtin 10000 ppm @ 1ml/lit.	4.57 (2.13)	3.42 (1.85)	2.92 (1.71)	1.97 (1.39)	3.62 (1.90)	3.25 (1.80)	2.66 (1.63)	2.0 (1.40)	140.5 (4.94)
T4- Buprofezin 25 SC @ 1.5 ml/lit.	4.0 (1.99)	2.45 (1.56)	1.42 (1.19)	1.32 (1.15)	2.58 (1.61)	2.25 (1.45)	1.25 (1.11)	1.08 (1.04)	241.25 (5.49)
T5- Control	3.92 (1.97)	4.77 (2.18)	4.82 (2.20)	5.17 (2.27)	7.0 (2.64)	6.66 (2.58)	6.25 (2.50)	5.83 (2.41)	97.25 (4.61)
SEm (±)	0.05	0.03	0.04	0.06	0.04	0.04	0.03	0.05	0.04
CD (at 5%)	NS	0.08	0.13	0.20	0.13	0.14	0.12	0.16	0.12
CV (%)	5.43	2.94	4.95	8.40	4.06	4.73	4.50	6.94	1.52

DAS- Days after spray * Figures in the parenthesis are square root transformed values.
** Figures in the parenthesis are Log transformed values.

FLOWER

29. JASMINE

29.1 Management of bud worm and blossom midge on jasmine (TNAU)

Name of the Farmer : Th.R.Brahmagiri, Chellapampalayam, Annur block
Variety : Ramnad local
Plot size : 8 x5 m

Treatments

T1 - Azadirachtin 1500 ppm @ 2ml/L; three times starting from bud initiation stage at 10 days interval

T2 -Release of *T. chilonis* @ 50,000/ acre at 10 days interval for two months from bud initiation based on light trap monitoring + release of *Chrysoperlazastrowisillemi* 5000 nos/ha from bud initiation

T3 - T2+ three rounds of spraying with *Beauveria bassiana*NBAIRformulation ($1x10^8$ spores/g) @ 5g / litre at 10 days interval

T4 - T2+ three rounds of spraying with *Metarhiziumanisopliae*NBAIR formulation ($1x10^8$ spores/g) @ 5g / litre at 10 days interval

T5 - Soil drenching with *Metarhiziumanisopliae*10^9 spores/ha- two times at fifteen days interval

T6 - Soil application of Neem cake @250 kg/ha two times per year

T7- Soil application of carbofuran 3G @ 20 gm/plant

T8- Control

Replications: Three

Methodology and observations

No. of plants per treatment: 10

No. of replications: 3

3 branches / plant / replication

No. of infested buds/ flowers counted on 7 days after each application

Per cent damage

The flower damage due to jasmine bud borer and blossom midge were assessed before and after imposing treatments. After third round of spray, among all the treatments, application of *Beauveria bassiana* (NBAIR formulation) at 5g/ litre of water along with 6 releases of *Trichogramm achilonis* (@50,000/acre) and *Chrysoperla* (5000 nos/ha) at 7 days interval from bud initiation stage was superior in checking the bud borer with minimum bud damage of 21.70% followed by soil application of carbofuran @ 20g/plant (25.44%). The data on blossom midge damage in treatment plots revealed that there was no significant difference between the treatments. The flower yield ranged between 1650 and 1945 Kg/ha in the treatments while it was 1450Kg/ha in control **(Table 177).**

Table 177. Efficacy of biocontrol agents in suppression of bud borer and blossom midge in jasmine

Treatments	Pre Treatment		Per cent damage 7 days after I spray		Per cent damage 7 days after II spray		Per cent damage 7days after III spray		Per cent reduction over control		Yield Kg/ha	CB ratio
	Bud borer	Blossom midge	Bud borer	Blossom midge	Bud borer	Blossom midge	Bud borer	Blossom midge	Bud borer	Blossom midge		
T1- Azadirachtin 1500 ppm @ 2ml/L	62.38	15.95	48.4 (44.01)^{bc}	20.04 (26.5)^{c}	26.30 (30.8)^{b}	16.29 (23.7)^{ab}	27.52 (31.6)^{bc}	21.92 (27.9)^{ab}	16.21	11.97	1715^{cd}	3.15
T2 - *T. chilonis* @50,000/acre +*Chrysoperlazastrowi sillemi* 5000 nos/ha	67.50	13.29	40.2 (39.3)^{a}	19.59 (26.2)^{c}	19.13 (25.9)^{a}	16.83 (24.2)^{ab}	21.70 (27.7)^{a}	26.12 (30.7)^{bc}	33.44	5.48	1945^{a}	3.09
T3 – T2+ *B. bassiana*(NBAIR) @5g/l	67.41	10.06	48.7 (44.2)^{c}	18.52 (25.4)^{bc}	29.08 (32.6)^{b}	13.87 (21.7)^{a}	30.91 (33.7)^{c}	23.53 (28.9)^{b}	10.79	15.46	1875^{abc}	1.88
T4 – T2+ *M.anisopliae*(NBAIR) @5g/l	65.71	8.16	45.4 (42.3)^{bc}	15.05 (22.8)^{a}	23.45 (28.9)^{ab}	12.02 (20.2)^{a}	26.67 (31.0)^{bc}	19.85 (26.1)^{a}	21.53	29.07	1920^{ab}	2.07
T5 – Soil drenching *M. anisopliae*(NBAIR)	633.91	11.45	43.5 (41.2)^{ab}	17.72 (24.8)^{ab}	25.66 (30.3)^{b}	18.26 (25.2)^{c}	28.57 (32.2)^{bc}	25.67 (30.4)^{bc}	19.73	6.80	1650^{d}	1.96
T6 – Soil application of Neem cake @ 250 kg/acre	63.97	11.55	44.6 (41.8)^{abc}	18.06 (25.0)^{ab}	25.25 (30.3)^{b}	17.90 (24.9)^{b}	26.94 (31.2)^{bc}	24.65 (29.7)^{b}	20.50	8.39	1815^{abc}	1.65
T7- Soil application of Carbofuran @ 20g/plant	65.22	11.27	46.7 (43.1)^{bc}	19.13 (25.9)^{bc}	24.60 (29.7)^{ab}	17.92 (24.9)^{b}	25.42 (30.2)^{ab}	25.44 (30.2)^{bc}	20.55	5.53	1775^{bcd}	3.20
Control	65.97	9.44	46.6 (43.0)^{bc}	17.32 (24.5)^{ab}	36.25 (37.0)^{c}	18.05 (25.0)^{bc}	38.91 (38.5)^{d}	30.79 (33.6)^{c}	0.00	0.00	1450^{e}	-
SE d	-	-	1.3748	1.5025	1.7984	1.9427	1.4338	2.1051	-	-	75.21	-
CD(0.05%)	-	-	2.9491	3.2229	3.8577	4.1671	3.0755	4.4626	-	-	161.34	-

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

Figures in parentheses are arcsine transformed values, Values are mean of three replications

30. POLYHOUSE INSECT PEST

30.1 Management of cucumber sucking pests using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition (KAU, Thrissur)

An experiment was laid out during February, 2019 for the management of sucking pests in cucumber using the anthocorid predator, *Blaptostethus pallescens* under polyhouse conditions **(Fig 24).**

Design: RBD Variety: KPCH 1

Plot size: 2×2 m^2 Replications: 5

Treatments:

T1: *Blaptostethuspallescens*@ 10 nymphs/m row twice at 15 days interval

T2: *Blaptostethus pallescens* @ 20 nymphs/ m row twice at 15 days interval

T3: Spiromesifen 45SC @100g.a.i ha^{-1} twice at 15 days interval or recommended insecticide for use in polyhouse

T4: Control

The experiment is in progress.

Fig. 24 View of experiment on management of cucumber sucking pests using anthocorid predator, *Blaptostethus pallescens* under polyhouse conditions at College of Horticulture, Vellanikkara.

30.2. Management of red spider mite, *Tetranychusurticae* infesting rose in polyhouse conditions (MPKV, Pune)

The experimental trial was laid out to evaluate Entomopathogenic fungi against mites on rose under polyhouse conditions, the experiment was conducted at Hi-tech Floriculture Project, College of Agriculture, Pune on variety – Top secret, 5 × 2 m, 90 × 60 cm, RBD, 6/4, drip irrigation, light soil. Entomopathogenic fungi formulations and predatory mite obtained from the

National Bureau of Agricultural Inesct Resources (NBAIR), Bengaluru. The treatment details are as follows:

T1: *Lecanicillium lecanii* (NBAIR) 10^8 cfu/ml @ 5 g/lit.
T2: *Beauveria bassiana* (NBAIR) 10^8 cfu/ml @ 5 g/lit.
T3: *Metarhizium anisopliae* (NBAIR*)* 10^8 cfu/ml @ 5 g/lit.
T4: Predatory mites @ 20 per plant *Neoseiulus*sp @ 20 per plant
T5: Recommended insecticide as check (2-4 sprays)
T6: Untreated control

Result: The mite population were recorded on 3 leaves per plant and post count was recorded 7 days after each spray.The first release of predatory mite and spray of entomopathogenic fungi formulation was done on 04.04.2019, second application was given on 19.4.2019. Third application will be given on 4.5.2019. Trial is in progress.

30.3 Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse (PAU, YSPUHF)

30.3.1 PAU, Ludhiana

The capsicum seedlings (variety Indra) were transplanted under protected conditions according to agronomic practice norms on 14th November, 2018. The crop was transplanted with plant to plant spacing of 30 cm and row to row spacing of 90 cm. The crop was monitored for the incidence of sucking pests (aphids, whitefly, mites and thrips). However, the attack of green peach aphid, *Myzuspersicae* was observed on the capsicum plants in the month of January 2019. The pre-treatment data of aphid population was recorded on three leaves (top, middle and bottom) per plant. Thereafter, following treatments were evaluated against the aphids.

Season	:	*Rabi* 2018-19
Variety	:	Indra
Design	:	RBD
Replications	:	4
Treatments	:	7

T1: *Metarhizium anisopliae* (NBAIR) 1X10^8 spores/ g @ 5 g/litre of water
T2: *Lecanicillium lecanii* (NBAIR) 1X10^8 spores/ g @ 5 g/litre of water
T3: *Beauveria bassiana* (NBAIR) 1X10^8 spores/ g @ 5 g/litre of water
T4: Azadirachtin 1500 ppm @ 2 ml/litre of water
T5: Chemical control (malathion 50EC @ 4 ml/litre of water)
T6: *Chrysoperla zastrowi sillemi* @ 4 larvae / plant
T7: Untreated Control
Number of sprays/ releases: 3 at weekly interval

The aphid population was recorded from randomly selected five plants before spray and after 7 days of each spray / release of predator.

The aphid population varied from 36.30 to 139.50 aphids per plant) in all the plots before treatment **(Table 178)**. Chemical control (Malathion 50 EC @ 4 ml/litre) was found most effective in reducing the aphid population after three sprays (89.15% reduction over control; 6.08 aphids per plant). It was followed by releases of *C. zastrowisillemi*@ 4 larvae/ plant (88.17% reduction; 23.0 aphids per plant). Among the biopesticides, significant reduction of aphid population was observed in *L. lecanii* (76.39% reduction; 12.06 aphids per plant) followed by *M. anisopliae* (68.45 % reduction; 31.75 aphids per plant), *B. bassiana* (56.34% reduction; 22.73

aphids per plant), and Azadirachtin 1500 ppm @ 2 ml/litre (17.49% reduction; 41.75 aphids per plant).

Table 178.Evaluation of biocontrol agents for the control of aphids in capsicum under polyhouse during 2018-19

Treatments	Pre-treatment	Aphid population per capsicum plant 7 days after spray/ release				Per cent reduction over control*
		I	II	III	Pooled	
Metarhizium anisopliae (NBAIR) $1X10^8$ spore/ g @ 5g/lt	72.20[b] (8.55)	48.75 (7.05)	27.05 (5.29)	19.45 (4.52)	**31.75**[d] **(5.62)**	68.45
Lecanicillium lecanii (NBAIR) $1X10^8$ spore/ g @ 5g/lt	36.65[a] (6.10)	20.45 (4.62)	11.25 (3.50)	4.50 (2.31)	**12.06**[b] **(3.47)**	76.39
Beauveria bassiana (NBAIR)$1X10^8$ spore/ g @ 5g/lt	37.35[a] (6.17)	42.90 (6.62)	17.50 (4.29)	7.80 (2.92)	**22.73**[c] **(4.61)**	56.34
Azadirachtin 1500 ppm @ 2ml/litre of water	36.30[a] (6.09)	72.65 (8.56)	35.90 (6.02)	16.70 (4.19)	**41.75**[e] **(6.25)**	17.49
Chemical control (Malathion @ 50 EC @ 4 ml/litre water)	40.20[a] (6.39)	14.35 (3.91)	3.10 (2.02)	0.80 (1.33)	**6.08**[a] **(2.42)**	89.15
Chrysoperlazastrowisillemi @ 4 larvae/ plant	139.50[d] (11.79)	53.25 (7.35)	14.75 (3.95)	1.00 (1.41)	**23.00**[c] **(4.24)**	88.17
Control	91.30[c] (9.57)	116.75 (10.83)	117.15 (10.84)	147.90 (12.20)	**127.27**[f] **(11.29)**	-
CD(5%)	(0.97)	(0.53)	(0.70)	(0.37)	**(0.30)**	

*calculated with Henderson and Tilton (1955) formula

30.3.2 YSPUHF, Solan

An experiment for the evaluation of biocontrol agents *viz*. *Metarhizium anisopliae*,*Lecanicillium lecanii*, *Beauveria bassiana* (5g/L of 10^8 conidia/ g each), *Chrysoperla zastrowi sillemi* (4 larvae /plant), *Blaptostethus pallescens* (30 nymphs/ m row length) and azadirachtin (2ml/L of 1500ppm) in comparision with imidacloprid (0.5ml/L) as chemical control and water spray as absolute control for the control of sucking pests in capsicum (cv. Callifornia Wonder) under polyhouse conditions was laid at the experimental farm of YSP University of Horticulture and Forestry, Nauni, Solan. During the experimental period only aphid, *Myzus persicae* was recorded as pest on the capsicum, hence the evaluation of bioagents was done only against *M. persicae*.

The experiment was laid in a randomized block design with each treatment replicated three times.All the treatments were applied twice at 10 days interval and the aphid polulation was recorded on 10 randomly selected plants before treatment and 5, 7 and 10 days after treatment of first and second spray/ release of biocontrol agent. The data thus recorded were converted in to per cent reducrion over pretreatment count which was further converted to percent reduction over control by applying abbott's formula. The data were then analysed after arc sine transformation and the results are presented in **Table 179.**

Results of the experiment reveal that imidacloprid (0.5ml/L) was the best treatment resulting in 98.8 to 100% reduction in the aphid population at different time intervals after the first and the second spray. Among biocontrol agents, *C. zastrowisillemi* (4 larvae/ plant) resulted in the maximum reduction (55.8%) in aphid population over control 10 days after the first spray/ release, which was, however, on par with that resulted by *L. lecanii* (50.3%) and azadirachtin (49.8%). Other bioagents resulted in 33.1 to 39.2% pest reduction over control. Ten days after the second spray/ release, among biocontrol agents, *C. zastrowi sillemi* (4 larvae / plant) resulted in the highest (78.1%) reduction in the aphid population followed by on par reduction by *L. lecanii* (5g/l of 10^8 conidia/ g) (68.9%)and azadirachtin (2ml/L of 1500ppm) (66.5%). Other biocontrol agents resulted in 49.2 to 51.3% reduction in the aphid population over control 10 days after the second spray/ release.

Table 179.Evaluation of biocontrol agents for the control *Myzuspersicae* in capsicum under polyhouse

Treatment	**% reduction in aphid population over control after indicated days of I and II spray/ release**					
	I spray/ release			**II spray/ release**		
	5	**7**	**10**	**5**	**7**	**10**
Metarhizium anisopliae (5g/l of 10^8 conidia/ g)	16.4 (23.8)d	23.6(29.1)c	39.2 (38.7)c	43.8(41.4)c	45.1 (42.1)c	49.2 (44.5)c
Lecanicillium lecanii (5g/l of 10^8 conidia/ g)	27.2(31.4)cd	37.1(37.5)c	50.3(45.1)b	58.4(49.8)b	63.8(53.0)bc	68.9(56.1)b
Beauveria bassiana (5g/l of 10^8 conidia/ g)	19.8 (26.4)d	23.5 (28.9)c	36.3(37.0)c	44.4(41.7)c	51.3(45.7)c	53.9 (47.2)c
Chrysoperla zastrowi sillemi (4 larvae / plant)	32.3 (34.6)c	37.2(37.5)c	55.8(48.3)b	64.7(53.5)b	69.2(56.2)b	78.1 (62.1)b
Blaptostethuspallescens @ (30 nymphs/ m row)	21.6(27.7)cd	29.2(32.7)c	33.1(35.1)c	37.3(37.6)c	47.2 (43.3)c	51.3(45.7)c
Azadirachtin (2ml/L of 1500ppm)	54.7(47.6)b	56.9(48.9)b	49.8(44.8)bc	69.9(56.7)b	68.1(55.6)b	66.5(54.6)bc
Imidacloprid (0.5ml/L)	100.0(90.0)a	100.0(90.0)a	98.8 (83.7)a	100.0(90.0)a	100.0(90.0)a	100.0(90.0)a
CD (p=0.05)	(7.2)	(9.6)	(6.7)	(8.0)	(7.4)	(7.9)
CV (%)	26.1	32.9	35.5	24.5	32.1	28.2

Figures in parantheses are arc sine transformed values

31. TRIBAL SUB PLAN

31.1 Biological interventions to enhance the crop production and productivity of tribal farmers of Narmada district in Gujarat (AAU-Anand)

Two hundred tribal farmers were selected from Dediyapada, Sagbara and Tilakwada talukas of Narmada district. Area covered was ~1 acre/farmer. In association with Krishi Vigyan Kendra (KVK), Dediyapada, Navsari Agricultural University, khedut shibir and training programmes were organized in the month of September, November 2018 and March 2019 to train the farmers on use of biocontrol inputs and strategies to tackle key pests and diseases to achieve sustainable crop production. The following bio-inputs were distributed to farmers

Sl. No	Inputs	Quantity/farmer
1	Tricho card	10 No
2	*Beauveria bassiana* (NBAIR strain)	2 kg
3	*Metarhizium anisopliae* (NBAIR strain)	2 kg
4	*Bacillus thuringiensis* (NBAIR strain)	2 kg
5	*Trichoderma viride* (NBAIR strain)	2 kg
6	*Pseudomonas fluorescens* (NBAIR strain)	2 kg
7	Azadirachtin 1500ppm	1 litre
8	Bio-fertilizers (Bio NPK)	2 litre
9	Pheromone trap and lures	10 No
10	Yellow sticky traps	5 No

Field visits were conducted to record the use of bio-inputs by the farmers and bio-efficacy of inputs.

31.2 Bio-input distribution under Tribal Sub plan project (AAU- Jorhat)

Baksa District: 200 Farmers from four villages (Kochukota, Khatpara, Tamulpara and Rongia) in Baksa District were selected. Only 2 villages (Kochukota and Khatpara) have been completed till now in regards to training and distribution of bio-inputs among the farming community. Presently, due to parliamentary election, as there is a temporary prohibition for holding training and input distribution among the farmers, the schedule programme will be resume after 18th April, 2019.

Materials already distributed to the TSP farmers:
Knapsac Spryaers: 100 nos.
Neem pesticides, YST, Pheromone trap
Bio agents (*Trichogramma)* and Biopesticides
Knapsac Sprayers: 100 nos.
Apron: 100 nos.
Khupri: 100 nos.
Neem pesticides, YST, Pheromone trap
Bio agents (*Trichogramma)* and Biopesticides

Impact of TSP project: The training were conducted with cooperation from KVK, Baksa at Kachukata and Khatpara area of Baksa B. T. A. D. area on 05.02.19 and 06.02.19 respectively. A total of 100 numbers of farmers participated in this training programme. The main subjects covered in the training were insect pest of rice and vegetables. The eco-freindly way of management of insect pests were emphasized along with the proper use of Biopesticides with knapsac Sprayer. They asked various question regarding insect pests of *rabi* & *kharif* crops and their biological control approach. They were happy with the practical of training.

Glimpses of the TSP training programme

Training and material distribution at Kochukota& Khatpara villages of Baksa

31.3 ANGRAU, Anakapalle

Locations: 11villages inAraku valley and Chinthapalli areas of Visakhapatnam district

Area & crops covered: 143 acres of paddy, rajmah, ginger crops

Number of farmers benefited: 162 farmers through FLD's. &168 farmers benefitted through trainings

Constraints identified:

Paddy: Poor tillering, Stem borer, leaf folder, blast, sheath blight
Turmeric: Low plant population, poor plant growth, root rot, leaf spot and termites
Ginger: Low plant population, poor plant growth, rhizome rot and termites
Vegetables (Tomato, cabbage, beans): Sucking pests, borers, wilt, leaf spot

Technologies implemented:
Organic farming in Paddy
Organic farming in Turmeric
Organic farming in Ginger
Organic farming in vegetables
*Trichogramma chilonis*production in Tribal areas

Interventions: Demonstrations, awareness cum training Programmes, Rythusadassu

Inputs to be supplied to FLD farmers:

Biopesticides: *Pseudomonas flourescens* for seed treatment and foliar spraying in paddy, turmeric, vegetables; *Trichoderma viridae* forturmeric, gingerv, vegetables; *Metarhizium anisopliae* for soil application in Ginger against termites.
Liquid Biofertilizers: *Azospirillum* , *Phosphobacteria*, *Potassium fixing bacteria* each @ 500 ml/ acre for paddy, turmeric, ginger, vegetables; VAM @ 5 kg/ acre for turmeric, ginger, vegetables
Biocontrol agents: Trichocards (*Trichogramma japanicum* and *Trichogramma chilonis*) for the management of stem borer and leaf folder in paddy, borers in vegetables.
Solar Hand Sprayers (one for a group of 15 farmers) for spraying biopesticides.

Conducted skill training to Tribal farmers onTrichocard production using *Corcyra* eggs at RARS, Anakapalle on 5.7.18.

Organised farmers meet of ICAR-NBAIR and stay at Arakuvalley on 6.7.18 on the occasion of silver jubillee celebrations of NBAIR, Bengaluru and emphasized the importance of biological control of crop pest in organic farming and encouraged the tribal farmers of Araku Valley to use the biocontrol agents in field extensively. The Pedalabudu farmers were encouraged to use the biocontrol agents like *Trichogrammma* cards and *Pseudomonas* powder in paddy with demonstration and distribution of biocontrol agents. Around 130 farmers participated in the programme.

Mobilized 25 tribal farmers from Asarada, Chinthapalli for participation in kisan mela. Conducted awareness cum training programme on Trichocard production during exposure visit to 25 Tribal farmers of Asarad, GK Veedhi mandal, Chinthapalli division and distributed inputs for Trichocard production under TSP programme of AICRP on Biological controlon 15.2.19. Trichocard production was initiated by tribal farmers for release in *kharif* paddy.
Organised two rythusadassu's at Kollaput, Dumbriguda mandal, Arakuvalley on 27.3.19 and at Aratichetlaveedhi, GK veedhi mandal, Chinthapalli, Visakhapatnam district on 28.3.19. Motivated 78 tribal farmers of seven hamlet villages under Kollaput, Araku valley and 64 tribal farmers of four hamlet villages under Aratichetlaveedhi, Chinthapalli for conducting demonstrations on Organic farming in paddy, turmeric, ginger and vegetables.
Imparted training on importance of bicontrol agents (*Trichogramma*), botanicals (neem oil, neem cake), biopesticides (*Trichoderma*, *Pseudomonas*, *Metarhizium*) and Biofertilizers (*Azospirillum*, Phosphobacterium, potash solubulizing bacteria, VAM) benefiting 142 tribal farmers of 11 tribal villages cultivating paddy, turmeric, vegetable and ginger in Araku valley and Chinthapalli areas in Visakhapatanam district.

31.4 GBPUAT, Pantnagar

The fund in TSP component was released late in December 2018 that was not the season of any crops in tribal area of Uttarakhand. The programme will be executed in coming season. The inputs are purchased and will be distributed in upcoming season of 2019.

Input purchased to be distributed to Tribal farmers

S.No.	Name of Input	Quantity
1.	Neem oil	240 liter
2.	Pheromone Trap	480 No.
3.	Different Lure	1000 No.
3.	*Trichoderma*	500 kg
4.	*Pseudomonas*	500 kg
5.	Polytheen roll	40 No.
6.	Vermicompost	30 qt.
7.	Quality seed	
8.	Need based Chemicals	

Area Selected for the TSP Programme in Block Khatima of District U.S.Nagar

1. Bankatia
2. Debari

31.5 Integrated management of Codling moth, *Cydiapomonella* in Ladakh (Kargil&Leh) (SKUAST, Srinagar)

Fifteen villages in each subdivision (Kargil and Leh) have been selected for implementation of the programme and supply of inputs. Since the National Highway from Srinagar to Laddakh remains closed from November to 1st week of May. The programme will therefore be initiated just after opening of the National Highway. Adhar card will be taken prior to distribution of inputs to the beneficiaries. Items for distribution to farmers under Tribal sub plan (2018-19) have been purchased. Out of the total 30 villages around 100 farmers will be provided all inputs for the management of Codling moth. Detailed report of implementation 2018-19 will be submitted during Annual workshop of 2019-20.

31.6 TNAU, Coimbatore

Trainings on production of biocontrol agents and biointesive pest mamagement were conducted to benefit the ribal farmers from Coimbatore, Erode and Tirupur Districts. The details of training are furnished below.

Sl.No.	Date of training	Name of the tribal villages	No. of farmers	Inputs given
1	07.03.19	Jambukandy, Senguttai – Coimbatore Dt.	35	Parasitoids, Predators, Battery operated sprayer, neem oil, teepol, plastic bucket, plastic mug, plastic trays, cumbu grains, maize grains, vegetable seeds, training bag
2	21.03.19	Hosur, Bejeletti – Erode Dt.	35	Parasitoids, Predators, Battery operated sprayer, neem oil, teepol, plastic bucket, plastic mug, plastic trays, vegetable seeds,training bag
3.	28.03.19	Karumutti – Tirupur Dt.	30	Parasitoids, Predators, Battery operated sprayer, neem oil, teepol, plastic bucket, plastic mug, plastic trays, vegetable seeds,training bag

TRIBAL SUB PLAN TRAININGS

Training at Biocotrol laboratory,TNAU – Farmers from Jambukandy and Senguttai, Coimbatore Dt. - 07.03.19

Training at Biocotrol laboratory, TNAU – Farmers from Jambukandy and Senguttai, Coimbatore Dt. – 07.03.19

Training at Hosur, Erode Dt. – 21.03.19

Training at Karumutti, Tirupur Dt. – 28.03.19

31.7 YSPUHF, Solan: Eco-friendly management of insect-pests of temperate fruits and vegetables to minimize the use of chemical pesticides on these crops.

Location details: Two villages, Khani & Holi were selected in Chamba District, Himachal Pradesh. 100 farmers were benifited (50from each villages). The crops covered include Apple (60ha), Almonds (5ha), Peas (10ha), Beans (5ha), cauliflower & cabbage (15ha). Totally 95 ha were covered.

IPM technologies demonstrated/ implemented

Use of *Metarhizium anisopliae*, *Beauveria bassiana* and azadirachtin for the management of apple root borer and apple stem borer.

Use of *Trichoderma* far the management of diseases in apple and vegetable nursery.

Use of azadirachtin and mechanical control in cabbage and cauliflower for the management of cabbage caterpillars.

Avoidance of indiscriminate use of insecticides for the conservation of parasitoids of apple woolly aphid and other natural enemies.

Use/conservation of predatory mites in beans and apple against phytophagous mites.

Training/ demonstration conducted: Trainings and demonstrations were organized at Khani and Holi villages of Chamba district of Himachal Pradesh in which 100 farmers participated 25-26 October 2018. Farmers were trained and demonstrated regarding the use of above said bio-pesticides for the management of insect and mite pests of apple, almond, peas, beans, cauliflower and cabbage. The farmers of the area were exposed to the use of bio-pesticides for the management of crop pests for the first time. Besides above trainings two more trainings to benefit 100 farmers will be organised in district Kinnaur after the modal code of conduct is lifted. The inputs for the same have already been purchased.

Inputs supplied to the farmers: 50 kgeach of *Metarhizium anisopliae* and *Beauveria bassiana*, 50 litres of Neem oil, 200 kg of *Trichoderma viride* and 200 copies of package of practices for fruit crops.

Outcome of the project: The tribal farmers were exposed for the first time in this area to use biopesticides for pest & disease management of horticultural crops. There was a reduction of 2 sprays of chemical pesticides in peas, beans, cauliflower and cabbage. In case of apple, farmers saved about Rs 15000/- per hectare by avoiding chemical treatment for the control of apple root borer.

Farmers taking part in the training programmes

31.8 CAU, Pasighat

The Tribal Sub Plan at Pasighat centre was executed in the three district of Arunachal Pradesh e.g. East Sing, Upper Siang and Leparada within 23 villages. The total 100 number of farmers are covered under the scheme with Aadhar Card.

List of Villages Under TSP							
1.	Ayeng	7.	Padu	13.	Takilalung	19.	Jomlo Bari
2.	Geku	8.	Paglek	14.	Tekang	20.	Pagi
3.	Jampani	9.	Regi	15.	Yagrung	21.	Yingkiong
4.	Jarku	10.	Ringing	16.	Kiyit	22.	Sipu
5.	Mirbuk	11.	Runne	17.	Pasighat	23.	Bilat
6.	Napit	12.	Sibut	18.	Riga		

The major insect pests such as yellow stem borer, cutworm, brinjal shoot and fruit borer, *Helicoverpa armigera*, *Spodoptera litura*, fruit sucking moth, fruit flies and brinjal Leaf roller and many more nocturnal insect pests were common in this area. The farmers are unable to identify the above mentioned pests. We have distributed light trap for proper identification as well as monitoring of pest problem in the farmers field.

Farmer’s communities in Arunachal Pradesh are very eager to adopt the organic farming and they are using negligible insecticides. Based on the idea we have distributed the 50 No. of Knapsack sprayers with neem oils to promote the organic cultivation as well as conservation of natural enemies.

Since the farmers of Arunachal Pradesh are using local vegetables varieties and receiving low production. So that we have distributed the improved vegetables seeds which are purchased from Government institute. They are very much happy about the performance of vegetables seeds

Varieties such as Swarn Priya (French bean), Swarna Syamali, Swarna Pratibha (Brinjal), Arka Niketan (Onion), Swarna Praphulya (Chili) and Swarna Lalima (Tomato) were purchased from ICAR Research Complex for Eastern Region, Research Center, Ranchi, Jharkhand and distributed to the farmers.

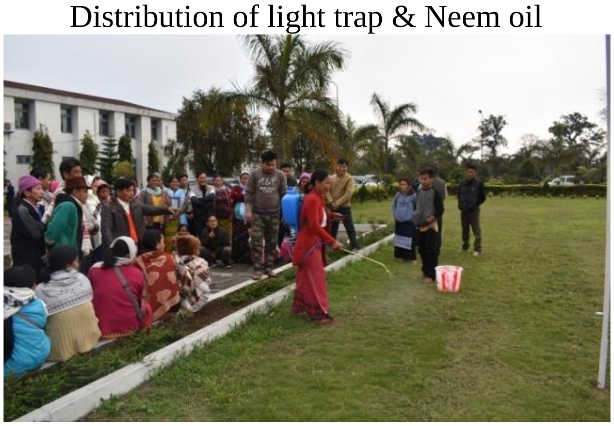
Materials supplied to the TSP farmers with clear financial details:

S. No.	Components	Quantity (No./kg/L)	No. of Farmers	Area/person covered (ha)	Total Expenditure
1.	Light trap	100 no.	100 no.	100 ha.	183500.00
2.	Knapsack spryer	50 no.	50no.	50	174260.00
3.	Neem oil	50 litre	50 no.	50	
4.	Vegetable seeds		1000 no.	-	
	French bean	40kg	-	-	17350.00
	Brinjal	6kg	-	-	24250.00
	Onion	3kg	-	-	6125.00
	Chilli	10kg	-	-	30500/-
	Tomato	10kg	-	-	40500.00
5.	Training	-	100 no.	100 no.	85973.00
Total					**562458.00**

Distribution of inputs under TSP, 2019 funded by ICAR, NBAIR, Bengaluru


Distribution of light trap & Neem oil


Distribution of light trap


Distribution of Knapsack sprayer


Distribution of vegetables seeds

Three days Training programme “***Integrated Pest Management in Horticultural Crops***” from 23-25 March, 2019 under TSP, at Collage of Horticulture & Forestry, Pasighat funded by ICAR, NBAIR, Bengaluru, India.




31.9 IGKV, Raipur

The Tribal sub Plan under IGKV, was allotted with a fund of Rs. Five lakhs. The area selected under TSP was Jagdalpur. (Bastar) belonging to the Bastar plateau zone of Chhattisgarh. About 150 ST farmers in six villages (Lamker, Pallichakwa, Badechakwa, Nadisagar, Tahkapal & Tandpal) were selected and their adhaar card numbers and Bank account numbers were recorded.

The TSP was launched along with training on 12/01/2019, in which men & women farmers and school students belonging to Vilage –Badechakwa (Jagdalpur) attended the training and also saw the live bioagents displayed.

The second training was held on 31/01/2019 in the village- Badechakwa. Initially a training and demonstration programme of preparation of Trichocards was given to the farmers. Then visit to the farmers fields was made and the correct method of applying the Trichocards cards in the field was demonstrated.

Training under TSP on Biocontrol, in village–Badechakwa, Jagdalpur on 31/01/19

31.10 UBKV, Pundibari: Biological control of pests and promotion of bee keeping in the northern tract of West Bengal for maintenance of ecological sustainability and upliftment of rural livelihood of tribal farmers.

Location of the tribal area where TSP was implemented: Alipurdwar, Cooch Behar and Dakshin Dinajpur districts of West Bengal.

No of the villages covered and number of tribal farmers benefitted:

Sl. No.	Village	Date of training/ Input distribution	No. of farmers
1.	Uttar Chakoakheti	06.03.19	40
2.	Dakshin Santali	13.03.19, 26.03.19	60
3.	Balurghat, DakshinDinajpur	25.02.19	30
4.	Pundibari	20.03.19	30

Inputs supplied to the tribal farmers:

S. No.	Inputs	Quantity
1	Biocontrol (Microbial) agent for rice/ vegetables/pulses	185 kg (1.85 kg/farmer and total number of farmers were 100)
2.	Pheromone Trap (Cue lure fruit fly trap) for cucurbits	500 pieces (5 traps/farmer and total number of farmers were 100)
3.	Bee-hives (*Apismellifera*) with accessories	210 bee-hives, 50 honey extractors and other equipments (3 beehives/farmer were distributed to the 30 farmers and 6 beehives/farmer were distributed to the 20 farmers; 1 extractor/farmer). Total number of farmers were 50.

Outcome of the project:

The awareness cum training programme on use of biocontrol agent for management of pest and diseases of different crops was provided first time to all the tribal farmers.
Microbial biocontrol agents were given to the trained tribal farmers for field demonstration against diseases of crops.
Pheromone traps were distributed among trained tribal farmers for management of cucurbit fruit fly.
Training and inputs for bee-keeping were given to the tribal farmers of Alipurdwar, Cooch Behar and DakshinDinajpur districts of West Bengal for upliftment of their livelihood.

32. GENERAL INFORMATION

32.1 Functioning of the co-ordinated project

32.1.1 Scientific Staff Position (2018-19)

Sl. No.	Name	Designation	Date Of joining ICAR/SAU	Date of joining present position
1	Dr. Chandish R. Ballal	Director	06.02.1985	18.07.2016
2	Dr. S. K. Jalali	HOD, DIGR	06.02.1985	Dec. 2008
3	Dr. N. Bakthavatsalam	HOD, DIGC&U	21.03.1985	21.03.2006
4	Dr. B. Ramanujam	Pl. Scientist (Pl. Patho.)	16.04.1986	28.09.2006
5	Dr. K. Veena Kumari	Pl. Scientist (Agri. Ento.)	05.12.1989	Dec. 2006
6	Dr. A. N. Shylesha	Pl. Scientist (Agri. Ento.)	21.01.1992	09.12.2007
7	Dr. T. Venkatesan	Pl. Scientist (Agri. Ento.)	10.11.1993	01.01.2009
8	Dr. P. Sreerama Kumar	Pl. Scientist (Pl. Patho.)	25.07.1994	25.07.2009
9	Dr. K. Srinivasa Murthy	Pl. Scientist (Agri. Ento.)	25.07.1994	25.07.2009
10	Dr. T. M. Shivalingaswamy	Pl. Scientist (Agri. Ento.)	25.07.1994	01.01.2009
11	Dr. M. Nagesh	Pl. Scientist (Nemato.)	09.10.1990	09.10.2007
12	Dr. Sunil Joshi	HOD, DIGC&C	21.07.1993	22.07.2010
13	Dr. R. Rangeshwaran	Pl. Scientist (Microbiol.)	21.07.1993	24.07.2011
14	Dr. Kesavan Subaharan	Pl. Scientist (Agri. Ento.)	03.07.1998	03.07.2013
15	Dr. M. Pratheepa	Sr. Scientist (Com. App.)	21.04.1997	21.07.2012
16	Dr. A. Kandan	PI.Scientist (Pl.Patho)	26-02-2011	26-02-2017
17	Dr. Kolla Sreedevi	Sr. Scientist (Agri. Ento)	03-05-2012	03-05-2015
16	Dr. Deepa Bhagat	Sr. Scientist (Or. Chem.)	18.11.1999	24.08.2013
17	Dr. G. Sivakumar	Pl. Scientist (Microbiol.)	30.12.2008	30.12.2014
18	Dr. R. Gandhi Gracy	Scientist (Agri. Ento.)	08.01.2007	08.01.2012
19	Dr. Ankita Gupta	Scientist (Agri. Ento.)	15.12.2009	15.12.2013
20	Dr. K. J. David	Scientist (Agri. Ento.)	21.04.2009	21.04.2014
21	Dr. S. Salini	Scientist (Agri. Ento.)	21.04.2009	21.04.2014
22	Dr. M. Mohan	Pl. Scientist (Agri. Ento.)	16.04.2003	30.08.2014
23	Dr. Mahesh Yandigeri	Sr. Scientist (Microbiol.)	29.06.2006	30.12.2013
24	Dr. Jagadeesh Patil	Scientist (Nemato.)	20.04.2010	20.04.2014
25	Dr. Richa Varshney	Scientist (Agri. Ento.)	01.01.2015	01.01.2015
26	Ms. Rachana R R	Scientist (Agri. Ento.)	01.01.2015	01.01.2015
27	Dr. R. S. Ramya	Scientist (Agri. Ento.)	01.01.2016	01.01.2016
28	Dr. N. S. Omprakash	Scientist (Agri. Ento.)	01.01.2016	01.01.2016
29	Dr. M. Sampath Kumar	Scientist (Agri. Ento.)	11.05.2010	11.05.2014
30	Dr. Amala U	Scientist (Agri. Ento.)	15.09.2011	15.09.2011
31	Dr. K. Selvaraj	Scientist (Agri. Ento.)	27.04.2011	27.04.2015
32	Dr. G. M. Mahendiran	Scientist (Agri. Ento.)	04.11.2009	04.11.2013
33	Dr. Veeresh Kumar	Scientist (Agri. Ento.)	01.07.2015	01.07.2015

Central Tobacco Research Institute, Research Station, Guntur				
1	Dr. P. Venkateswarulu	Scientist (Ento.)	2015	Continuing
Central Plantation Crops Research Institute, Regional Station, Kayangulam				
1	Dr. Chandrika Mohan	Pl. Scientist (Ento.)	01.04.1996	Continuing
Indian Agricultural Research Institute, New Delhi				
1	Dr. B. Paul	Senior Scientist (Ento.)	2012	Continuing
2	Dr. Shankar Ganesh	Scientist (Ento.)	2015	Continuing
Indian Institute of Sugarcane Research, Lucknow				
1	Dr. Arun Baitha	Sr. Scientist (Ento.)	01.10.2006	Continuing
Indian Institute of Horticultural Research, Bengaluru				
1	Dr. P. N. G. Visalakshy	Pl. Scientist (Ento.)	1987	
2	Ms. Jayanthi Mala	Scientist (Ento.)	2016	Continuing
3	Dr. N.R. Prasannakumar	Scientist (Ento.)	2016	Continuing
National Centre for Integrated Pest Management, New Delhi				
1	Dr. Anoop Kumar	Pl. Scientist (Pathology)		Continuing
2	Dr. Mukesh K. Khokhar	Scientist (Pathology)		
Indian Institute of Millet Research, Hyderabad				
1	Dr. G. Shyam Prasadt	Princ. Scientist (Ento.)	2015	Continuing
Central Institute of Sub-Tropical Horticulture, Lucknow				
1	Dr. B. Gundappa	Scientist (Ento.)	2013	Continuing
2	Dr. P. K. Shukla	Scientist (Ento.)	2017	Continuing
Indian Institute of Rice Research, Hyderabad				
1	Dr. Chitra Shanker	Princ. Scientist (Ento.)	2013	Continuing
2	Dr. C. Kannan	Princ. Scientist (Ento.)	2017	Continuing
Indian Institute of Vegetable Research, Varanasi				
1	Dr. Jaydeep Halder	Scientist (Ento.)	21.04.2009	24.05.2013
Anand Agricultural University, Anand				
1	Dr. D. M. Mehta	Principal Res. Scientist	July 2012	Continuing
2	Dr. B.L. Raghunandan	Asso. Res. Scientist	2015	Continuing
Acharya N. G. Ranga Agricultural University, RARS, Anakapalle				
1	Dr. M. Visalakshi	Sr. Scientist (Ento.)	Apriul 2015	Continuing
Assam Agricultural University, Jorhat				
1	Dr. D. K.Saikia	Principal Scientist (Ento.)	23.03.2001	Continuing
2	Dr.R. Borkakati	Scientist (Ento.)	22.08.2014	Continuing
Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar				
1	Dr. Anand Kumar Tewari	Professor, Pl. Pathology		Continuing
2	Dr. Roopali Sharma	Junior Research Officer	12.01.2006	Continuing
Kerala Agricultural University, Thrissur				
1	Dr. Madhu Subramanian	Professor (Ento.)	2015	Continuing
Mahatma Phule Krishi Vidyapeeth, Pune				
1	Dr. S.M. Galande	Asst. Entomologist	01.08.2013	Continuing
2	Dr. S. A. More	Asst. Entomologist	01.02.2019.	Continuing
Professor Jayashankar Telangana State Agricultural University, (PJTSAU) Hyderabad				
1	Dr. S.J Rahman	Professor & Head	Feb. 2007	Continuing
Punjab Agricultural University, Ludhiana				
1	Dr Neelam Joshi	Senior Microbiologist	08.05.1997	Continuing
2	Dr Parminder Singh Shera	Asstt. Entomologist	09.05.2015	Continuing

Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar				
1	Dr. Jamal Ahmad	Associate Professor	Nov. 2007	Continuing
2	Mr. Sajad Mohi-ud-din	Assistant Professor	June 2013	Continuing
Tamil Nadu Agricultural University, Coimbatore				
1	Dr. S.Jeyarajan Nelson	Professor	08.01.2018	Till date
Dr. Y.S. Parmar University of Horticulture and Forestry, Solan				
1	Dr. P. L. Sharma	Principal Scientist (Ento.)	21.11.1995	05.2008
2	Dr. S. C. verma	Principal Scientist (Ento.)	30.11.1995	01.2016
Central Agricultural University, Pasighat				
1	Dr. Raghubir K Patidar	Asso. Prof. (Ento.)	2015	Continuing
Maharana Pratap University of Agriculture & Technology, Udaipur				
1	Dr. M.K.Mahla	Asso. Prof. (Ento.)	2018	Continuing
Orissa University of Agriculture & Technology, Bhubaneshwar				
1	Dr. Bhagaban Patro	Prof. (Ento.)	12.08.1985	29.06.2015
University of Agriculture Sciences, Raichur (Voluntary Centre)				
1	Dr. Arunkumar Hosmani	Asso. Prof. (Ento.)	2015	Continuing
Indira Gandhi Krishi Vishwavidyalaya(IGKV) Raipur				
2	Dr. Jayalakshmi Ganguli	Asso. Prof. (Ento.)	2015	Continuing
Kerala Agricultural University(KAU- K), Kumarakom				
1	,Dr. Sible George Varghese	Asso. Prof. (Pl.Patho.)	2018	Continuing
2	Dr. Anu G. Krishnan	Asso. Prof.(Horti)	2018	Continuing
Kerala Agricultural University(KAU- V) Vellayani				
1	Dr. Rejirani,	Asst. Prof. (Ento.)	2018	Continuing
Uttar BangaKrishi Viswavidyalaya(UBKV), Pundibari				
1	Dr. S. K. Sahoo	Asso. Prof. (Ento.)	2018	Continuing
2	Ms. Moulita Chatterjee	Asst. Prof. (Ento.)	2018	Continuing
3	Mr. D. Chakraborty	Asst. Prof. (Ento.)	2018	Continuing
Sun Agro Biotech, Chennai (Voluntary Centre)				
1	Dr. S. Sithanantham	Director	2018	
Panjabro Deshmukh Krishi Vidyapeeth(PDKV) (Voluntary Centre)				
1	Dr. B.D. Udirwade	Professor & Head (Ento.)	2018	Continuing
2	Dr. S. K. Bhalkare	. Prof. (Ento.)	2018	Continuing
3	Dr. Niraj Satpute	I/C, Biocontrol Lab		

32.2 Budget of AICRP for 2018-2019

Item of Expenditure	**Sanctioned and allotted grants (Rs. in lakh)**	**Grants released during2018-19 from ICAR (Rs. in lakh)**	**Total expenditure (Rs.)**
Pay and allowances	215.55	215.55	215.55
Rec. Contingencies	396.85	396.85	396.85
T.A	70.90	70.90	70.90
TOTAL	**683.30**	**683.30**	**683.30**

PROBLEMS ENCOUNTERED DURING THE YEAR (2018-19)

AAU-J:

1. Survey and collection of natural enemies from different Agro-ecological zone, demonstration and field trials on farmers' fields are very much essential to carryout in due time. In this context, it would be better to have prompt response from NBAIR particularly identification of the specimens.

MPKV:

1. Grants may be release well in advance.

TNAU

1. Prevalence and spread of coconut rugose whitefly in various districts of Tamil Nadu was observed. The natural enemies like *Encarsia* spp were collected and redistributed to farmers. Apart from that, *Chrysoperla zastrowisilemmi* is being supplied to farmers for the management of this invasive pest.
2. Incidence of maize fall armyworm was observed in different districts of Tamil Nadu and contingent remedial measures were recommended to the farmers.

CPCRI

1. Flood in Kerala during August 2018

32.4 Visitor

AAU-Anand

Sr. No.	Visitors	Total
1	Students	312
2	Trainees/ Students	43
3	Trainees/farmers	165
	Total	**520**

AAU- Jorhat

1. QRT team headed by Dr. V. V. Ramamurty, visited AICRP-BC Jorhat centre, Assam Agricultural University, Jorhat on 20th and 21st August,2 018 to review the progress of the research programme.
2. Visit of Dr. O.P. Navik, Scientist, NBAIR, Bengaluru to AICRP-BC Jorhat centre on 23rd August,2018
3. Visit of a few unemployed youth from Meghalaya to Biocontrol laboratory of Department of Entomology on 4th October 2018
4. Visited by the participants of CAFT training on "Techniques in Bio-fertilizers and Bio-pesticides Production for Organic Agriculture" sponsored by ICAR, New Delhi and Organized by "Centre of Advanced Faculty Training (CAFT) in OrganicFarming", Department of Soil Science, Faculty of Agriculture, Assam Agricultural University, Jorhat: 785013, Assam, from 14th Nov.- 4th Dec.2018
5. Entomologist Dr. Dionysios Perdikis from Greece visited our Biocontrol laboratory on 19th December 2018

6. Visited by the participants of CAFT training on "Developments in Organic Agriculture" sponsored by ICAR,New Delhi and Organized by "Centre of Advanced Faculty Training (CAFT) in OrganicFarming", Department of Soil Science, Faculty of Agriculture, Assam Agricultural University, Jorhat: 785013, Assam, from 6th – 26th December, 2019)

ANGRAU

1. Dr. B. Ramanujam, AICRP-Biocontrol incharge from NBAIR, Bengaluru visited sugarcane white grub demonstration plots in Navabharath sugars (Samalkota) operational area at Peddapuram and Chebrolu, East Godavari district on 03.01.19.

KAU, Thrissur

1. Dr. Chandish R. Ballal, Director, NBAIR, Bengaluru visited the Centre from 26 to 27th of February, 2019 to review the activities of the centre as well as to take part in the harvest festival at Alathur in Palakkad.

MPKV

1. Dr. V.V. Ujjainkar and Dr. M.R. Wandhare, Asstt. Prof. of Botany, College of Agriculture, Dr. PDKV., Akola visited Biocontrol laboratory along with sixty students on 01.06.2018.
2. Dr. P.N. Rasal, Associate Dean, College of Agriculture, Pune and Dr. S. D. Masalkar, Associate Dean, College of Horticulture, Pune visited Biocontrol laboratory on 7.7.2018 and took review of the progress of work.
3. Dr. P.N. Rasal, Associate Dean, College of Agriculture, Pune and Dr. S. D. Masalkar, Associate Dean, College of Horticulture, Pune visited Biocontrol laboratory on 18.7.2018 and took review of the progress of work.
4. DR. B.S. Chunawat, Chairman, Peer Review Team (PRT) and Former Vice Chancellor, SDAU, Dantiwad along with other members visited Biocontrol laboratory on 25.7.2018 and took review of the progress of work.
5. Dr. Sithanantham, President and Director, Sun Agro Biotech Research Centre, Chennai and Former Entomologist, ICRISAT, Hyderabad visited Biocontrol laboratory on 2.8.2018.
6. Dr. Y. S. Nerkar, Former Vice- chancellor, MPKV, Rahuri, and Team of Deccan Sugar Technologist Assocaiation, Pune visited Biocontrol laboratory on 30.8.2018 and collected the information of Bioagent production and white Grub management.
7. Dhanjay Kale, Sr. Manager, RCF, Ltd, Chembur-74 visited Biocontrol laboratory on 31.8.2018 alongwith 25 Particpants under ITEC programme (Ministery of External Affairs, Govt. of India and collected the information of Bioagent production.
8. Shri. Girishji Bapat, Minister, Food, Civil Supplies and Consumer Protection, Food and Drug Adminstration, Parliamentary Affairs, Govt. of Maharashtra, inaugurated Ago Technology Exhibition at College of Agriculture, Pune and visited stall of Biocontrol laboratory on18.9.2018.
9. Dr. Dilip Monga, Head, ICAR, CICR Regional Station, Sere (Haryana) Dr. Rishi Kumar, Principal Scientist (Entomology), CICR Regional Station, Sere (Haryana) and Karpagam, Sr. Scientist (Entomology), RAR- CICR, Coimbatore (T.N) visited biocontrol laboratory on 20.11.2018.
10. Dr. Kolla Sreedevi, Sr. Scientist, NBAIR, Banagalore visited the Biocontrol laboratory and experiment in the field. Monitored the research activity of the AICRP on Biocontrol,

Pune on 21. 12. 2018. Dr. M. Nagesh, Principal Scientist, Division of Genomic Resources, NBAIR, Bengaluru visited the Biocontrol laboratory and the experiments in the field. Monitored the research activity of the AICRP on Biocontrol, Pune on 21.1.2019.

11. Shri Shrisail S. Heganna, Chief Agril. Officer, Datta Sugar factory, Shirol visited Biocontrol laboratory on 8.1.2019
12. Shri. Philip Varghese, Asstt. Director of Agriculture Agency, Kerala, Team leader and 12 Officer from State Dept of Agriculture, Kerala visited Biocontrol laboratory on 17.01.2019.

PAU, Ludhiana

1. Officials (ADO) from Ministry of Agriculture, Irrigation, Livestock, Government of Afghanistan visited biocontrol laboratory on 16.4.2018.
2. Scientists from IARI, New Delhi – Dr J P Singh, Dr Naresh M. Meshram, Dr P R Shashank and Dr (Ms) S N Bhagyashree visited biocontrol laboratory on 14.9.2018.
3. Scientists from NIPHM Hyderabad – Dr Lavanya and Dr Bindu Madhavi visited biocontrol laboratory on 5.10.2018.
4. B.Sc. (Agriculture) students from Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP) visited biocontrol laboratory 9.10.2018
5. Trainees from HAU Hisar under CAFT programme visited biocontrol laboratory on 15.10.2018.
6. Dr K Sree Devi, Sr Scientist, NBAIR, Bengaluru visited biocontrol laboratory 28.11.2018.
7. Dr Chandish R. Ballal, Director, NBAIR, Bengaluru visited biocontrol laboratory on 30.11.2018.
8. Sh Davinder Singh (IAS), Managing Director, Sugarfed Punjab and General Managers, Cooperative Sugar mills of Punjab visited biocontrol laboratory on 7.2.2019.

SKUAST

1. Visit of Visits of 60 students of B.Sc. (under Organic farming) to Bio control laboratory on 29.06.2018.
2. Visit of students of B. Sc. 3rd year for learning mass production of *Trichogramma* spp.
3. Visit of CITH scientist in Biocontrol laboratory to learn mass production technique of *Corcyra cephalonica* and anthocorid bugs on 25.3.2019.

PJTSAU

1. **Dr. M.V.Ramana**, Associate Director of Research, PJTSAU visited the Centre in January, 2019.
2. **Dr. S.N.Puri**, Former Vice Chancellor, CAU & Adjunct Faculty PJTSAU, visited the Centre in March, 2019

TNAU

S.No.	DATE	VISITORS	PURPOSE
1	01.10.18 and 02.10.18	Dr. Helga Bango Metzler, Entomologist, University of Costa Rica, Sanjose, Costa Rica Mrs. Rossy Marcela Morera Montoya, Entomologist, University of Costa Rica, Sanjose, Costa Rica	To see the activities of biocontrol laboratory
2.	20.12.18	Joint Director of Agriculture from 6 Districts of Tamil Nadu	To attend brain storming session on the management of rugose whitefly and maize fall armyworm.
3.	12.02.19	Prof.G.Mukunthan Dean, Faculty of Graduate Studies, University of Jaffna	To see the activities of biocontrol laboratory

YSPUHF

1. Quinquennial review team of AICRP-BC comprising of Dr VV Ramamurthy, Dr Chandish R Ballal, Dr RS Gill, Dr Lalith Achoth and Dr J Patil visited the centre on22 June 2018 to review the AICRP progress. The team also visited laboratories and fields to review the ongoing research trials.
2. Experts from Newzealand visited the AICRP Biocontrol Research Laboratory on 20 February 2019
3. Input dealers (25no) of Solan district visited the Biocontrol Research Laboratory on 7 December 2018
4. Students (25 no) from Eternal University Baru Sahib visited the Biocontrol Research Laboratory under RAWE on 7 December 2018
5. Students (16 no) from KK Wagh College of Agriculture Nasik visited the Biocontrol Research Laboratory on 21 February 2019
6. Students (14 no) from Sardar Balabh Bhai Patel University of Agriculture and Technology,Meerut visited the Biocontrol Research Laboratory on 26 March 2019

CAU, Pasighat

1. Dr. Kolla Sreedevi, Senior Scientist, ICAR-NBAIR, Bengaluru visited to review the AICRP-Biological Control at Pasighat centre as well as tribal sub plan from 19/03/2019 to 21/03/2019.

32.6. Awards/Honours/Recognition

MPKV

1. Dr. S.M. Galande awarded Best Poster Presentation Award in 1st International conference on Biological Control - Biocontrol Approaches and Application held at Hotel Le Meridian, Bengaluru 2018 on 27th to 29th September, 2018.
2. Dr. S.M. Galande awarded "Satara Bhushan Award from Nehru Yuva Kendra, Satara, Ministry of Youth Affairs and Sports, Govt. of India at *Planning Bhavan Hall*, Collectorate Office, Sataraon 2.3.2019 for his contribution in teaching, research and extension activities in the field of Agricultural Entomology.

3. The Director, NBAIR , Bengaluru nominated Dr. S. M. Galande as ICAR representative in High Power Committee Meeting for Fall armyworm and accordingly he attended this meeting on 14.11.2018 at Krishi Bhawan, New Delhi .

PAU, Ludhiana

1. Dr P.S. Shera got best oral presentation award during First International Conference on Biological Control: Approaches and Applications (ICBC-2018) held at Bengaluru from September 27-29, 2018**.**

2. Dr P.S. Shera appointed as Editor 'Journal of Insect Science' published by Society for Advancement of Insect Science, PAU, Ludhiana**.**

3. Dr Sudhendu Sharma appointed as member Editorial Committee 'Journal of Insect Science' published by Society for Advancement of Insect Science, PAU, Ludhiana

SKUAST

1. Dr. SajadMohiudin received best poster award in National Seminar entitled "Climate Change and its impact on food safety" held in SKUAST-K, Srinagar, dataed 13-14' March' 2019.
2. Dr. Jamal Ahmad acted as *In Charge* Head, Entomology, SKUAST-K from 20th December' 2016 till 15th October' 2018.
3. Dr. Jamal Ahmad acted as Member for Academic Council, SKUAST-K.
4. Dr. Jamal Ahmad acted as Chairman, comprehensive package of Practices for Royal Spring Golf, Srinagar.
5. Dr. Jamal Ahmad acting as Dean P.G. Nominee of M.Sc. student of Ag. Statistics, SKUAST-K .Acted as Dean, P.G. Nominee for M. Sc. (Pathology) student of SKUAST-K.

PJTSAU:

1. As Member of Apex/Statutory Committees of Central & State Government.
2. Dr. S. J. Rahman, Principal scientist & University Head of Entomology.
3. Expert Member for Telangana State Bio Diversity Board (TSBDB), Govt. of Telangana
4. Expert Member for Committee for developing Effective Vector Control practices by ICMR, New Delhi
5. Member of Review Committee on Genetic Manipulations (RCGM), Ministry of Science & Tech., Govt. of India
6. Member of High level Expert Committee on Environmental Risk Assessment (ERA), Ministry of Environment, Forests and Climate Change, Govt. of India
7. Member of Genetic Engineering Appraisal Committee (GEAC), Ministry of Environment, Forests and Climate Change, Govt. of India

32.7 Education &Training

AAU- Anand

Details of Khedut Shibirs/farmers day/training programmes organized during 2018-19

Sr. no	Date	Village & Taluka	No. of farmers attended
1	04/10/2018	Krushi Vigyan Kendra, Dediyapada	70
2	19/11/2018	Village: Bujetha, Limpura Tilakvada	100
3	02/03/2019	Krushi Vigyan Kendra, Dediyapada	100

Lectures and demonstrations were conducted to the students/farmers on 'Biological Control of Crop Pests' during their visit to the Laboratory

Sr. No	Date	Visitors (No.)	Visitors/Trainee details
1	13/07/2018	Students (32)	Aga Khan Rural Support Programme Ahmedabad
2	10/09/2018	Students (18)	P. M. Patel Institute of PG studies and Research in Science, Annad
3	25/09/2018	Trainees/ Students (43)	NCIPM, Pusa, Delhi
4	17/11/18	Trainees/farmers (13)	ATMA, Belgari, Karnataka State
5	16/01/19	Students (47)	College of Horticulture AAU, Anand
6	12/02/19	Students (57)	ACHF, NAU, Navsari
7	28/02/19	Students (34)	College of Agriculture Information Technology, AAU, Anand
8	6/03/19	Students (49)	College of Horticulture, JAU, Junagadh
9	6/03/19	Students (36)	College of Horticulture, Jagudan
10	18/03/19	Farmers (56)	Sadhavita, Shinor
11	27/03/19	Farmers (55)	GNFC, Vadodara
12	28/03/19	Farmers (25)	SIRD, Ahmadabad
13	29/03/19	Farmers (16)	VRTI, Vallabhipur
14	29/03/19	Students (39)	Agriculture Information Technology, AAU, Anand

AAU- Jorhat

1. Dr. D.K.Saikia, Principal Scientist was appointed as external question setter for Umroi, Umiam Meghalya for comprehensive examination.
2. Dr. D.K.Saikia, Principal Scientist was appointed as examiner for thesis evaluation of M. Sc. (Ag.) of Nagalang University.
3. Dr.D.K.Saikia, Principal Scientist conducted Ph.D courses on Recent trends in Biological control (ENT-606)),Advanced Insect Ecology (ENT 604), Insect Behavior (ENT- 605) and Advanced IPM (ENT-612)
4. Seven Ph.D students are being carried out P.G. research work under the guidance of Dr. D.K.Saikia,
5. Dr. D.K.Saikia, Principal Scientist act as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) students.
6. Dr. D.K.Saikia act as a Co- investigator in the Biopesticides programme under DBT – AAU, Centre

7. R. N. Borakakati, Jr. scientist acted as a course leader of UG course "Pests of crops, stored grain and their management" (Ento- 323). Besides this he also acts as course instructor of PG courses like Biological Control (ENT 507) and IPM (Ent510).
8. R. N. Borakakati, Jr. scientist, act as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) student**s**
9. Three M.Sc (Agri) student is being carried out P.G. research work under the guidance of R. N. Borakakati
10. Mr. R. N. Borkakati and Dr. Saikia acted as resource person of CAFT training on "Mass multipliaction techniques of important biopesticide agents" at the Department of Soil Science, AAU, and Jorhat during 27th November 2018, 19th and 20th February 2019.
11. Mr. R. N. Borkakati acted as resource person for the Model Training Course on IFS for Sustainable Agriculture on 26.11.2018

PJTSAU:

1. Trained as Bio Safety Expert under UNEP-GEF Programme by MoEF &CC, Govt. of India, New Delhi.

KAU, Thrissur

Sl. No	Date of training	Classes handled by	Topic	Venue	Beneficiaries
1	15.12.2018	Dr. Madhu Subramanian, Professor	Biocontrol of crop pests	RATTC Malampuzha	Farmers
2	11.7. 2018	Dr. Madhu Subramanian, Professor	Mass production of bioagents	RATTC Malampuzha	Agrl. Officers
3	22.9.2018	-do-	Post flood soil crop management	Kuzhur krishibhavan	Farmers
4	5.12.2018	-do-	Monthly Agro Clinic and Farm Advisory Conclave	K.K.T.M Govt. College, Kodungallur	Farmers
5	13.7.2018	-do-	Mass production of bioagents	Biocontrol lab, College of Horticulture,Vellanikkara	Agrl. Officers
6	13.2.2019	-do-	Mass production of bioagents	BCCP, College of Horticulture,Vellanikkara	Farmers
7	6.3. 2019	-do-	Mass production of bioagents	BCCP, College of Horticulture,Vellanikkara	Farmers

MPKV

1. Dr. S.M. Galande conducted Semester End Theory examination at College of Agriculture / College of Horticulture, Paniv and worked as Senior Supervisor for the examination period during 25.4.2018 to 5.5.2018.

2. Dr. S. M. Galande worked as Senior Supervisor for conducting theory examination at College of, Baramati on 12.11.2018.
3. **Dr** S. M. Galande **conducted the practical classes of course No. ENT – 487 (0+ 17 = 17)** : Mass Production of Bio-agent and Bio-pesticides under UG programme. 31 students of **VIII** Semester of B.Sc. (Agri.) registered this course underExperiential Learning Programme Module (ELPM).

PAU, Ludhiana

Title of the lecture	Event, Date and Venue
Dr Neelam Joshi	
Bacterial pathogens in pest management	Students of Diploma in Agriculture at College of Agriculture, PAU Ludhiana on 16.4.2018
Mass production of fungal and viral biopesticides	Students of Diploma in Agriculture at College of Agriculture, PAU Ludhiana on 16.4.2018
Development of biopesticides and their role in pest management	Ten days International training on 'Crop protection chemicals for food security, safety and their residue management' for officials (ADO) of MOA, Irrigation, Livestock, Government of Afghanistan held at PAU, Ludhiana on 19.4.18
Biological suppression of maize pests	Technical session 'Biological suppression of pests of rice and maize crops' during at 27th Annual Biocontrol Workers' Group Meetingof All India Coordinated Research Project on Biological Control of Crop Pests held at KAU, Thrissur, Kerala from May 17-18.5.2018
Naturally infected insects and their utilization in insect control	Training on 'Production of biocontrol agents, biopesticides & biofertilizers' at PAMETI, PAU, Ludhiana on 5.2.2019
Production of *Beauveria bassiana* and its application	Training course on 'Organic Grower' organized by Skill Development Center, Directorate of Extension Education, PAU, Ludhiana on 22.3.2019
Dr Parminder Singh Shera	
Producing safe food by using biocontrol agents	Training on 'Organic farming: from farm to fork approaches' for extension officers of State Agriculture & aligned departments at PAMETI, PAU, Ludhiana on 6.8.2018
Conservation and utilization of biological control agents	Training camp on 'Safe and judicious use of pesticides and integrated pest management' at village Bhasod (Sangrur) on 15.11.2018
Identification of insect pests and natural enemies in cereal crops	Three months training course on 'Integrated crop production for young farmers of Punjab' organized by Skill Development Center, Directorate of Extension Education, PAU, Ludhiana on 24.1.2019
Biocontrol of insect pests: identification, conservation and utilization	Training camp for PAU organic farming club members organized by Skill Development

	Center, Directorate of Extension Education, PAU, Ludhiana on 30.1.2019
Biocontrol – importance and scope	Training on 'Production of biocontrol agents, biopesticides & biofertilizers' at PAMETI, PAU, Ludhiana on 4.2.2019
Insect pests of *kharif* crops and their management	Regional *Kisan mela* at Faridkot on 8.3.2019
Insect pests of field crops and their non-chemical management	Training course on 'Organic grower' organized by Skill Development Center, Directorate of Extension Education, PAU, Ludhiana on 27.3.2019

SKUAST

Dr. Sajad provided trainings to farmers

1. Dr. Sajad organised two days training programme in Kargil on management of Codling moth infesting apple and other pests from 16.05.2018 to 17.05.2018.
2. Dr. Sajad organised training programme in Kargil on Integrated management of Codling moth infesting apple from 27.08.2018 to 17.08.2018
3. Dr. Sajad provided technical guidance and advisory to farmers during event organized by dept. of Horticulture on 25-11-2108
4. Dr. Sajad provided technical guidance and advisory to farmers during event organized by dept. of Horticulture at SKICC on 18-12-2018
5. **Dr. Jamal Ahmad conducted field visits a**s a member of monitoring team, visited different locations at districts Srinagar, Ganderbal, Pulwama and Shopian under Agro chemical evaluation of pesticides on dated 4th, 7th and 9th May' 2018.

Dr. Sajad conducted diagnostic field visits:

Date	Problem	Nature of duty
18-06-2018	Visit to Pazwalpora Shalimar regarding management of apple pests	Resource person
18-07-2018	Visit to Budgam regarding management of San Jose scale	Resource person
12-08-2018	Visit to dist. Shopian and Kulgam regarding management of European red mite and other insect pests	Resource person

Attended summer /winter schools

S. No.	Year	Title of training course	Duration			Name of the Organizing Insti-tute
			From	To	Days	
1.	2018	Pest Surveillance	07-05-2018	11-05-2018	5	NIPHM, Hyderabad
2.	2019	On farm production of bio-control agents and microbial bio-pesticides	18-03-2019	27-03-2019	10	NIPHM, Hyderabad

TNAU

Sl.No.	Title of the training /lecture	Beneficiary /participants	Date	Sponsor
1	Mass Production of biocontrol agents	One year Diploma in DAESI programme	29.06.17	ICAR- MYRDA KVK
2	Mass Production of biocontrol agents	Department Officials Kerala state Department of Agriculture, Chawara	14.11.18	Kerala state Department of Agriculture
3	Mass Production of biocontrol agents	Department Officials Kerala state Department of Agriculture Kotayam	19.11.18	Kerala state Department of Agriculture
4	Mass Production of biocontrol agents	B.Sc. (Ag) Students	27.12.18, 10.01.19 07.02.19	APHC, Kalavai AC&RI, Coimbatore

YSPUHF

SN	Title of training	Place	Date	No of participants
1	Rearing techniques for predatory mite and *Trichogramma* spp.	UHF, Nauni	22.05.2018 10.07.2018	30 30
2	Identification of common natural enemies and their utilization in Zero Budget Natural Farming	UHF, Nauni	22.05.2018 04.07.2018 09.01.2019	30 30 30
5	Identification of *kahrif* crop pests and their natural enemies w.r.t Zero Budget Natural Farming	UHF, Nauni	10.07.2018	30
6	Role of biocontrol agents in pest management, their identification and multiplication	ATMA, Solan	11.08.2018 07.12.2018	25 25
7	Important insect-pests of vegetable crops, identification of symptoms and cure	UHF,Nauni	21.08.2018	40
8	Eco-friendly management of insect-pests of crops under TSP	Khani (Bharmaur) Holi (Bharmaur)	25.10.2018 26.10.2018	50 50
11	Biocontrol agents of temperate fruits and vegetable crops	UHF, Nauni	10.12.2018	25
12	Protection against pests in micro-irrigation crops	UHF, Nauni	27.12.2018	50
13	Bio-intensive management of potato	UHF, Nauni	03.01.2019	

	pests			
14	Insect-pests management of vegetable crops	UHF, Nauni	04.1.2019	30
15	Integrated pest management with emphasis on biological control in kiwi and other temperate fruits	UHF, Nauni	05.01.2019	
16	Pest management in Subhash Palekar Natural Farming System	UHF, Nauni	09.01.2019	30
18	Insect-pests management of vegetable crops under natural farming system	UHF, Nauni	22.01.2019 29.01.2019	30 30
19	Insect-pests management of vegetable crops under natural farming system	UHF, Nauni	29.01.2019	30

UAS, Raichur:

1. **Dr. Hosamani conducted 11 days training programme on "**Production and Utilization of Biocontrol Agents - A way forward for Sustainable Agriculture" from 11th to 21st February, 2019 at biocontrol lab, UAS Raichur. During training programme totally 29 guest speakers delivered the lecture and also imparted the hands on training on mass production of biocontrol agents as indicated below on various aspects of pest management.

CPCRI

Trainings conducted for Farmers /students / NGOs:

1. One-day capacity building initiative on "Technological Advances in Palm Health Management" was conducted **for Agricultural Officers (376 Nos.) of Department of Agricultural Development and Farmers' welfare, Govt. of Kerala from 12 districts.** A total of 16 programmes were conducted.

Imparting training to farmer clusters in each district:

1. About 3294 farmers in different districts were empowered on Advances in Palm Health Management in 46 training programmes conducted in the respective districts.

Training farm women and rural youth:

1. As part of training youth and women farmers on skill development, selective groups were constituted in each district to inculcate skill development as means of livelihood security. About 1292 participants were trained and empowered in 16 programme. The technology of *Trichoderma c*oir pith cake developed by ICAR-CPCRI as an income generating bio-management strategy doable by women and youth was taken up and up-scaled by Department of Agriculture, Govt. of Kerala in flood-affected villages for prophylactic disease suppression strategy. In Alathur block (25000 palms) & Aluwa (5000 palms) were treated with *Trichoderma* coir pith cake.

Training manual

1. **Chandrika Mohan**, Josephrajkumar, A., Anes, K.M., Merin Babu, and Krishnakumar, V. (2018) Training Manual on *Advances in Palm Health Management*, September 2018, ICAR-CPCRI, Regional Station, Kayamkulam 37p.
2. **Chandrika Mohan**, Kalavathi, S., Josephrajkumar, A., Anes, K.M., Merin Babu, and Krishnakumar, V. (2019) Training Manual on *Recent Trends in Palm Health Management*, January 2019, ICAR-CPCRI, Regional Station, Kayamkulam 47p.

MPUAT

1. Three farmer trainings were conducted in farmers field at Veerpura and Pilader villages of Jaisamand for awareness of bio-control and conserve the natural enemies populations.
2. Published two technical folders on fall armyworm and biological control of insect pests.
3. Two posters were printed for display in Bio-control lab.

PJTSAU:

1. Imparted training on "Biological Control as viable component of Pest Management" to First & Second batch MAOs under Govt. Telangana programme, "Agro Technologies for Productive & Profitable Agriculture in Telangana State".
2. Imparted training on "Strengthening of mass production of Bio Agents & Bio Pesticides" to all the staff of State Bio Agent Production Units/Labs under Govt. Telangana.

UBKV

Extension Literature

1. S. K. Sahoo (2019). PrakKharif Dal SasyerRokPokarSusangataNiyantran, Krishi Jagran, **4**(3) March, 2019 issue
2. JaibikUpayeFasalerKitsatruNiyantran (2019)
3. JaibikUpayeFalerMachiNiyantran (2019)

32.8 Trainings/ Training camps organized

ANGRAU

Awareness on maize fall armyworm management:

1. Dr. M.Visalakshi, PS (Entomology) participated in AMC level Farmers Scientist Interaction at Cheepurupalli and Pusapatirega on 17.8.18 and 18.8.18, respectively organised by Department of agriculture and imparted knowledge on Maize fall armyworm identification and management.
2. Dr. M.Visalakshi, PS(Entomology participated as resource person in Fall armyworm awareness and training programme organized by ADA, Kothavalasa at Annamrajupeta village, Jami mandal, Vizianagaram district on 16.11.18, created awareness to farmers of Annamrajupeta before sowing maize in 300 ha area .
3. Dr. M.Visalakshi, PS (Entomology) participated as resource person in Orientation district level training programme to farmers and FPOs on Pest Identification and management during training programme on production technology of pulses under APRIGP programme funded by SERP at RARS, Anakapalle on 7.1.19.
4. Dr. M.Visalakshi, PS (Entomology) conducted field visits for Awareness on fall armyworm and stem borer management in maize during February, 2019 in Srikakulam and Vizianagram districts.

Awareness cum training programme on Trichocard production organised:

1. Dr. M.Visalakshi, PS (Entomology), AICRP on Biological controlconducted awareness cum training programme on Trichocard production during exposure visit to 25 Tribal farmers of Asarad, GK Veedhi mandal, Chinthapalli division and distributed inputs for Trichocard production under TSP programme of AICRP on Biological controlon 15.2.19.

MPKV

1. College Of Agriculture organized Ago Technology Exhibition on 18.9.2018 and 08.02.2019 more than 500 farmers visited the stall during Ago Technology Exhibition.

The Scientists provided the information of Bioagent and Biopesticide to the Dignitaries and farmers.

2. Dr. S. M. Galande delivered lecture on “Integrated white grub management” in farmers rally organized by RAWE students at Bhandgaon. Tal. Daund Dist. Pune on 11.10.2018

PAU, Ludhiana

Programme	Venue	Dates
Training on ‘Biological control of insect pests and diseases in organic rice’ in collaboration with KVK, Sangrur	KVK Sangrur	12.6.2018
Training on ‘Biological control of insect pests in rice and maize crop’ in collaboration with KVK, Hoshiarpur	Village Badowal (Hoshiarpur)	1.8.2018
Training on ‘Biological control of insect pests’ in collaboration with KVK, Samrala	KVK Samrala (Ludhiana)	29.8.2018
Training on ‘Biocontrol of insect pests’ in collaboration with KVK and Regional Research Station, Kapurthala	KVK, Kapurthala	30.8.2018
Training on ‘Mass production and utilization of biocontrol agents’ for technical staff of Sugar Mills and PAU Regional Stations	PAU, Ludhiana	6-7.9.2018
Training on ‘Management of insect pests through bioagents’	Village Sahauli (Patiala)	12.10.2018
Training on ‘Identification and utilization of bioagents in pest management’	Village Gunike (Patiala)	2.11.2018
Training on ‘Promotion of biological control of insect pests and diseases’ in collaboration with KVK, Moga	KVK, Moga	21.11.2018

SKUAST

1. **Training Organised:**
2. Two days’ training cum awareness programme was organised on **Integrated Management of Codling moth**from 15-16 May’ 2018 at University station Kargil, Mingy and KVK at Mangomre (Plate 13). About 20-30 farmers and divisional scientists participated in the camp. Dr.SajadMohiudin demonstrated the use and importance of*Trichogramma* spp. and mass trapping technique of Codling moth both at adult and larval stages through pheromone traps and trunk banding respectively.

TNAU

Sl. No.	Date	Title of Program	Benificiary/ Participants	Organizers
1.	31.08.18	Farmers grievance day	Farmers	District Collector Coimbatore
2.	19.09.18	Monthly Zonal Workshop	Department Officials	JDA, Tirupur
3.	9.10.18	Diagnostic field visit (Brinjal)	Farmers	JDA, coimbatore
4.	16.11.18	Rugose spiralling whitefly and	Farmers	ATMA –

		maize fall armyworm awareness campaign		Valukkuparai block
5.	19.11.18	Maize fall armyworm awareness campaign	Farmers	ATMA-Udumalpet block
6.	30.11.18	Maize fall armyworm awareness campaign	Farmers	SPAC starch products India Limited, Poonachi
7.	20.12.19	Brain storming session on Rugose spiralling whitefly and maize fall armyworm	Scientists and Department Officials	Director, CPPS
8.	29.12.18	State level workshop on FAW	Department Officials	Director of Agriculture
9.	8.02.19	Rugose spiralling whitefly and maize fall armyworm awareness campaign	Farmers	ATMA – Karamadai
10.	11.03.19	Rugose spiralling whitefly awareness campaign	Farmers	ATMA – Namakkal

CPCRI

Awareness programs and field days:

1. A total of 7 programs were conducted in 4 districts with >500 participants

NCIPM

Awareness program

Creating awareness among farmers about IPM in cotton with major emphasis on conservation of natural enemies at Khuiyan Sarwar block, District Fazilka (Punjab) along with state department of Agriculture under Mission Tandrust Punjab.

DRYSRUH

1. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) Participated Awareness workshop on "Management of coconut rugose spiraling whitefly" organized by CPCRI, Department of Horticulture, at CTRI, Rajahmundry on 07.05.18 and shared his experience on Rugose spiraling whitefly and its management.
2. Dr. Chalapathi Rao, Participated in rugose spiraling whitefly awareness meeting and a demonstration on the feasibility of using Drone technology in rugose spiraling whitefly management on 24.05.18 at Kadiyapulanka village.
3. Dr.Chalapathi Rao, attended the Human Resource Development Training Programme (HRD) on rugose Spiralling Whitefly on coconut, oilpalm and other Horticultural Crops at Agricultural Market yard, Ambajjipeta, East Godavari District being organized by Central integrated pest management centre (CIPMC), Vijayawada and briefed about the integrated pest and disease management with emphasis on rugose spiraling whitefly to the farmers on 13-06-2018, wherein 200 farmers participated.
4. As resource persons Dr. V.Chalapathi Rao, participated in a Training programme on Production and protection aspects of coconut at Kaviti village of Srikakulam district being organized by SERP – ICRISAT, Hyderabad and scientists explained about the production and pest management practices to the Farmers Producer Organization on 28.06.18 where about 100 farmers attended.
5. A farmers meet was organized at HRS, Ambajipeta in collaboration with AICRP on Biological control as part of silver Jublee celebrations of ICAR, NBAIR (National Bureau of Agricultural Insect Resources), Bengaluru on 05.07.2018 mobilized and

created awareness on use of bio control agents and its role in management of pests and diseases. Clarified the quarries raised by the farmers. About 150 farmers were attended the meeting.

6. Dr. Chalapathi Rao, Senior Scientist (Ento.) attended training programme on Master Trainers for Training of Master Trainers (ToMT) organized by Agriculture Skill Council of India (ASCI) and Dr.YSRHU at KVK, VR Gudem from 29th – 31st August, 2018.
7. Dr. Chalapathi Rao participated in awareness meeting on rugose spiralling whitefly at Punyakshetram village of Rajanagaram Mandal East Godavari district on 11.10.18 and demonstrated the control measures and created awareness among the farmers.
8. Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ento.) participated in awareness meeting on Rugose spiralling whitefly at Chinthapalli village of Pusapatiregha Mandal bring organized by Department of Horticulture, Vijayanagaram on 14.11.18 and explained through power point presentation and created awareness among the farmers on rugose spiralling whitefly and its management..
9. The scientists of HRS, Ambajipeta viz., Dr. G.Ramanandam, Principal Scientist, (Hort.) & Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ento.) as resource persons participated in the training programme on rugose spiralling whitefly management being organized by Department of Horticulture, West Godavari district and 3F oil palm company, Tadepalligudem at Ghantavarigudem (V) of Nallagerla mandal on 4.12.18 where in the Scientists of NBAIR, Bengaluru also participated and demonstrated entomo pathogenic fungus (Isaria fumasorosea) spray against rugose spiralling whitefly on oil palm at Devarapalli village of West Godavari district.
10. A field demonstration was conducted by the scientists of HRS, Ambajipeta on spraying of Entomo pathogenic fungal culture against rugose spiralling whitefly in the farmers field at Pulletikurru village of East Godavari district on 6.12.18 where in the farmers from Korukonda, Anaparthi, Kadiyam villages of East Godavari district have participated.
11. Organized Eleven one day skill training programmes @ (20 farmers per/batch) on “Mass production of *Isaria fumosorosea* for the control of rugose spiralling whitefly” sponsored by ADH, Amalapuram (5 nos.), Rajahmundry (3 nos.) and Narsipatnam (1 no) Ruchi Soya (1 no.) 3F oil palms (1 no.) on 8.02.19, 12.02.19, 14.0219, 15.02.19, 21.02.19, 22.02.19, 23.02.19, 25.02.19, 27.02.19, 28.02.19 & 01.03.19 at Horticultural Research Station, Ambajipeta.

32.9 Demonstration

YSPUHF

a) Demonstrations on the management of apple root borer using *Metarhizium anisopliae*:

SN	Location	Number of orchards
1	Rohru, district Shimla	4
2	Chaupal, district Shimla	2
3	Kotkhai, district Shimla	3
3	Shilai, district Sirmaur	1
4	Rajgarh, district Sirmaur	1
5	Gohar district Mandi	4
	Total	15

b) Demonstrations under TSP

SN	Topic	Location	Number of farmers
1	Demonstrated the use of *Metarhizium anisopliae, Beauveria bassiana, Trichoderma* and azadirachtin for the management of insect pests and diseases in apple and vegetable crops	Khani	50
2	Demonstrated the use of *Metarhizium anisopliae, Beauveria bassiana, Trichoderma* and azadirachtin for the management of insect pests and diseases in apple and vegetable crops	Holi	50
	Total		100

c) Mera Gaon Mera Gaurav:

S. No.	Date	No. of Farmers	Purpose/ activity
i)	02.08.2018	15	Farmers were suggested control measures of different insect pests of tomato and capsicum
ii)	17.07.2018	11	Farmers were advised regarding the bio-intensive management of insect pests of tomato. Farmers were also advised for the management of fruit borer in pomegranate
iii)	16.01.2019	7	Farmers were advised regarding plant protection measures in cole crops, citrus, training structures for kiwi fruits.
iv)	16.02.2019	18	Farmers were suggested control measures of insect pests of cole crops

CISH

Farmer Field School and participatory technology demonstration:

1. Pest and disease management, soil health management, good planting material production, mass production of bioagents, farming system approach for enhancing productivity were conducted in the villages and practically demonstrated for technology dissemination. About 43 FFS sessions were conducted in various districts which brings scientist to the farmer's field for co-learning and technology refinement.

32.10. Radio/ TV talk

AAU- Jorhat

SL. NO.	TITLE	NAME OF RESOURCE PERSON	REMARKS
1	Hello Krishi darshan (Door Darshan Programme) Episode:3199	R. N. Borkakati	Telecasted on 27.06.2018(5.30pm)
2	Live phone in programme by AIR JORHAT	R. N. Borkakati	Broadcasted on 09.08.2018
3	Phone in programme by AIR Dibrigarh on 27.08.2018	R. N. Borkakati	Broadcasted on 27.08.2018
4	Radio programme *Rabi* Xashyar Keet Potanga Niyantran	R. N. Borkakati	Recorded on **05.10.2018** and broadcasted on **07.10.2018**

	(AIR DIBRUGARH)		
5	Hello Krishi darshan (Door Darshan Programme) Episode:3329	R. N. Borkakati	Telecasted on 26.12.2018(5.30pm)
6	Hello Krishak Vani (Radio programme) (AIR JORHAT)	R. N. Borkakati	Recorded on 12.02.2019 and broadcasted on 13.02.2019
7	Live phone in interaction with farmers by AIR Nagaon	R. N. Borkakati	Recorded on 22.03.2019 and broadcasted on 31.02.2019

ANGRAU

1.**Radio talk:** Dr. M.Visalakshi, PS (Entomology) delivered radio talk on maize fall armyworm management at AIR, Visakhapatnam on 13.11.8.

2.**Publicity through print and electronic media:** Dr. M.Visalakshi, PS(Entomology)attended recording of annadata TV programmes on Utilization of Biocontrol agent as Trichocards for the management of stem borers and fall armyworm in maizeBiological means of controlling coconut rugose whitefly through annadata TV programme recorded on 2.2.19

PJTSAU:

1. Participated in several Radio Talks on Bio Agents & Bio Pesticides at All India Radio, Hyderabad during 2017.
2. Participated in Doordarshan Phone in Live Programme and answered the queries of farming community on Biological Control at Doordarshan Kendra, Hyerabad during 2017.

SKUAST

T.V Talks:

Dr. SajadMohiuddin delivered talks on:

1. Cultural practices for management of different fruit pests on 11-08-2018
2. Delivered TV Advisory regarding HMOs for management of apple pests on 25-02-2019

DRYSRUH

Radio programmes :

1. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ento.) gave a radio interview on “Kobbarini aasinche purugulu – Yajamanya Paddathulu” at All India Radio, Visakhapatnam on 10.10.18.

TV programmes:

1. Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ento.) gave a programme on “Kobbari thotallo Keetaka yajamanyam” through Doordarshan Saptagiri, Vijayawada on 7.09.18.
2. Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ento.) gave a programme on “Cocoalo Purugula Yajamanyam” through ETV, Annadata on 24.09.18.
3. Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ento.) participated a programme on “Pest management in coconut” through 10 TV on 5.01.18.

32.11. Post/under graduate teaching

AAU-Anand

Sr. No.	Name of Teacher	Courses offered	PG Students Guiding
1.	Dr. D. M. Mehta	ENT 602 - Immature Stages of Insects (1+1)	1 (M.Sc)
		ENT 606 - Recent Trends in Biological Control (1+1)	
		ENT 514- Insect Vectors of Plant Viruses and other Pathogens (1+1) ** Cross linked with Plant Pathology Division*	
2.	Dr. Raghunandan B.L.	ENT 611 - Molecular Approaches in Entomological Research (1+1)	NIL
		MICRO 509 – Plant Microbe Interactions (3+0)	
		MICRO 506 – Food and Dairy Microbiology (2+1)	

KAU, Thrissur

1. Scientists of the Project have been handling classes on biocontrol and IPM for U.G, P.G. and Ph. D programmes as well as guiding M.Sc and Ph.D students on regular basis

PAU, Ludhiana

Teacher	No. of courses taught	
	PG	UG
Dr Neelam Joshi	3	3
Dr Parminder Singh Shera	2	6
	No. of PG students guiding/guided	
	Ph. D.	**M.Sc.**
Dr Neelam Joshi	1	3

SKUAST

1. Dr. Jamal Ahmad and Dr. SajadMohiuddin involved in teaching of 8 different courses of UG and PG classes of Horticulture Courses (Entomology)
2. **Dr. Sajad Mohiudin**functioning as Major Advisor and Chairman of Advisory Committee of Two M.Sc. Students, Division of Entomology.

PJTSAU:

1. B.Sc. (Ag.), M.Sc. (Agri.) and Ph.D. students of College of Agriculture, Rajendranagar, Hyderabad were trained different methodologies in rearing of different natural enemies and culturing & field use of microbial formulations.
2. Guiding M.Sc. (Agri) and Ph.D. students for their Research work in the capacity of Major guide & Member of Advisory Committee.
3. Eighth Batch of AELP on Biological Control is being trained for entrepreneurship on mass production of Bio agents as part of B.Sc. (Agri) under graduation programme.

TNAU
Courses handled:
UG courses:

1. EXP401 – Commercial production of biocontrol agents (0+5) – Dr.S.Jeyarajan Nelson and Dr.R.Vishnupriya
2. AEN 401 Pests of Horticultural Crops and their Management (2+1) - Dr.S.Jeyarajan Nelson

Ph.D courses:

- ENT 822 – Entomophages (2+1) - Dr.S.Jeyarajan Nelson

YSPUHF

Course No	Title	Credit hours	Teachers' name
ENT-505	Insect Ecology	1+1	PL Sharma and S C Verma
ENT-517	Soil Arthropods and Their Management	1+1	P L Sharma and S C Verma
ENT-507	Biological Control of Crop Pests and Weeds	1+1	P L Sharma and S C Verma
ENT-511	Pests of Field Crops	1+1	S C Verma and Kiran Rana
ENT-513	Storage Entomology	1+1	Devender Gupta and SC Verma
ENT-602	Immature Stages of Insects	1+1	P L Sharma and S C Verma
ENT604	Advanced Insect Ecology	1+1	P L Sharma
ENT-606	Recent Trends in Biological Control	1+1	P L Sharma and S C Verma
ENT-609	Advanced Host Plant Resistance	1+1	P L Sharma and SC Verma
PPE-221	Insect-pests of Fruits, plantation, Medicinal and Aromatic crops	2+1	SC Verma and Kiran Rana
ENT-591	Master's Seminar	1+0	S C Verma

Students guided: P.L. Sharma has guided 2 Ph.D and 3 M.Sc. students and S C Verma guided 1Ph. D and 3 M.Sc. students.

IGKV
M.Sc. (Ag.) Prev.

1. ENT-501 –Insect Morphology
2. ENT-502-Insect Anatomy, Physiology and Nutrition

Ph.D

1. ENT-606-Recent Trends in Biological Control
2. ENT-611-Molecular Approaches in Entomological Research

Dr. Ganguli guided 5 M.Sc and 4 Ph.D. students.

32.12. List of Publication

AAU- Anand

Research paper

- Raghunandan, B.L. Godhani, P.H. Patel, M.V. Patel, N.M. and Mehta, D.M. (2018) Field evaluation of microbial bio-pesticides for the management of sucking pests in *Bt* cotton. *Journal and Entomology and Zoology Studies,* 6(4): 994-998.
- Sisodiya, D.B. Raghunandan, B.L. Bhatt, N.A. Verma, H.S. Shewale, C.P. Timbadiya, B.G. and Borad, P.K. (2018) The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae); first report of new invasive pest in maize fields of Gujarat, India. *Journal and Entomology and Zoology Studies,* 6(5): 2089-2091.
- Raghunandan, B.L. Patel, M.V. Patel, N.M. and Mehta, D.M. (2018) Bio-efficacy of different biological control agents for the management of chilli fruit rot/anthracnose disease. *Journal of Biological Control.,* 32(3): 172-178

Book Chapter

Raghunandan B.L. Vyas R.V. Patel H.K and Jhala Y.K. (2019) Perspectives of Seaweed as Organic Fertilizer in Agriculture In: Panpatte D.G. and Jhala Y.K. (eds) Soil fertility management for sustainable development. p 267-289 doi: 10.1007/978-981-13-5904-0_13.

Popular articles

- Raghunandan, B.L, Patel, N.M. and Solanki, C.G. (2018). An Overview on Entomopathogenic Nematodes. *Readers shelf.*, 14(09): 57-58.
- Patel, N. M, Raghunandan, B.L. and M.V. Patel (2018). □□□□□□□□□ □□□□□ □□□□□□ □□□□□□□□□ □□□□□ □□□□□□□□, □□□□ □□□□□□□□, ૪૨-૪૩.
- Nehaben, M. Patel, Raghunandan, B.L. Mayank. V. Patel and Mehta, D.M. (2018). □□□□ □□□□□□□ □□□□□ □□□□□□□□□□□ □□□□. □□□□ □□□□: □□□□□□□□□ □□□□□□. ૧૬૦-૧૬૫

AAU- Jorhat

Research papers:

1. Borkakati, R. N., Saikia, D. K., and Buragohain, P., (2018). Natural enemy fauna of agri-horti ecosystem of Assam. *Indian Journal of Entomology*. 80(3): 658-661.
2 .Borkakati, R. N. and Saikia, D. K. (2019). Efficacy of *Beauveria bassiana* (Bals.) Vuill. against *Helopeltis theivora* Waterhouse in tea. *Journal of Entomology and Zoology studies* 7(1): 52-53.
3. Saikia, D. K. and Borkakati, R. N. (2019). Efficacy of BIPM module against major insect pests of tomato. *Journal of Entomology and Zoology studies*. 7(1): 986-988.
4. Borkakati, R. N., Venkatesh MR and Saikia, D. K. (2019). Insect pests of Brinjal and their natural enemies. *Journal of Entomology and Zoology studies*. 7(1): 932-937.
5. Borkakati, R. N., Saikia, D. K. and Ramanujam, B. (2019). Evaluation of certain bio pesticides against sucking pests of Bhut Jalakia. *Journal of Biological Control.* 32(3): 172-178.
6. Mili Phunu, Dervee Anjumoni and Saikia, D. K. (2018). Carabid beetles collected from vegetable ecosystem. *Journal of Pharmacology and Phytochemistry*. 7(6): 1581-1590.

Books:

1. Harshita A. P., Saikia, D. K. and Borkakati, R. N. (2018).Major Insect Pests of Tomato Ecosystem: An Approach for Eco-friendly management. Lambert Academic Publishing, Germany (ISBN: 978-613-9- 81538-8).

2. Venkatesh M.R., Borkakati, R. N. and Saikia, D. K. (2019).Crop Diversification for Pest Management: An Experiment on Brinjal Ecosystem. Lambert Academic Publishing, Germany (ISBN: 978-3-659-74474-7).
3. Kashyap G., B. C. Dutta and Borkakati, R. N. (2019).Management of subterranean pests of Potato. Lambert Academic Publishing, Germany (ISBN: 978-3-330-31976-9).

Book chapter:

1. Saikia, D. K. and Borkakati, R. N. (2018). **Trap Technologies in Pest Management p**. 184-187 In: Compendium of CAFT training on *"Techniques in Bio-fertilizers and Bio-pesticides Production for Organic Agriculture"* sponsored by ICAR, New Delhi and Organized by"Centre of Advanced Faculty Training (CAFT) in Organic Farming", Department of Soil Science, Faculty of Agriculture, Assam Agricultural University, Jorhat: 785013, Assam, from 14th Nov. 4th Dec.2018).
2. Saikia, D. K. and Borkakati, R. N. (2018). **Culturing Technique and Mass Multiplication Trichogrammatids** p. 188-190 In: Compendium of CAFT training on *"Techniques in Bio-fertilizers and Bio-pesticides Production for Organic Agriculture"* sponsored by ICAR, NewDelhi and Organized by"Centre of Advanced Faculty Training (CAFT) in OrganicFarming", Department of Soil Science, Faculty of Agriculture, Assam Agricultural University, Jorhat: 785013, Assam, from 14th Nov. 4th Dec.2018).
3. Saikia, D. K. and Borkakati, R. N. (2018). **Biointensive integrated pest management in organic farming** p. 117-119 In: Compendium of CAFT training on *"Developments in Organic Agriculture"* sponsored by ICAR, New Delhi and Organized by"Centre of Advanced Faculty Training (CAFT) in OrganicFarming", Department of Soil Science, Faculty of Agriculture, Assam Agricultural University, Jorhat: 785013, Assam, from 6th – 26th December, 2018).
4. Borkakati, R. N. (2018). **Production and use of Biocontrol Agents with reference to Trichogrammatid s**p. 146-148 In: Compendium of CAFT training on *"Developments in Organic Agriculture"* sponsored by ICAR,New Delhi and Organized by"Centre of Advanced Faculty Training (CAFT) in OrganicFarming", Department of Soil Science, Faculty of Agriculture, Assam Agricultural University, Jorhat: 785013, Assam, from 6th – 26th December, 2018).
5. Borkakati, R. N. and Saikia, D. K. (2018). Lao Jatiyo Pacholor Apokaree Borolia Pookar Niyantron Byabasthapona. "Abad" an agricultural annual magazine from KVK, Chirang. 7(1):14&15.
6. Saikia, D. K. and Borkakati, R. N. (2019). Role of Biological Control for Pests Management. Advances in Agricultural Entomology (Vol-4) (In press).

Leaflets: Published from AICRP-BC, AAU, Jorhat centre in local language

Sl. No.	**Title**	**Official AAU No.**
1	***Xur Pukor Niyantran Kaushal***	**AAU/DR/19/BU/249/2018-19**
2	Xu-Xanhata Padhhatire Udyan Xasyar Keet-Potonga Niyantron	**AAU/DR/19/BU/259/2018-19**
3	Apokaree Keet-Potangor Niyantron Byabasthapona	**AAU/DR/19/BU/260/2018-19**
4	Anistokaree Keet-Potongor Jaiwik Niyantronor Babe Trichogrammar Proyug	**AAU/DR/19/BU/281/2018-19**
5	Bhut Jolokiyar Kheti Aru Iyar Xashya Rakshya	**AAU/DR/19/BU/282/2018-198**

Popular article/Technical/ Extension Bulletin (s):

1. Rahman, A. and Borkakati, R. N. (19.03.2019). March-April Mahaor Keet Potangar Bybasthapona. Dainik Asam: 13
2. Borkakati, R. N.and Saikia, D. K. (05.03.2019). Bhut Jalakiyar Kheti aru Iyar Xashya Rakshya. Dainik Asam: 13
3. Rahman, A. and Borkakati, R. N. (05.02.2019). February Mahaor Keet Potangar Bybasthapona. Dainik Asam: 13
4. Rahman, A. and Borkakati, R. N. (04.12.2018). Xeet Kaloraor Keet PotangarNiyatron Bybasthapona. Dainik Asam: 13
5. Borkakati, R. N.and Saikia, D. K. (13.11.2018). Keibidhmab Xeetkaleen Pacholir Xashya Rakshya. Dainik Asam: 13
6. Borkakati, R. N. (14.08.2018). Xurpukor Akromonor Prati Xatorko Houk. Dainik Asam: 11
7. Borkakati, R. N. andRahman, A. (31.07.2018). Dhanor Kshatikarok Soroha Puk Niyantronor Koushal. Dainik Asam: 11
8. Rahman, A. and Borkakati, R. N. (12.06.2018). Jun Mahor Keet Potangar Bybasthapona. Dainik Asam: 11
9. Rahman, A. and Borkakati, R. N. (08.05.2018). May Mahaor Keet Potangar Bybasthapona. Dainik Asam: 11
10. Rahman, A. and Borkakati, R. N. (10.04.2018). April Mahaor Keet Potanga Pratirudhar Bybasthapona. Dainik Asam: 11

ANGRAU

1. Dr. M.Visalakshi, PS (Entomology) prepared broucher on New invasive pest fall armyworm in maize and integrated management practices in telugu. It was released during kisan mela held on 28.11.18 at RARS, Anakapalle.

GBPUAT

Research papers:

1. Roopali Sharma, Richa Bhatt, Archana Negi, Bhupesh Chandra Kabdwal, A. K. Tewari, and J. Kumar, 2018. Evaluation of potential biological control agents for the management of sheath blight of rice. International Journal of Basic and Applied Agricultural Research. Vol. 16(2):135-141.
2. Bhupesh Chandra Kabdwal, Roopali Sharma, Rashmi Tewari, Anand Kumar Tewari, Rajesh Pratap Singh and Jatinder Kumar Dandona, 2019. Field efficacy of different combinations of *Trichoderma harzianum, Pseudomonas fluorescens* and arbuscular mycorrhiza fungus against the major diseases of tomato in Uttarakhand (India). Egyptian Journal of Biological Pest Control. Vol. 29:1; https://doi.org/10.1186/s41938-018-0103-7.
3. Ambika Rautela, Nandani Shukla, Abhijeet Ghatak, AK Tewari and J Kumar " Field evaluation of different copper sources in a consortium of 'Copper-Chitosan-*Trichoderma*' for management of late blight disease of tomato" *Journal of Pharmacognosy and Phytochemistry* 2018; 7(4): 1260-1266.
4. Erayya Nandani Shukla Kahkashan Arzoo and J. Kumar "Mass screening of *Trichoderma* spp. for their antagonism against some plant pathogenic oomycetes fungi" *Journal of Applied and Natural Science* 2018;10 (3): 813 – 817.

5. Akansha Singh, Nandini Shukla, B.C. Kabadwal, A.K. Tewari and J. Kumar. "Review on Plant-*Trichoderma*-Pathogen Interaction" International Journal of Current Microbiology and Applied Sciences 2018; 7(2): 2382-2397.
6. Erayya, Nandani Shukla, Kahkashan Arzoo andJ. Kumar "In vitro screening of *Trichoderma* spp. For their antagonism against soil borne fungi Annals of Plant Protection Sciences. 2018; 10.5958/0974-0163.
7. Meenakshi Dwivedi and A. K. Tewari (2018). Crop- specific growth promoting effect of native *Trichoderma* species. *Indian Phytopathology*.70 (4): 457-462.
8. A Rautela, N Shukla, A Ghatak, AK Tewari, J Kumar (2018). Field evaluation of different copper sources in a consortium of 'Copper-Chitosan-Trichoderma' for management of late blight disease of tomato *Journal of Phrmacognosy and Phytochemistry*. 7(4): 1260-1266.
9. Manju Sharma, A. K. Tewari, Roopali Sharma, and J. Kumar, 2019. Evaluation of Potential bioagents against chickpea wilt complex. International Conference on Biological Control: Approaches and Applications. Journal of Biological Control (Accepted- Jan.2019).
10. Bhupesh Chandra Kabdwal, Roopali Sharma, Rashmi Tewari and J. Kumar, 2019. Bio-Intensive Management of foliar blight and wilt of Tomato Uttarakhand. International Conference on Biological Control: Approaches and Applications. Journal of Biological Control (Accepted- Feb.2019).

Papers presented in conferences:

1. Bhupesh Chandra Kabdwal, Roopali Sharma, Rashmi Tewari, A. K. Tewari, R. P. Singh and J. Kumar. Bio-Intensive Management of Major Diseases in Tomato at Golapar Area of District Nainital in Uttarakhand. National Symposium on Plant Health Management: Embracing Eco-Sustainable Paradigm. Indian Phytopathological Society, New Delhi. Organized by Assam Agriculture University, Jorhat, held on February 15-17, 2018. 103-104 pp.
2. Roopali Sharma, Richa Bhatt, Archana Negi, Bhupesh Chandra Kabdwal, , A. K. Tewari, and J. Kumar. Eco- friendly Management of Sheath Blight of Rice in Uttarakhand. National Symposium on Plant Health Management: Embracing Eco-Sustainable Paradigm. Indian Phytopathological Society, New Delhi. Organized by Assam Agriculture University, Jorhat, held on February 15-17, 2018. Pp.104.
3. Bhupesh Chandra Kabdwal, Roopali Sharma, Rashmi Tewari, A. K. Tewari, and J. Kumar. Bio-Intensive Management of foliar blight and wilt of Tomato Uttarakhand. International Conference on Biological Control: Approaches and Applications. ICAR-NBAIR, Society of Biological Advancement, Bengaluru, India, held on September 27-29, 2018. Pp109.
4. A. K. Tewari, Manju Sharma, Roopali Sharma and J. Kumar. Validation of bioagent consortium at farmers' fields. International Conference on Biological Control: Approaches and Applications. ICAR-NBAIR, Society of Biological Advancement, Bengaluru, India, held on September 27-29, 2018. Pp107.
5. Manju Sharma, A. K. Tewari, Roopali Sharma and J. Kumar. Evaluation of Potential bioagents against chickpea wilt complex. International Conference on Biological Control: Approaches and Applications. ICAR-NBAIR, Society of Biological Advancement, Bengaluru, India, held on September 27-29, 2018. Pp106.
6. V. Amritha Lingam, A. K. Tewari, Manju Sharma, Jatinder Kumar and Roopali Sharma. Evaluation of bioagents for their compatibility for the development of consortium to enhance their efficiency. ICAR-NBAIR, Society of Biological Advancement, Bengaluru, India, held on September 27-29, 2018. Pp 97.

7. Bhupesh Chandra Kabdwal, Roopali Sharma and J. Kumar. Success Story of Bio-intensive IPM in Small Farms of Uttarakhand. National Symposium on Recent Challenges and Opportunities in Sustainable Plant Health Management. Indian Phytopathological Society, New Delhi. Organized by Banaras Hindu University, Varanasi held on February 26-28, 2019.

Proceeding Articles:

1. Roopali Sharma. 2018. Innovative Approaches in delivery of microbial antagonists for bio control of plant diseases. *In* Proceedings of the 36th Training on "Bio-pesticides for Crop Protection and Improvement: Emerging Technology to Benefit Farmers". February 02-22, 2018. 46-51pp.
2. Roopali Sharma. 2018. Methods of Isolation, Quantification and Screening Techniques for Selection of Effective *Trichoderma* Isolates. *In* Proceedings of the 36th Training on "Bio-pesticides for Crop Protection and Improvement: Emerging Technology to Benefit Farmers". February 02-22, 2018. 176-181pp.
3. Roopali Sharma. 2018. Mass Production of Bio-control agents and their Applications. *In* Proceedings of the 36th Training on "Bio-pesticides for Crop Protection and Improvement: Emerging Technology to Benefit Farmers". February 02-22, 2018. 182-186pp.
4. Roopali Sharma. 2018. Advanced technology in delivery of microbial antagonists for bio control of plant diseases. *In* Proceedings of the 37th Training on "Advanced Technology in Plant Health Management and Pest Risk Analysis for Improvisation of Indian Agriculture and Farmers". September 05-25, 2018. 77-82pp.
5. Roopali Sharma. 2018. Mass Production of Trichoderma and Pseudomonas. *In* Proceedings of the 37th Training on "Advanced Technology in Plant Health Management and Pest Risk Analysis for Improvisation of Indian Agriculture and Farmers". September 05-25, 2018. 227-231pp.
6. Roopali Sharma. 2019. Isolation and Characterization of *Trichoderma*: A Biocontrol Agent. *In* Proceedings of the 38th Training on "Modern Concepts in Plant Disease Management for Enhancing Quality and Productivity". February 08-28, 2019. 158-160pp.
7. Roopali Sharma. 2019. Mass production, Formulations and Quality assessment of *Trichoderma* spp. and *Pseudomonasfluorescens*. *In* Proceedings of the 38th Training on "Modern Concepts in Plant Disease Management for Enhancing Quality and Productivity". February 08-28, 2019. 161-165pp.

KAU, Thrissur

Research papers

1. Nasiya-Begum A.N., Madhu Subramanian (2018) Bases of Resistance in Cowpea against Spotted Pod Borer, *Maruca virata* (Fab.) (Lepidoptera: Crambidae). *J. Environment and Ecol.*36:4A 1185-1190.

MPKV

Scientific Publications

1. **Galande, S. M.,** Nakat, R.V., Pokharkar, D.S., Tamboli, N.D., Hole, U.B. and Kharbade, S.B.2018. Evaluation of bio-control agents against shoot and fruit borer, *Earias vittella* (Fab.) on okra. Proceeding of 1st International conference on Biological Control - Biocontrol Approaches and Application, **(ICBC, 2018)** " held at Hotel Le Meridian, Bengaluru 2018 on 27th to 29th September, 2018 : 177

2. Sithanatham, S. Prabhakar, S. Doureeiswamty, V. Bhaskar, B. Bhavani., **S.M. Galande,** K. Jhansi and V.N. Patil.2018. Survey of adoption of practices and perception in sugarcane pest management with focus on chemical insecticide use among sugar factories in South India. Proceeding of SISSTA 2018: 46th Annual Convention,169- 176.

Popular articles/ Extension bulletin:

1. News entitled, "African Pest attacks Maize Crops in State," published in Pune Mirror, Times of India, Pune on 27.11.2018.
2. News entitled, "Manage American larva of Fall Armyworm (*Makyavar American Laskari Ali Rokha*)*:* Dr Sharada Galande published in Namaste Phaltan: 3.12.2018.
3. News entitled, "Maize Crops Across State Reel Under Fall Armyworm Attack (FAW)," published in Pune Mirror, Times of India, Pune on 17.1.2019.

PAU, Ludhiana
List of publications

Research papers in referred journals:

1. Devi K, Joshi N and Sangha K S (2018). Oils as UV protectants of *Beauveria bassiana* conidia and bioefficacy against *Lipaphis erysimi* (KALT*) Indian Journal of Entomology* 80 (3) doi No.10.5958/0974-8172.2018.00189X.**(NAAS rating 5.90)**
2. Kaur K and Kaur R (2018). Development and reproductive potential of predatory pirate bug, *Blaptostethus pallescens* (Poppius) at different temperatures. *Journal of Biological Control* 32: 108-115. **(NAAS rating 5.34**)
3. Sangha K S, Shera P S, Sharma S and Kaur R (2018). Natural enemies of whitefly, *Bemisia tabaci* (Gennadius) on cotton in Punjab, India. *Journal of Biological Control* 32 (4): 270-274. **(NAAS rating 5.34)**
4. Sangha K S, Shera P S, Sharma S and Kaur R (2018). On-farm impact of egg parasitoid, *Trichogramma* spp. against lepidopteran pests in organic basmati rice. *Journal of Biological Control* 32: 116-20.**(NAAS rating 5.34)**
5. Sharma S, Shera P S and Sangha K S (2018). Impact of bio-intensive integrated pest management practices on insect pests and grain yield in *basmati* rice. *Journal of Biological Control* 32: 137-41.**(NAAS rating 5.34)**
6. Sharma S and Aggarwal N (2018). Safety assessment of selected biopesticides/ botanicals to *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) in basmati rice. *Indian Journal of Experimental Biology* (Accepted). **(NAAS rating 7.48)**
7. Sharma S, Kooner R, Arora R, Jindal V, Kumar V, Suri K S, Arora P K, Sharma S and Aggarwal N (2018). Indoxacarb: a novel oxadiazine insecticide for management of tomato fruit borer, *Helicoverpa armigera*. *Indian Journal of Plant Protection* (Accepted). **(NAAS rating 5.07)**
8. Shera P S, Karmakar P, Sharma S and Sangha K S (2018). Impact of *Bt* cotton expressing single (Cry1Ac) and dual toxins (Cry1Ac and Cry2Ab) on the fitness of the predator, *Chrysoperla zastrowi sillemi* (Esben-Petesen): prey mediated tritrophic analysis. *Egyptian Journal of Biological Pest Control*. https://doi.org/10.1186/s41938-018-0102-8.**(NAAS rating 6.18)**

Extension Articles

1. Shera P S, Sharma S and Kaur R (2018). Manage lepidopteran insect-pests using bioagents in major *kharif* crops. *Progressive farming*, April 2018. pp 15-16.
2. Shera P S, Sharma S and Kaur R (2018). *Sauni vich haneekarak keeriyandee jaivik roktham*. *Changi Kheti* April 2018. pp 17-18.
3. Shera P S, Sharma S amd Kaur R (2019). Identification and conservation of bioagents in *rabi* crops. *Progressive farming*, February, 2019. pp 25-27.
4. Sharma S, Shera P S and Kaur R (2019). *Haari deeyan fasla de mittar keere ate ohna da bachao*. *Changi Kheti* February, 2019. pp 25-26, 28.

Extension folder

1. Shera P S, Sharma S, Kaur R and Joshi N (2019). *Mass production and utilization of Trichogramma for the bio-suppression of insect pests*. Department of Entomology, Punjab Agricultural University, Ludhiana.
2. Shera P S, Kaur R, Sharma and Joshi N (2019). *Mittar keera trichogramma de utpadan dee vidhi ate upyog.* Department of Entomology, Punjab Agricultural University, Ludhiana.

Extension pamphlet

1. *Mittar Kirian rahi haneekarak kirian dee roktham*, Punjab Agricultural University, Ludhiana (2019).

Research paper in conference/ symposia

1. Joshi N (2018). *Isolation, characterization and formulation of entomopathogens of insect crop*. Presented at ICAR sponsored Winter School on 'Advances in Management of Agriculturally Important Insects', Department of Entomology, Punjab Agricultural University, Ludhiana.
2. Joshi N, Sangha K S, Shera and Buttar D S (2018). Management of chilli anthracnose using mycopesticides. *Abstract Book. First International Conference on Biological Control: Approaches and Applications (ICBC-2018)* held at Bengaluru from September 27-29, 2018, p 83.
3. Kaur R, Shera P S, Sharma S and Sangha K S (2018). BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* (Guenee) in eggplant, *Solanum melongena* L. *Abstract Book. First International Conference on Biological Control: Approaches and Applications (ICBC-2018)* held at Bengaluru from September 27-29, 2018, p 122.
4. Sharma S, Shera P S and Sangha K S (2018). A comparison on abundance of parasitoids and predators in organic and conventional basmati rice. *Abstract Book. First International Conference on Biological Control: Approaches and Applications (ICBC-2018)* held at Bengaluru from September 27-29, 2018, p 30.
5. Shera P S (2018). *Biocontrol resources for eco-friendly pest management*. In: Kumar Y, Yadav S S and Kumar H (eds.) Proceedings of Advanced Training Course on Recent Trends in Pest Status, Pesticide Usage and Pest management Strategies in Agriculture" from October 5-28, 2018, CCSHAU, Hisar.
6. Shera P S (2018). *Role of behaviour modifying chemicals in tri-trophic interactions.* Presented at ICAR sponsored Winter School on 'Advances in Management of Agriculturally Important Insects', Department of Entomology, Punjab Agricultural University, Ludhiana.
7. Shera P S, Karmakar P, Sharma S and Sangha K S (2018). Impact of transgenic *Bt* cotton (Cry1Ac and Cry2Ab) on the parasitoid *Aenasius arizonensis* (Girault): a host mediated tri-trophic analysis. *Abstract Book. First International Conference on Biological Control*

: Approaches and Applications (ICBC-2018) held at Bengaluru from September 27-29, 2018, p 123.

SKUAST

1. Askary, T.H., **Ahmad, M.J**., Wani, A.R. and Mohiddin, S. (2018) Behavioural Ecology of *Steinernema* and *Heterorhabditis*, Entomopathogenic Nematodes for Insect Biocontrol. In: Ecology for Agriculture (eds. S. Gaba, B. Smith, and E. Lichtfouse). Springer Netherlands (in press).
2. Iram Khursheed, **Ahmad, M.J.**, and Aijaz Ahmad Sheikh (2018). Description of a new species of *Halticoptera spinola* (Chalcidoidea: Pteromalidae) from Kashmir, India. *Journal of Entomology and Zoology studies*, **6**(2): 3081-3084.
3. SajadMohi-ud-din and NaveedAnjum and M. Jamal Ahmad. 2018. Seasonal incidence and natural enemy complex of aphid, *Aphis punicae* (Hemiptera: Aphididae) infesting pomegranate in Kashmir. *Journal of Biological Control* 32(**3**): 172-178.
4. SajadMohi-ud-din, NaveedAnjum and M. Jamal Ahmad. 2019. Seasonal incidence and natural enemy complex of aphid, *Aphis punicae* (Hemiptera: Aphididae) infesting pomegranate in Kashmir: Poster presentation in Ist International Conference on Biological Control: Approaches and Application at Bengaluru from 27-09-2018 to 29-09-2018.
5. Sajad Mohi-ud-din and M. Jamal Ahmad. 2019. Laboratory evaluation of feeding potential of *Chilocorus infernalis* against *Lecanium* scale on plum: Poster presentation in National Seminar on Climate Change and its Impact on Himalyan Ecology and Food Security at SKUAST-K, Shaliamr from from March 13-14, 2019.

Popular article in newspaper:

1. Sajad, M. and M. Jamal Ahmad. Scourge of Codling moth in Ladakh and its management published in daily news paper *Greater Kashmir* on 8th June, 2108.

TNAU

1. S.J. Nelson and A. Suganthi. 2018. A new approach in the tricho card preparation for the inaundative release of *Trichogramma* spp. I n: First International Conference on Biological Control, Bengaluru 27.10.18 to 29.10.18, Abst. P.No. 165
2. A.Suganthi, S.J.Nelson and S. Sridharan. 2018. Biointensive pest management strategies for the control of bud borer (*Hendecasis duplifascialis* Hampson) and blossom midge (*Contarinia maculipennis* Felt) in jasmine. In: First International Conference on Biological Control, Bengaluru, 27.10.18 to 29.10.18. Abst. P.No. 174
3. Ranjith, M., S.J.Nelson and S.Sithanantham.2018. Active dispersal of *Trichogramma chilonis* Ishii and *T. pretiosum* Riley towards host eggs under confined condition and their parasitisation efficiency. **Madras Agricultural Journal**, 105(1-3):61-65

YSPUHF

Research papers:

1. Manohar TN, Sharma PL, Verma SC and Chandel RS. 2019. Demographic parameters of the indigenous egg parasitoids, *Trichogramma* spp., parasitizing the invasive tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *Egyptian Journal of Biological Pest Control*, 29:9 https://doi.org/10.1186/s41938-019-0112-1.
2. Devi Diksha, Verma SC, Sharma PL, Sharma HK, Gupta Neha and Thakur Pallavi. 2019. Effect of climate change on insect pests of fruit crops and adaptation and

mitigation strategies: A review. *Journal of Entomology and Zoology Studies* 7(1): 507-512.
3. Gupta Neha, Verma SC, Sharma PL, Thakur Meena, Sharma Priyanka and Devi Diksha. 2019. Status of invasive insect pests of India and their natural enemies. *Journal of Entomology and Zoology Studies* 7(1): 482-489.
4. Mohinder Singh, PL Sharma, VK Rana, Deeksha Sharma and Priyanka Sharma. 2018. Population dynamics of fruit flies, *Bactrocera* spp. infesting vegetable crops in Himachal Pradesh, India. *Indian Journal of Plant Protection* 45(2): 113-119.
5. Saini A and Sharma PL. 2018. Functional Response and Mutual Interference of *Cotesia vestalis* (Hymenoptera: Braconidae) on *Plutella xylostella* (Lepidoptera: Plutellidae). *Journal of Entomological Science*, 53(2): 162-170 https://doi.org/10.18474/JES17-36.1.
6. Verma S C, Sharma P L, Chandel R S and Negi Saraswati. 2018. Spatial distribution of green peach aphid, *Myzus persicae* Sulzer and its parasitoid, *Aphelinus asychis* Walker in bell pepper under polyhouse conditions. *Journal of Entomology and Zoology Studie*s 6(3):776-780**.**
7. Negi S, Sharma PL, Sharma KC and Verma SC. 2018. Effect of host plants on developmental and population parameters of invasive leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *Phytoparasitica*, https://doi.org/10.1007/s12600-018-0661-y.
8. Nisha Devi, P.R. Gupta, K.C. Sharma, P.L. Sharma and B.R. Negi. 2018. Fertility Table Parameters of Predatory Bug *Orius bifilarus* Ghauri (Hemiptera: Anthocoridae) Preying upon *Thrips palmi* and eggs of *Corcyra cephelonica. International Journal of Current Microbiology and Applied Sciences, 7*(3): 2574-2586.

Pamphlets/ technical bulletin:

1. Sharma PL, Verma SC, Chandel RS. 2019. "American pin worm, *Tuta absoluta* Ka Prakop Evam Roktham" (under publication)

Newspaper coverage:

1. AICRP BC centre of Dr YS Parmar University of Horticulture & Forestry, Nauni, Solan (HP) in collaboration with KVK Chamba organised training and demonstration programmes for farmers of Khani and Holi villages of Bharmaur district Chamba under STP on 25 and 26 October 2018. In these trainings 100 farmers participated and were benefited through receipt of inputs like *Metarhizium anisopliae*, *Beauveria bassiana*, Neem Baan, *Trichoderma viride*, literature (Package of practices for fruit crops), etc. and technologies to use these inputs in different crops. The activates demonstrated to the farmers were covered in local newspapers and the clipping is given below

CISH

Publications

1. Gundappa., Balaji Rajkumar and Shukla P K. (2018).Survey and Surveillance of natural enemies in mango ecosystem. In: Abstracts of International conference on Biological Control: Approaches and Applications during 27-29, September 2018 at Bengaluru. P.20

CPCRI, Kayakulam

1. Shameer, K.S. Nassaer, M., **Chandrika Mohan** and Ian C. W. Hardy (2018) Direct and indirect influence of intercrops on the coconut defoliator *Opisina arenosella*. *J. Pest Science* 91:259–275:

2. Josephrajkumar, A., **Chandrika Mohan**, Poorani, J., Merin Babu, Daliyamol, Krishnakumar, V., Vinayaka Hegde and Chowdappa, P. (2018) Discovery of a sooty mould scavenging beetle, *Leiochrinusnilgirianus* Kaszab (Coleoptera:Tenebrionidae) on coconut palms infested by the invasive rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae). *Phytoparasitica* DOI: 10.1007/s12600-017-0635-5.*)*
3. **Chandrika Mohan**, Josephrajkumar, A., Merin Babu, Arya Krishna and Krishnakumar, V. (2019) Occurrence of Invasive Bondar's Nesting Whitefly on coconut in Kerala. *Indian Cocon. J.* **61**(9): 17-18.
4. **Chandrika Mohan**, Josephrajkumar, A., Singh, L.S. and Alpana Das (2018) New Distributional Record of rugose spiralling whitefly on coconut in Kamrup and Nalbari districts of Assam. *Indian Cocon. J.* **61** (4): 19-21.

Technical bulletin/Books:
Book:

1. Chowdappa, P., **Chandrika Mohan** and Josephrajkumar, A. (2018) *Pests of Plantation Crops*, Daya Publishing House, New Delhi, 256 p.

Book chapters

1. **Chandrika Mohan**, Josephrajkumar, A. and Chowdappa, P. (2018) Coconut. *In*: *Pests of Plantation Crops*, (Eds.) P. Chowdappa, Chandrika Mohan and A. Josephrajkumar, pp 1-54. Daya Publishing House, New Delhi.
2. Josephrajkumar, A., **Chandrika Mohan,** Prathibha, P.S., Rajkumar, Nalinakumari, T., and Nair, C.P.R. (2019) Pest dynamics and suppression strategies, pp 557-634 In: The coconut palm (*Cocos nucifera* L.) Research and Development perspectives (K.U.K. Nampoothiri, V. Krishnakumar, P.K.Thampan and M.achuthan Nair Eds) Springer Nature, Signapore 834p https://doi.org/10.1007/978-981-13-2754-4.

Technical /Popular articles

1. Josephrajkumar, A., **Chandrika Mohan** and Krishnakumar, V. (2018) Taming coconut pests by Green Warriors. *LEISA* June 2018 (Biological Crop Management) Issue **20**(2): 6-9.
2. Josephrajkumar, A., **Chandrika Mohan**, Thomas, R.J. and Krishnakumar, V. (2018) Ecological bioengineering in coconut system to deter pests. *Indian Cocon. J.* **61**(6): 16-18
3. Josephrajkumar, A., **Chandrika Mohan**, Merin Babu, Arya Krishna and Krishnakumar, V. (2019) Bondar's Nesting Whitefly, *Paraleyrodes bondari* Peracchi –Yet another invasive pest recorded on coconut from India. *eKerala Karshakan* **6**(7): 29-30.
4. Thampan, C. **Chandrika Mohan**, Jesni Vijayan and Raveendran P. (2018) Participatory technology transfer for effective plant protection program in coconut (Malayalam) *Indian Naleekera Journal* **10**(9): 5-6.
5. Kalavathi S., **Chandrika Mohan** and Thampan, C., (2018) Technology support for plant protection campaign in coconut. *Indian coconut Journal* **LXI** (4): 10-14.

DRYSRUH
Research papers

1. Chalapathi Rao, N.B.V., Nischala, A., Ramanandam, G. and Maheswarappa, H.P. 2018. Biological suppression of coconut black headed catrerpillar Opisina arenosella outbreak in East Godavari district of Andhra Pradesh – eco friendly technology. *Current Science* Vol.115 (8) : 1588-1594.

2. N. B. V. Chalapathirao , A. Snehalatha Rani, N. Emmanuel, G. Ramanandam and H. P. Maheswarappa (2018) .Impact of Innundative Releases of Bio Agents in the Management of Coconut Black Headed Caterpillar *Opisina arenosella* in Andhra Pradesh under Out Break Conditions . *Int. J. Pure App. Biosci.* 6 (2): 427-433.

3. N.B.V. Chalapathi Rao, D Rakshith Roshan, G Krishna Rao and G Ramanandam (2018). A review on rugose spiralling whitefly, *Aleurodicus rugioperculatus* martin (Hemiptera: Aleyrodidae) in India. *Journal of Pharmacognosy and Phytochemistry* 2018; 7(5): 948-953.

4. N.B.V. Chalapathi Rao, A. Snehalatharani, A. Nischala, G. Ramanandam and H.P. Maheswarappa (2018). Management of rhinoceros beetle (*Oryctes rhinoceros* L.) by biological suppression with *Oryctes* baculovirus in Andhra Pradesh.*Journal of Plantation crops*. 46 (2) 124-127.

Popular articles

1. Kobbarini Aasinchu Ganoderma Tegulu – Yajamanya Paddathulu (Ganoderma disease management in coconut) was published by Neeraja, B. Ramanandam, G., Chalapathi Rao, N.B.V. Padma, E. 2018. in Rythunestam. Vol. 13 (9): 59-60 – A monthly magazine in Telugu.

IGKV

Research papers published:

1. Kolhekar Sonalika, Paikra Mamta, Gupta Krishna and **Ganguli Jayalaxmi (2019)** Feeding potential of Coccinellidae predator, *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae) on mustard aphid, *Lipaphis erysimi*, Jour. Phar. Phyt. 2019; SP2: 35-36.

Research paper published/accepted in conference/seminar:

1. Nagdev Priyanka, Ganguli Jayalaxmi, Sahu Sandhya, Incidence of rice Hispa, *Dicladispa armigera* (Coleoptera: Chrysomelidae) on paddy at Raipur, Chhattisgarh, International Conference on Sustainable Organic Agri-Horti Systems, Doctor's of Krishi Evam Bagwani Vikas Sanstha to be held from 28th – 30th Nov.'2018.
2. Ganguli Jayalaxmi, Kolhekar Sonalika, Ganguli R.N. and Padamshali Saurabh, Feeding potential of the coccinellid, *Cheilomenes sexmaculata* (Fabricius) (Coleoptera: Coccinellidae), on cowpea aphid, *Aphis craccivora* Koch, 1st International Conference on Biological Control, Sep. 27-29, 2018, S6-PP-07
3. Padamshali Saurabh, Ganguli Jayalaxmi, Ganguli R.N., Tri-trophic interaction of the different diet-fed *Corcyra cephalonica* (Stainton) on feeding efficiency of reduviid predator, *Sycanus collaris* (Fabricius), under laboratory conditions, 1st International Conference on Biological Control, Sep. 27-29, 2018, S6-PP-08

Popular Articles published:

1. **Lady Bird Beetle: Mahu aur Maini ke dushman**
2. By: Saurabh Padmashali, Soanalika Kolhekar and Jayalaxmi Ganguli Published in Chhattisgarh Kheti, Jan-March'2018, pp26.
3. **Fasalon me bimari evam Keet ke lakshan**
4. By: Smt. Rashmi Gauraha, Smt. Jayalaxmi Ganguli evam Sonali Deole Published in Krishak Suraksha, 15 August'2018, pp 44-45.
5. **Tamatar ke pramukh keet evam rog**

6. By: Rashmi Gauraha, Dr. Jayalaxmi Ganguli, Dr. Sonali Deole evam Diptimayi Das Published in Krishak Suraksha, 15 August'2018, pp 40-41.
7. **Gajar Ghas: Samasya tatha Samadhan**
8. By: Sachin Kumar Jaiswal, Smt. Jayalaxmi Ganguli, Rashmi Gauraha Published in Chhattisgarh Kheti, July-Sep.'2018, pp5.

9. **Reduviid Bug: Ek bahupayogi parbhakshi keet**
10. By: Saurabh Padamshali, Sonalika Kolhekar, Jayalaxmi Ganguli, Rashmi Gauraha Published in Chhattisgarh Kheti, July-Sep.'2018, pp36-37

Pamphlets published:

1. Mexican Beetle- *Zygogramma bicolorata* dwara gajar ghas ka jaivik unmulan

By: Sachin Kumar Jaiswal, Dr. Jayalaxmi Ganguli evam Dr. V.K. Dubey

2. Lady Bird Beetle- Mahu/Maini ka bahupayogi parbhakshi keet

By: Ambika Nag, Sachin Kumar Jaiswal, Dr. Jayalaxmi Ganguli evam Dr. V.K. Dubey

Lecture delivered:

1. Jaivik keet niyantran- Krishi fasalon ds mahatva ki drishti se, date 22/09/2018 for DAESI (Diploma in Agriculture Extension Services For Input Dealers)
2. Biocontrol, Meaning, its importance and various predator, parasites, its role in IPM, date 16/09/2018 for DAESI (Diploma in Agriculture Extension Services For Input Dealers)
3. Classificaiton of insecticides, date 28/10/2018 for DAESI (Diploma in Agriculture Extension Services For Input Dealers)

UBKV

Research Publications :

1. **Sahoo, S. K.** (2018). Investigation on insect dynamics in Indian mustard at different sowing dates.*Journal of Entomological Research*, **42**(3): 343-347. NAAS rating **5.05**(ISSN:0378-9519).
2. Sahoo, U., Das, J., Saha, S., Das, S.K., Roy, D., Debnath, M.K. and **Sahoo, S. K.**(2018). Preparation of herbal extracts and evaluation of their efficacy against rice weevil (*Sitophilusoryzae* L. (Curculionidae; Coleoptera). *Journal of Entomology and Zoology Studies*,**6**(5): 2236-2240. NAAS rating **5.53** (ISSN: 2349-6800).
3. **Sahoo, S.K.**and Saha, A. (2018). Monitoring of alate mustard aphid (*Lipaphiserysimi*Kalt.) by using yellow sticky trap in West Bengal. *Journal of Crop and Weed*, **14**(3): 149-152. NAAS rating **5.28** (ISSN: 0974-6315).

32.13. Participation in Seminor/ Symposia/ Workshops, etc

AAU- Anand

1. Dr. Raghunandan, B.L. participated in workshop on 'Knowledge management system and web designing for agricultural and allied field' from 25th to 30th June 2018 at Extension Education Institute, Anand Agricultural University, Anand, Gujarat.
2. Dr. Raghunandan, B.L. participated in national workshop on 'Yogic Farming, Organic Farming and Zero budget natural farming' from 17th to 18th September 2018, Anand Agricultural University, Anand, Gujarat.
3. Dr. Raghunandan, B.L. participated in 'First International Conference on Biological Control' (ICBC-2018) from 27th to 29th September 2018 at Bangalore, India.
4. Dr. Raghunandan, B.L. participated in 21 days training programme (CAFT) on ' Facets in Biopesticide and Botanical Formulation Production' from 28th November to

18th December 2018 at Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, India.

ANGRAU

1. **Farmers meet organised in collaboration with NBAIR, Bengaluru:** Organised farmers meet of ICAR-NBAIR and stay at Arakuvalley on 6.7.18 on the occasion of silver jubillee celebrations of NBAIR, Bengaluru.
2. **Interaction meeting on Fall armyworm on maize:** Participated inInteraction meeting on Fall armyworm on maize at Seminar hall, APGC, LAM, Guntur.
3. **Fall armyworm workshop:** Participated as resource person in Fall armyworm workshop organized by JDA, Vizianagaram at ZP Hall, Vizianagaram on 6.11.18 in presence of Special Commissioner for Agriculture, Andhra pradesh and gave presentation about invasion of new pest, *Spodoptera frugiperda,* its identification, nature of damage and integrated pest management practices and created awareness to extension staff (ADA's, AO's, MPEO's), dealers and progressive farmers of vizianagaram district .
4. **Farmers Scientist Interaction:** Participated in AMC level Farmers Scientist Interaction at sabbavaram on 26.7.18 organised by Department of agriculture and imparted knowledge on paddy pest management practices and biological control in paddy.
5. **Workshop attended:** Attended XXVI annual group meet on AICRP on Biological control of crop pests at KAU, Thrissur from 16-17th May, 2018; presented achievements of AICRP centres on biological contol of maize and sorghum pests ; participated as rappoteur for session on tribal sub plan programme

Training programmes participated:

1. Dr. M.Visalakshi, PS (Entomology) participated in training programme to MPEO's organized at RARS, Anakapalle by Scientist, Extension and Delivered talk on Biological control of pests in sugarcaneon 14.12.18 .
2. Dr. M.Visalakshi, PS (Entomology) participated in MPEO's Training programme organized by ADA, Cheepurupalli at Cheepurupalli on 22.12.18 and interacted on present status of fall armyworm in maize in cheepurupalli division and management practices adopted in *rabi* maize.
3. Dr. M.Visalakshi, PS (Entomology) participated in vocational training programme on Friends of coconut tree and interacted with coconut farmerson rugose whitefly damage and management at KVK, Amadalavalasa on 2.2.19.

GBPUAT

National Conference/Seminar/Workshop attended:

1. Drs. A K Tewari, Dr Roopali Sharma and Manju Sharma, attended First International Conference on Biological Control: Approaches and Applications organized by NBAIR at Bengaluru from September 27-29, 2018.
2. Drs. AK Tewari and Manju Sharma attended QRT meeting of AICRP- Biological control at Nauni, Solan on June 22, 2018.

KAU, Thrissur

1. Dr. Madhu Subramanian, Professor attended XXVII Biocontrol Workers Group Meeting held on 17th to 18th May, 2018 at Kerala Agricultural University, Vellanikkara, Thrissur.

PJTSAU

1. Participated in Bio Safety Conference organized by Ministry of Env., Forests & Climate Change at different parts of country during 2017-18
2. Participated in ZREAC (*Kharif &Rabi*) meetings in Telangana during 2017-18

MPKV

Research Meetings:

1. Dr. S.M. Galande attended 1st International conference on Biological Control - Biocontrol Approaches and Application, (ICBC, 2018) " held at Hotel Le Meridian, Bengaluru 2018 on 27th to 29th September, 2018
2. Dr. S. M. Galande attended High Power Committee meeting held at ICAR, New Delhi on 14.11.2018 on Fall Armyworm. Discussed Management strategies for FAW
3. Dr. S. M. Galande and Dr S.A Landge attended RRC meeting held at MPKV. Rahuri on 26.12 2018. Dr. S. M. Galande presented the RRC report and presented the recommendation on Okra in the meeting.
4. Dr. S. M. Galande attended the State level Sub-committee meeting on "fall armyworm and White grub "on 18.1.2019 at ATMA hall, Commissioneroate of Agriculture, Pune presented management strategies for fall armyworm and white grub and participated in the discussion.
5. Dr. S. M. Galande and Dr S.A. More attended Research Programme Planning Meeting in Plant protection held at MPKV, Rahuri on 1.3.2019. Dr. S. M. Galande presented the Technical programme of Biocontrol for the year 2019-2020.

PAU, Ludhiana

1. Dr Neelam Joshi participated in QRT meeting of All India Coordinated Research Project on Biological Control of Crop Pests held at AAU, Anand (Gujarat) on April 11, 2018.
2. Dr Neelam Joshi participated as resource person in International training on 'Crop protection chemicals for food security, safety and their residue management' for officials (ADO) of MOA, Irrigation, Live stock, Government of Afghanistan held at PAU, Ludhiana from April 9-19, 2018.
3. Dr Neelam Joshi and Rabinder Kaur participated in 27th Biocontrol Workers' Group Meeting of All India Coordinated Research Project on Biological Control of Crop Pests at Kerala Agricultural University, Thrissur from May 17-18, 2018.
4. Dr Neelam Joshi, P.S. Shera and Rabinder Kaur participated in Research and Extension Specialists Workshop for *Rabi* crops at PAU Ludhiana on August 16, 2018.
5. Dr Neelam Joshi, P.S. Shera, Rabinder Kaur and Sudhendu Sharma participated in First International Conference on Biological Control: Approaches & Applications organized by Society of Biocontrol Advancement Bengaluru, India, ICAR- National Bureau of Agricultural Insect Resources, Bengaluru, India and Centre for Agriculture and Bioscience International (CABI), UK at Bengaluru from September 27-29, 2018.

Participation in *Kisan melas*

Kisan mela	**Date**	**Name of Scientist(s)**
Regional *Kisan mela*, Gurdaspur	11.9.2018	P.S. Shera
Kisan mela, PAU, Ludhiana	20-22.9.2018	Neelam Joshi, P.S. Shera, Sudhendu Sharma, Rabinder Kaur
Regional *Kisan mela*, Faridkot	8.3.2019	P.S. Shera, Sudhendu Sharma
Kisan mela, PAU, Ludhiana	15-16.3.2019	Neelam Joshi, P.S. Shera, Sudhendu Sharma, Rabinder Kaur

SKUAST

Dr. Jamal Ahmad

1. Attended meeting with Director Research, SKUAST-K on dated 29th March' 2018 for price fixation of different products prepared in the University. Attended and presented Progress of work and future plan of the Division in 29th Extension Council Meeting in Secretariat of Vice Chancellor, SKUAST-K on dated 16th April, 2018.
2. Attended 55th RCM (*Kharif*) and presented Research work carried out by the Scientists of the Division of Entomology in Secretariat of Vice Chancellor, SKUAST-K on 12-13 April' 2018.
3. Attended 27th Annual Group Meet of AICRP on Biological Control held at KAU, Thrissur, Kerala 17-18th May' 2017.
4. Attended QRT and presented work done (2012-17) of SKUAST-K on 22nd June' 2018 in Dr.Y.S.Parmar University of Forestry and Horticulture, Solan.
5. Attended a brain storming session on banning of pesticides in the Directorate of Research on 6th September' 2018.
6. Attended 56th RCM (*Rabi*) and presented Research work carried out by the Scientists of the Division of Entomology in Secretariat of Vice Chancellor, SKUAST-K on 29th September' 2018.
7. Participated in Ist International Conference on *Biological Control: Approaches and Application* at Bengaluru from 27-09-2018 to 29-09-2018.
8. Attended NationalSeminar on Climate *Change and its Impact on Himalyan EcologyandFood Security* from13-03-2019 to 14-03-2019 at SKUAST-K, Shalimar.

YSPUHF

1. Attended 27th group meeting of AICRP on Biological Control of Crop Pests and Weeds on 17-18, May 2018 organised by NBAIR at KAU Thrisur
2. Organised and attended Quinquennial Review Meeting of AICRP -BC on 22 June 2018 at YSPUH&F, Solan
3. Participated and presented paper in "First International Conference on Biological Control: Approaches and Applications" organised by Society for Biocontrol Advancement in association with NBAIR, ICAR centre for Agriculture and Bioscience International, International Organization of Biological Control of Bengaluru w.e.f 27-29 September 2018.
4. Attended one day workshop on "Eco-innovations for resilient mountain farming'' organised by YSP UHF, Nauni, Solan on 16 March 2019.
5. Attended meeting with World Bank team regarding development of entrepreneurs in Biocontrol on 18 April and 13th November 2018.
6. Attended meeting with Biocontrol experts for Newzealand regarding scope of biocontrol of apple pests in the state on 14 May, 5th June and 25 September 2018.
7. Attended meeting with experts from Newzealand regarding biocontrol of apple pests on 20 February 2019.

Presented in conferences/symposia:

1. Sharma PL, Negi S, Verma SC. 2018.Thermal requirements of *Tuta absoluta* (Meyrick) and influence of temperature on its population growth on tomato. First International Conference on Biological Control: Approaches and applications, held at Bengaluru, India w.e.f 27-29 September 2018, abstract book page 214.
2. Negi S, Sharma PL, Verma SC. 2018.Functional response of indigenous *Nesidiocoris tenuis* (Reuter) to invasive leafminer, *Tuta absoluta* (Meyrick). First International Conference on Biological Control: Approaches and applications, held at Bengaluru, India w.e.f 27-29 September 2018, abstract book page 217.

3. Verma SC, Sharma S, Sharma PL. 2018. Spatial distribution of cabbage aphid, *Brevicoryne brassicae* (L) and its parasitoid, *Diaeretiella rapae* (McIntosh) under sub-temperate conditions of Himachal Pradesh, India. First International Conference on Biological Control: Approaches and applications, held at Bengaluru, India w.e.f 27-29 September 2018, abstract book page 167.

CPCRI

1. Attended Annual General Meeting of AICRP on Palms held at Indian Institute of Oil Palm Research, Pedavegi during May 24-26, 2018 and chaired session on "pest Management"
2. Attended 27th Annual Group Meeting of AICRP on Biological control of crop pests held at Kerala Agricultural University, Thrissur during May 17-18, 2018 and presented work done on pests of coconut palm.

Presentation in Conference/Symposia/seminars/other fora:

1. **Chandrika Mohan**, Josephrajkumar, A., Vinayaka Hegde, Krishnakumar, V. and Chowdappa, P. (2018) Area-wide suppression tactics of red palm weevil, *Rhynchophorus ferrugineus* Oliv., infesting coconut palms in India. ESA, ESC, and ESBC Joint Annual Meeting of the Entomological Society of America (ESA), November 11-14, 2018, Vancouver, BC Canada. WebEx presentation. Abstract No 2384. p 227.
2. **Chandrika Mohan**, Anithakumari, P. and Josephrajkumar, A. (2018) Area-wide Farmer participatory bio-management of rhinoceros beetle in coconut plantations. pp127. *In*: Abstracts: First International Conference on Biological Control, 2018, (Eds.) M. Mohan *et al*. September 27-29, Bengaluru, 219p.
3. Josephrajkumar, A. and **Chandrika Mohan** (2018) Gradient Outbreak of Coconut Pests and Mitigation Strategies. *In*: Book of Abstracts-National Seminar on Climate Change, Habitat Destruction and Emergence of Insect Pests and Vectors, (Eds.) D.A. Evans, October, 11-12, 2018, Department of Zoology, University College, Thiruvananthapuram, pp 1-3.

DRYSRUH

Trainings attended:

1. Dr.N.B.V. Chalapathi Rao, Senior Scientist (Ent.) attended training programme on Master Trainers for Training of Master Trainers (ToMT) organized by Agriculture Skill Council of India (ASCI) and Dr.YSRHU at KVK, VR Gudem from 29th – 31st August, 2018.

Workshops Attended:

1. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) attended the 27th Annual Group meeting of AICRP on Biological Control from 17-18th May, 2018 at Kerala Agricultural University, Thrissur and presented the work done for the year 2017-18.
2. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) attended the 27th Annual Group meeting of AICRP on Palms on 25.05.18 at IIOPR, Pedavegi as special invitee and involved in the discussions on pest management technical session of AICRP on palms.
3. The Scientists of HRS, Ambajipeta participated in International symposium on plantation crops (PLACROSYM XXIII) from 6th – 8th March, 2019 at Chikkamagaluru, Karnataka and made oral presentation of research papers and posters.
4. Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ent.) participated in National level workshop on "Plant Health Management of Coconut: Challenges and Opportunities" at

NIPHM, Hyderabad on 14th & 15th March, 2019 and delivered a lecture on "The invasive species rugose spiraling whitefly a recent threat to coconut production" organized by CDB & NIPHM.

IGKV

1. Attended the **first International Conference on Biological Control** at Bengaluru and presented poster and on the **"Best poster award"**

32.14 Biocontrol agents maintained

AAU-Anand

- *Trichogramma chilonis*
- *Trichogrammatoidea bactrae*
- *Beauveria bassiana* (Bb-5)
- *Lecancillium lecanii* (Vl-8)
- *Metarhizium anisopliae* (Ma-1)
- *Bacillus thuringiensis* (PDBC-BT1, NBAII BTG-4)
- *Trichoderma harzianum* (Th-3)
- *Pseudomonas fluorescens* (Pf-1)
- *Paecilomyces lilacinus*
- Entomopathogenic nematode –*Steinernema pakistanens*

AAU- Jorhat

- *Trichogramma japonicum*
- *T. chilonis*
- *T. chilonis* (MITS)
- *T. pieridis*
- *Trichogramma pretiosum*
- *Telenomus sp* recovered from tea
- *Neochetina eichhorniae and N. bruchi*

The biocontrol agents (parasitoids and predators) produced and maintained in the laboratory are being utilized for teaching and training of farmers, execute APART programme, extension workers, entrepreneurs and also students of U.G. (ELP) and P.G. Research. Cultures of parasitoids (*Trichogramma japonicum, T. chilonis, T. pieridis)* and water hyacinth beetle *Neochetina eichhorniae* and *N. bruchi* have been supplied to different regional research stations of AAU, KVKs and Agricultural officers, Govt. of Assam for their field demonstration against pests of rice, sugarcane and vegetables.As per request from different departments and laboratory under AAU, Jorhat to carry out their research programme, trichogrammatids and eggs of *Corcyra*were supplied.

Revenue Generated through sale of Trichocard was Rs. 54,000.00 (till 31.3.19)

ANGRAU

Mass production of Biocontrol agents - Revolving fund

1. Mass production of egg parasitoid, *Trichogramma chilonis* and sale of 2759 Trichocards to farmers, Daattcentes, sugar factories and department of agriculture and revenue generated with Trichocards and *Corcyra* eggs was INR 1,45,450.00.
2. Mass production of Entomopathogenic fungi (EPF), *Metarhizium anisopliae* as conidiated rice - 1186 kg produced for sale @ Rs.120/- per kg and supplied to ADH, Vizianagaram, coconut farmers for the management of coconut rhinoceros beetle. Revenue generated with EPF was INR. 1,70,670.00.
3. Total revenue generated under revolving fund with Trichocards and EPF during 2017-18 was Rs. 2, 79,540.00.

KAU, Thrissur

1. Entomopathogenic micro organisms: *Pseudomonas fluorescens, Trichoderma viride, Metarhizium anisopliae var. anisopliae, Lecanicillium lecanii, Beauveria bassiana* (3 isolates), *Bacillus thuringiensis, Pochonia chlamydospora, Paecilomyces lilacinus, Heterorhabditis indica* and *Neoaplectana carpocapsae.*
2. Parasitoids: *Trichogramma chilonis, T. japonicum*
3. Predators: *Chryptolaemus montrouzieri*, *Blaptostethus pallescens, Sycanus collaris* (Reduviidae)

The centre has produced and sold biocontrol agents as follows during the year 2018-19

Sl. No.	**Particulars**	**Quantity**
1	*Pseudomonas fluorescens*	13514 kg
2	*Trichoderma viride*	2468 kg
3	*Beauveria bassiana*	1677 kg
4	*Verticillium lecanii*	1306 kg
5	*Metarhizium*	560 kg
6	*Trichocards*	4250 cc

PJTSAU:

S. No.	**Bio Agent being cultured and mass produced**	**Type of Bio Agent**
1.	*Trichogramma japonicum*	Egg parasitoid
2.	*Trichogramma pretiosum*	Egg parasitoid
3.	*Trichogramma chilonis*	Egg parasitoid
4.	*Trichogramma achae*	Egg parasitoid
5.	*Trichogramma brasilensis*	Egg parasitoid
6.	*Trichogrammatoidea bactre*	Egg parasitoid
7.	*Chelonus blackburni*	Egg larval parasitoid
8.	NPV of *Helicoverpa*	Bio Pesticide
9.	NPV of *Spodoptera*	Bio Pesticide

MPKV

Following cultures of bio-agents 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*, HaNPV, SlNPV, *Metarhizium anisopliae* and *Nomuraea rileyi* were mass cultured and used for action research demonstrations on research farms of the University, and farmers' fields. These were also distributed to needy farmers.

Parasitods:

- *Trichogramma chilonis* Ishii
- *Trichogramma chilonis* (TTS and SAS strains)
- *Trichogramma japonicum* Ashmead
- *Trichogrammatoidea bactrae*
- *Chelonus blackburni* Blanchard

Predators:

- *Cryptolaemus montrouzieri* Mulasnt
- *Chrysoperla zastrowi sillemi* (Esben.)

Microbial agents:

- *Metarhizium anisopliae*
- *Beauveria bassiana*
- *Lecanicillium lecanii*
- *Nomuraea rileyi*

Host insects:

- *Corcyra cephalonica* Stainton
- *Phthorimaea operculella* Zeller
- *Maconellicoccus hirsutus* Green

Sr. No.	Name of bioagents	Quantity produced	Quantity Sold	Receipt
1.	*Trichgramma* sp (Trichocards)	1020	254	12700/
2.	*Chelonus blackburni*	400	100	200
3.	*Cryptolaemus montrouzieri*	2500	370 Adult	1480/-
4.	*Metarhizium anisopliae*	500	125	25,000
5	*Lecanicillium lecanii*	500	51	
6	*Beauveria bassiana*	500	02	400

PAU, Ludhiana

Host insects	*Corcyra cephalonica, Phenacoccus solenopsis, Galleria mellonela, Plutella xylostella, Pieris brassicae, Spodoptera litura, Helicoverpa armigera*
Parasitoids	*Trichogramma chilonis, T. japonicum, T. brassicae, T. pretiosum, T. embryophagum, Bracon hebetor, Aenasius arizonensis, Cotesia glomerata*
Predators	*Chrysoperla zastrowi sillemi, Blaptostethus pallescens, Coccinella septempunctata*
Entomopathogen	*Beauveria bassiana*

- PAU centre has a well-established biocontrol laboratory for the rearing of *Corcyracephalonica* and mass production of bioagents. Tricho-cards are being mass produced and supplied to farmers of Punjab.
- At present, five sugar mills (3 cooperative & 2 private) are successfully running biocontrol laboratories under the technical guidance of PAU, Ludhiana. PAU centre is acting as nodal agency for transfer of technical expertise as well as core point for resources like nucleus cultures of the bioagents and training to staff of biocontrol laboratories in the state.
- The nucleus culture of *Corcyra* and *Trichogramma* has been provided to different institutes and SAU's in neighbouring states like State Bio-control Laboratory, Palampur (HP), Banaras Hindu University, Varanasi, Khalsa College, Amritsar and Division of Entomology, SKUAST, Jammu
- A total revenue of Rs. 74725/- was generated through sale of *Corcyra* eggs and tricho-cards to biocontrol laboratories and farmers, respectively

SKUAST

The culture of following bio agents (obtained from NBAIR, Bengaluru) including parasitoids and predator, along with their actual/ fictitious hosts, was maintained for the purpose of mass production mainly for distribution to farmers/ experimental purposes, teaching, training to P.G.students, farmers, FCLAs, extension workers and exhibitions in Kisanmelas etc.

S.No.	Hosts and bio agents	Source
1.	*Trichogramma brassicae*	from NBAIR
2.	*T. chlionis*	-do-
	T. chlionis (MITS)	-do-
3.	*T. cacoeciae*	-do-
4.	*T. embryophagum*	-do-
5.	*T. pretiosum*	-do-
6.	*Blaptostethus pallescens*	-do-
7.	*Quadraspidiotus perniciosus*	Local strain
8.	*Corcyra cephalonica*	NBAIR

YSPUHF

1. Entomopathogeic fungi: *Metarhizium anisopliae, Beauveria bassiana Lecanicillium lecanii*
2. Entomopathogenic nematodes: *Steinernema feltiae*. and *Heterorhabditis* sp (These are maintained by the Nematology section of the Department)
3. Parasitoids: *Trichogramma chilonis. T. pretiosum, T. achaeae* and *T. pieridis, T. embryophagum*
4. Predators: *Neoseiulus longispinosus, Chrysoperla zastrowi sillemi, Blaptostethes pallescens*
5. Host/prey insects: *Corcyra cephalonica, Tetranychus urticae, Plutella xylostella, Tuta absoluta*

OUAT

The trichocards produced at the Department of Entomology, OUAT, Bhubaneswar have been distributed among the farming communities of the state to control the lepidopteran borers of field, vegetable and polyhouse crops.

Trichocards distributed to control different lepidopteran pests of field and vegetable crops of Odisha during 2018-19

Sl. No.	Name of the indenter	Date	Tricho-cards Supplied(No.)	Crop(s)	Area(ac)
1.	AICRP on biological control	21.08.18 17.09.18 25.03.19	100 150 100	Paddy Sugarcane Polyhouse veg.	12.5 15.5 2.0
2.	AICRP on maize	21.08.18	10	Maize	2.5
3.	KVK, Balasore	03.09.18	10	Rice	2.5
4.	KVK, Sundargar 2,Raurkela	15.09.18	50	Rice	12.5
5.	Aska co-op. sugar industries Ltd.	05.10.18	150	Sugarcane	17.5
6.	KVK, Dhenkanal	19.09.18 28.09.18 12.12.18 03.01.19 20.02.19	50 100 150 170 120	Rice Rice Brinjal Brinjal Pulses	6.5 12.5 15.0 17.0 30.0
7.	KVK,Sundargarh 1, Kirei	17.09.18	50	Rice	6.5
8.	KVK, Deogarh	20.12.18 28.03.19	100 100	Brinjal Pulses	10.0 25.0
9.	KVK, Bhadrak	26.09.18	10	Rice	2.5
10.	Sakti sugars Ltd., Dhenkanal	28.09.18	75	Sugarcane	7.5
11.	ICAR-CIWA , Bhubaneswar	23.10.18	10	Okra	2.0
12.	AICCIP. Bhawanipatna	23.10.18	10	Cotton	2.0
13.	KVK, Jagatsinghpur	31.10.18	100	Rice	12.5
14.	KVK, Keonjhar	29.11.18 07.12.18	150 150	Brinjal Brinjal	18.5 18.5
15.	KVK, Ganjam 1,Bhanjanagar	21.01.19 20.02.19	100 80	Brinjal Pulses	10.0 20.0
16.	KVK. Bolangir	20.02.19	80	Brinjal	8.0
		Total :	2175	8 crops	289

IGKV

***Corcyra* eggs and other bioagents supplied from Bio-control laboratory, department of Entomology to different campus of IGKV.**

S. No.	Items	Qty.	Centre
1.	*Corcyra* eggs	07 cc	K.L. CoH, Rajnandgaon
2.	*Cryotolaemus montouzieri*	10	TCBCARS, Bilaspur
3.	*Galleria mellonella*	100	Basana Gowda, ICAR-NRRI, Cuttuck, Odisha
4.	Braco card	478	Various organizations
5.	EPN	30 ml	Rakhi Sharma
6.	*Zygogramma bicolorata*	102	Sukad Poultry Farm, Raipur

7.	Reduviid bug	72	Sonpairi, Dhamtari TCBCARS, Bilaspur
8.	Trichocard	748 Nos.	Various organizations
9.	Sentinel cards	4 Nos.	KVK, Mahasamund

32.15. Technology assessed/ transferred

AAU- Jorhat

- BIPM on rice
- BIPM on brinjal

PAU, Ludhiana

Recommendations included in PAU Package of Practice

- Management of stem borers and leaf folder with neem formulation, Achook (azadirachtin 0.15%) in *basmati* rice under organic and conventional conditions included in Package of Practice for *Kharif* Crops (2019).
- Management of melon fruitfly, *Bactrocera cucurbitae* (Swinhoe) in cucurbits (bitter gourd and sponge gourd) with Cue-lure based PAU fruitfly traps @ 16 traps per acre; in 3rd – 4th week of March (bitter gourd) and April (sponge gourd) in case of early season crop and 4th week of June in case of late season crop with recharge of septa at an interval of 25-30 days, included in Package of Practice for Cultivation of Vegetable Crops (2019).

Technology transferred

- Large scale demonstrations of biocontrol technologies using bioagents, *T. chilonis* and *T. japonicum* for the management of sugarcane borers conducted over an area of 4806 hectares at farmers' fields in collaboration with sugar mills of Punjab.

- Large scale demonstrations on the bio-suppression of stem borer, *Chilo partellus* using *T. chilonis* conducted over an area of 214 ha at farmers' fields in maize crop.

- Large scale demonstrations of biocontrol based pest management technologies using bioagents, *T. chilonis* and *T. japonicum* conducted over an area of 78 ha for the management of leaf folder, *Cnaphalocrocis medinalis* and yellow stem borer *Scirpophaga incertulas* at farmers' fields in organic *basmati* rice.

SKUAST

1. Mass production of *Corcyra cephalonica*
2. Mass production of *Trichogramma* spp.
3. Trunk banding for trapping of overwintering larvae of Codling moth, *Cydia pomonella* in Ladakh
4. Mass production technique of *Blaptostethus pallescens*
5. Supply of bioagents*Trichogramma cacoeciae, T. embryophagum, T. chilonis* and*T. brassicae* to farmers against Codling moth, *Cydia pomonella*, maize stalk borer, *Chilo partellus*, Diamond back moth, *Plutellaxylostella* and cabbage butter fly, *Pierisbrassicae.*
6. *T. chilonis* (MITS) was assessed against Brinjal shoot and fruit borer in Srinagar.

YSPUHF

1. Technology developed/ evaluated: Bio-intensive management of *Tuta absoluta* in tomato
2. Management of apple root borer, *Dorysthenes hugelii*by using *Metarhizium anisopliae*

PJTSAU:

1. *In situ* culturing & production of imported parasitoid, *Acerophagous papaye* through potato seedling technique by using papaya mealy bug, *Paracoccus marginatus* as host. - This method was followed by several farmers to maintain *Acerophagous papaya* populations in local areas of requirement across the state. The parasitoid was released in the infested fields and mealy bug management through Biological Control was achieved. - A case history of successful management of Papaya Mealy Bug through imported parasitoid, *Acerophagous papaye* has been celebrated at National level where in PJTSAU Centre was invited along with the two successful farmers to share their experiences at national level in the presence of DG, ICAR.
2. Standardized Bio suppression of aphids, *Uroleucon carthami* in safflower by using Entomo Pathogenic Fungi (EPF) *Verticillium* (*Lecanicillium*) *lecanii* -Two sprays of *Verticillium* (*Lecanicillium*) *lecanii* @ 5gm/litre at vegetative stage with 10 days interval is standardized as recommendation at national level to manage safflower aphid, *Uroleucon carthami* in non spiny safflower. – This recommendation was presented as an achievement of the PJTSAU centre at International Conference of Safflower held at Directorate of Oilseeds Research (now IIOR)
3. Developed Conservation protocols based on Pest Predator Ratios for Sugarcane Woolly Aphid (SWA), *Ceratovacuna lanigerum* and predators, *Dipha aphidivora*&*Micromus igoratus*.
4. Developed Mass Production Protocols for *Trichogramma, Chrysoperla*, *Ha* NPV, *Sl* NPV, *Trichoderma*&*Pseudomonas* amenable for the state of Telangana and they have been officially passed on to stake holders through Department of Agriculture, Govt. of Telangana on the basis of which several decentralized Bio Control Units are being run by rural youth besides nine State owned Bio Control Labs.
5. Upliftment of livelihoods of rural women groups by upscaling NPV production units through active support from NGOs such as Centre for Sustainable Agriculture (CSA) and Centre for peoples forestry (CPF).
6. Feedback analysis of yield gaps in several Horticultural Crops in reference to with or without State Horticulture Mission (SHM) was done to evaluate the programmes of SHM in capacity of member of Technical Support Group (TSG).

32.16 Diagnostic Field Visits

ANGRAU

Diagnostic Field Visits: Dr. M. Visalakshi conducted thirty one field visits in Visakhapatnam, Vizianagaram and Srikakulam districts of Andhra Pradesh monitored problems in paddy, sugarcane, maize and coconut and advised management practices to farmers and field staff of Department of agriculture, horticulture and sugar factories.

DRYSRUH

Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) conducted thirteen field visits in various districts of Andhra Pradesh, Telangana and Kerala and monitored problems in coconut, cocoa and cashewnut and advised management practices to farmers and field staff of Department of agriculture and horticulture

Exhibition Arranged
PAU, Ludhiana

Event	Date
Training on 'Biological control of insect-pests and diseases in organic rice' at KVK, Sangrur	12.6.2018
Training on 'Biological control of insect-pests in rice and maize crop' at village Badowal (Hoshiarpur)	1.8.2018
Research and Extension Specialists Workshop for *Rabi* crops at PAU Ludhiana	16.8.2018
Training on 'Biological control of insect-pests and diseases in organic rice' at KVK, Samrala	29.8.2018
Training on 'Biological control of insect-pests in organic basmati rice and maize crop' at KVK Kapurthala	30.8.2018
Regional *Kisan mela*, Gurdaspur	11.9.2018
Regional *Kisan mela*, Ballowal Saunkhri	11.9.2018
Regional *Kisan mela*, Patiala	14.9.2018
Regional *Kisan mela*, Amritsar	17.9.2018
Regional *Kisan mela*, Faridkot	17.9.2018
Kisan mela, PAU, Ludhiana	20-22.9.2018
Regional *Kisan mela*, Bathinda	26.9.2018
Training camp on 'Safe and Judicious use of Pesticides and integrated pest management' at village Bhasod (Sangrur)	15.11.2018
Training on 'Promotion of biological control of insect pests and diseases' at KVK, Moga	21.11.2018
Research and Extension Specialists Workshop for *Kharif* crops at PAU Ludhiana	26.2.2019
Regional *Kisan mela*, Bathinda	1.3.2019
Regional *Kisan mela*, Ballowal Saunkhri	6.3.2019
Regional *Kisan mela*, Amritsar	6.3.2019
Regional *Kisan mela*, Faridkot	8.3.2019
Regional *Kisan mela*, Gurdaspur	8.3.2019
Kisan mela, PAU, Ludhiana	15-16.3.2019
Regional *Kisan mela*, Patiala	19.3.2019

ACRONYMS

AICRP-BC	All India Coordinated Research Project of Biological Control of Crop Pests, Bengaluru
NBAIR	National Bureau of Agricultural Insect Resources, Bengaluru
AAU-A	Anand Agricultural University, Anand
AAU-J	Assam Agricultural University, Jorhat
ANGRAU	Acharya N.G.Ranga Agricultural University, Anakapalle
GBPUAT	Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar
KAU	Kerala Agricultural University, Thrissur
MPKV	Mahatma Phule Krishi Vidyapeeth, Pune
PAU	Punjab Agricultural University, Ludhiana
PJTSAU	Pandit Jayashankar Telangana State Agricultural University, Hyderabad
SKUAST	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
TNAU	Tamil Nadu Agricultural University, Coimbatore
YSPUHF	Y.S. Parmar University of Horticultural and Forestry, Solan
CAU	Central Agricultural University, Pasighat
MPUAT	Maharana Pratap University of Agriculture & Technology, Udaipur
OUAT	Orissa University of Agriculture & Technology, Bhubaneswar
UAS-R	University of Agricultural Sciences, Raichur
CISH	Central Institute of Subtropical Horticulture, Lucknow
CPCRI	Central Plantation Crops Research Institute, Kayamkulam
CTRI	Central Tobacco Research Institute, Rajahmundry
IIHR	Indian Institute of Horticultural Research, Bengaluru
IIMR	Indian Institute of Millet Research, Hyderabad
IIRR	Indian Institute of Rice Research, Hyderabad
IIVR	Indian Institute of Vegetable Research, Varanasi
NCIPM	National Centre for Integrated Pest Management, New Delhi
DRYSRUH	Dr. Y S R Horticultural University, Ambajipeta
IGKV	Indira Gandhi Krishi Viswavidhyalaya, Raipur
KAU RARS	KAU-Regional Agricultural Research Station, Kumarakom
KAU RARS	KAU-Regional Agricultural Research Station, Vellayani
UBKV	Uttar Banga Krishi Vishwavidyalaya, Pundibari, West Bengal
Sun Agro	Sun Agro Biotech, Chennai
PDKV	Panjabro Deshmukh Krishi Vidyapeeth