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

Annual Progress Report 2019-2020

AICRP on Biological Control

Compiled and edited by
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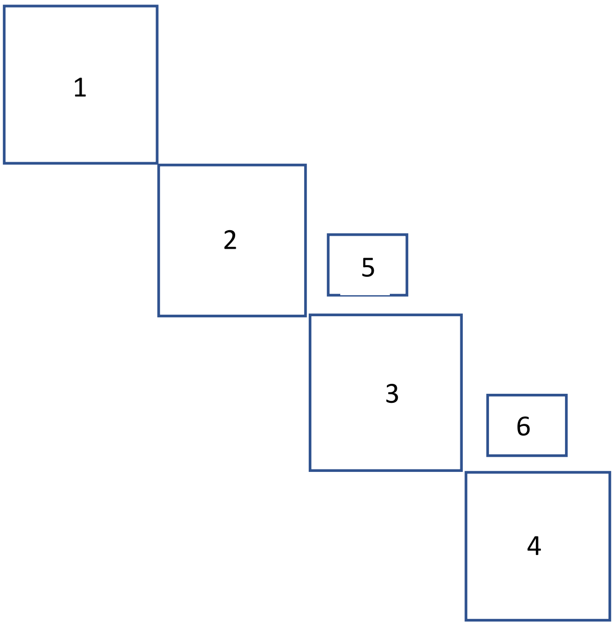

Cover page

1. *Trichogramma chilonis*
2. Final instar larva of fall armyworm
3. NPV infected fall armyworm larva
4. *Chelonus* sp. larva
5. Parasitized fall armyworm eggs
6. Adult moths of fall armyworm

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Cover design: G. Mahendiran

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EXPERIMENTAL RESULTS

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

1.1 ICAR-National Bureau of Agricultural Insect Resources, Bengaluru

1.1.1 Endophytic establishment of *Beauveria bassiana* and *Metarhizium anisopliae* in cabbage for management of diamond back moth (*Plutella xylostella* (L.)

a. Glasshouse studies

In glass house studies, the endophytic isolates of *B. bassiana* (ICAR-NBAIR Bb-5a & Bb-45) and *M. anisopliae* (ICAR-NBAIR-Ma-4 & Ma-35) caused 8.4-76% mortality on second instar larvae of *Plutella xylostella* when applied through different inoculation methods like, seed treatment, root inoculation & foliar spray (Table 1). Among the isolates tested, Ma-35 isolate showed highest mortality on *P. xylostella* in all the application methods.

In field experiment, among the four isolates tested, NBAIR Ma-35 isolate showed highest pest reduction 93.5% when applied through a foliar spray ($1x10^8$ cfu/ml) after 10days of transplanting of cabbage seedlings and rest of the isolates showed 56-81% of pest reduction over untreated control.

Table 1. Effect of endophytic *B. bassiana* and *M. anisopliae* isolates against *P. xylostella*in cabbage by different inoculation methods (Glasshouse studies)

S.no	Isolate	Seed treatment (% mortality)		Root inoculation (% mortality)		Foliar application (% mortality)	
		15DAT	30DAT	15DAT	30DAT	15DAT	30DAT
1	Bb-5a	29.6 c	43.2 b	8.4 c	0.0 c	76.67 a	13.70 bc
2	Bb-45	41.8 b	29.2 c	26.0 b	21.2 b	76.67 a	37.40 ab
3	Ma-4	0.00 d	48.8 a	40.0 ab	0.0 c	70.00 a	44.43 a
4	Ma-35	48.8 a	28.0 c	48.0 a	27.2 a	76.67 a	54.80 a
5	Control	0.00 d	0.00 d	0.00 d	0.00 c	23.33 c	3.33 c

b. Field trial

A field trial was conductedto evaluate theendophytic isolates of *Beauveria bassiana* (NBAIR-Bb-5a and 45) and *Metarhizium anisopliae* (NBAIR Ma-4 and Ma-35) through foliar applications of oil formulations against *Plutella xylostella* in Cabbage(Var. Unnati) at ICAR-NBAIR, Attur Research Farm, Bengaluru during kharif 2019. One foliar spray of the oil formulation of each isolate of *B. bassiana* and *M. anisopliae* ($1 x 10^8$ conidia/ml) was given at 15 days after transplanting. All the 4 isolates tested showed 56.1-93.5% pest reduction over control. Among these, Ma-35 isolate showed 93.5% of pest reduction over control. No significant differences were observed in the yield between treated and untreated control (Table 2).

Table 2. Field evaluation of endophytic entomopathogenic fungi against *Plutella xylostella* in Cabbage

Isolate	Pre count	Post count	% reduction over control	Average yield/5 plants (kg)	Average yield/hectares (kg)
Bb-5a	2.40	0.20[a]	81.30	5.49	87840
Bb-45	2.80	0.47[a]	56.07	5.61	89760
Ma-4	2.60	0.40[a]	62.61	5.59	89440
Ma-35	3.60	0.07[a]	93.46	5.46	87360
Control	3.20	1.07[b]	-	5.28	84480
CD @ 0.05	**NS**	**0.255**	**-**	**NS**	**NS**

1.1.2 Field trials of Entomopathogenic fungi against FAW

At ICAR-NBAIR YelahankaAttur Farm

Field evaluation with *B. bassiana* (ICAR-NBAIR Bb-45) and *M. anisopliae* (ICAR-NBAIR Ma-35) were carried out against *S. frugiperda* in maize (Var. BRMH-1 hybrid) during *Kharif* season (June, 2019 to Sept 2019). Three foliar sprays @ 5g/litre (Talc formulation containing $1x10^{8}$CFU/g) at 15, 30 & 45 days of the crop stage were given. ICAR-NBAIR-Bb-45 and Ma-35 showed 79 and 86% of pest reduction respectively (Table 3).

Table 3. Field evaluation of entomofungal pathogens against Maize FAW at Attur farm (2019-20).

Isolate	Pre count	No. of larvae /plant (3 sprays)	% decrease over control	% Leaves affected	No. of plants affected/ 10Plants	Average yield/10 Plants (Kg)
Bb-45	1.29	0.21[a]	79.0	3.57[a]	1.00[a]	5.34[a]
Ma-35	1.00	0.14[a]	86.0	5.95[a]	0.79[a]	6.16[a]
Control	1.57	1.00[b]	-	21.55[b]	2.57[b]	3.31[b]
CD@5%	NS	0.23	-	1.82	0.37	0.616

Farmers field at Bomanahalli in Chikkaballapur district, Karnataka

Field evaluation with *B.bassiana* (ICAR-NBAIR Bb-45) and *M.anisopliae* (ICAR-NBAIR Ma-35) were carried out in 30 days old crop against *S. frugiperda* in maize(Var. Prince) during *Kharif* season (July-Oct. 2019). Three foliar sprays @ 5g/litre (Talc formulation containing $1x10^8$ CFU/g) at 30, 40 and 50 days of the crop stage were given. ICAR-NBARMa-35 and Bb-45 showed 37.5 and 53.6% of pest reduction respectively (Table 4).

Table 4. Field evaluation of entomofungal pathogens against Maize FAW at Bomanahalli in Chikkaballapur district, Karnataka

Isolate	Pre count	No. of larvae /plant (3 sprays)	% decrease over control	% Leaves affected	No. of plants affected/ 10Plants	Average yield/10 Plants (Kg)
Bb-45	10.00	5.71[a]	37.52	30.90[a]	3.00[a]	5.09[a]
Ma-35	11.71	4.24[a]	53.61	34.78[a]	2.81[a]	6.23[a]
Control	12.29	9.14[b]	-	59.71[b]	5.24[b]	3.10[b]
CD@ 5%	NS	0.958	-	0.413	0.321	0.296

1.1.3 Evaluation of *Trichogramma pretiosum* (Th) and *Telenomus remus* against FAW eggs.

When FAW eggs were exposed to both parasitoids, *T. remus* resulted in 92.73 percent parasitism and *T. pretiosum* caused 45.51 percent parasitism. Percent adult emergence in case of *T. remus* was 95.01 percent while 68.13 percent adults were emerged from *T. pretiosum* parasitized FAW eggs.

Trichogramma pretiosum (Th) was released (four releases @ 50,000/ha) in FAW infested field at Chikballapur, Karnataka along with other IPM interventions (pheromone traps, entomopathogenic fungi and entomopathogenic bacteria) and resulted in 76.14 percent reduction in FAW egg mass at 60 days after first release.

1.1.4 Survey and collection of diseased larvae of fall armyworm, *S. Frugiperda*

Surveys were conducted in various parts of Tamil Nadu and Karnataka to collect the diseased larvae of *S. frugiperda*. Totally eight insect samples were collected out of which seven (Fig 1) were collected from Chikkaballpura, Karur, Ariyalur, Erode, Royakottai and Palakode areas from maize crop and one collected from sorghum crop. Nucleopolyhedroviruses (NPVs) have been extracted from all the samples and the occlusion bodies of NPV were observed under phase contract light microscope.

Table 5. Survey and collection of *S. frugiperda* diseased larvae

S.No.	Location	Crop	No of samples
1	Chikkaballapur	Maize	2
2	Karur	Maize	1
3	Ariyalur	Maize	1

4	Erode	Maize	1
5	Royakottai	Maize	1
6	Palakode	Sorghum	1

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

1.1.5 Field evaluation of bio-efficacy of SpfrNPVagainst fall armyworm

Field evaluation of *Spodoptera frugiperda* NPV (SpfrNPV) against maize armyworm *Spodoptera frugiperda* was carried out at Chikkaballapura, Karnataka. All the three concentrations of NPV (1.5×10^{12} POBs/ha, 1×10^{8} POBs/ha ,1×10^{4} POBs/ha) were found effective in reducing the larval population of armyworm. The number of larvae recorded for all the concentrations ranged from 4.55 to 6.76 where as it was 1.85 in the insecticide (Emamectin benzoate@ 0.4g/l) treated plots. The concentration 1.5×10^{12} POBs/ha was found most effective in reducing the larval numbers from 38.35 to 4.55 followed by concentration 1×10^{8} POBs/ha which reduced from 39.15 to 6.45. Insecticidal treatment reduced the larval numbers from 42.05 to 1.85 (Table 6).

Table 6. Field evaluation of bio-efficacy of SpfrNPV against maize FAW at Chikkaballapur

Concentrations (POBs/ha)	**No of larvae/ 10 plants**			
		Days after treatment		
	Pretreatment (20 days after sowing)	**3**	**5**	**7**
1.5×10^{12}	38.35	25.85	10.50	4.55
1.5×10^{8}	39.15	22.10	12.75	6.45
1.5×10^{4}	36.50	20.50	11.25	6.76
Emamectin benzoate (0.4 g/l)	42.05	12.50	6.55	1.85

Untreated control)	39.73	36.13	30.25	23.25
CD (P= 0.05)	--	5.68	4.02	3.23

1.1.6 Natural enemies of Fall armyworm

During survey, naturally infected or parasitized larvae of FAW were collected. From the eggs of fall armyworm an egg parasitoid, *Trichogramma* sp. and *Telenomus* sp. was collected. However, natural parasitism of larval parasitoids, *Campoletis chlorideae*, *Chelonus* sp., *Cotesia* sp., *Phenerotoma* sp., and *Eriborus* sp was recorded on the larval stage of fall armyworm. The natural infection of entomopathogenic fungi, *Metarhizium rileyi* (= *Nomuraea rileyi*) was also recorded on different larval stages of fall armyworm. Several parasitoids were obtained from fall armyworm from Karnataka which included, *Trichogramma* sp. *Trichogramma pretiosum*, *Telenomus remus*, egg larval parasitoidChelonus sp. and larval parasitoids like *Glyptapanteles creatonoti*, *Apanteles creatonoti*, *Campoletis chlorideae* and several predators like earwig Forficulasp, predatory bugs like *Andrallus spinidens*, *Eocanthecona furcellata* were recorded for the management of fall armyworm. In addition, one dipteran parasitoid*Pseudgourax* sp was recorded on the egg mass of fall armyworm. The maggots were found feeding on the eggs thereby showing a potential for management of FAW.

1.1.7 Mass rearing of C*helonus* sp, an egg – larval parasitoid of fall armyworm *Spodoptera frugiperda*

Chelonus sp. an egg – larval parasitoids were recorded frequently from field samples collected from different districts of Karnataka since March, 2018 incidence of fall army worm *Spodoptera frugiperda* was reported and was alerted across the country. The parasitoid specimens were processed for both morphological and molecular identification and the genus was confirmed as *Chelonus* (Fig. 2). Species level identification of these parasitoids are in progress. Adults of *Chelonus* sp. (a) were exposed to the eggs of natural host, *S. frugiperda*, *Spodoptera litura* and on laboratory host, *Corcyra cephalonica* for a time period of 48 hours at a temperature of 25 ± 2°C and 65± 5% RH. The hatched neonates were reared on artificial diet media. Adult longevity varied from 2 to 7days. Developmental period was found to be 20 to 25 days on natural host and 25 to 50 days in Corcyra. Percent parasitism was 10 to 19.4% and 45 to 57.5 % of adults successfully emerged from the cocoons reared on natural host whereas 85 to 98% adult emergence was recorded from Corcyra eggs. Successful rearing on Corcyra eggs enabled mass rearing and release of *Chelonus* sp, for management of fall armyworm in maize during monsoon and post monsoon season in different villages of Karnataka.

Small &Arrehenotokous **Big &Arrehenotokous**

Fig 2. Two different species of egg larval parasitoid *Chelonus*sp collected from Karnataka

1.1.8 Pentatomid predators – a potential biocontrol agent of *S. frugiperda*

Pentatomid predators, *Eocanthecona furcellata* and *Andrallus spinidens* were reared on different hosts like *Spodoptera frugiperda*, *S. litura*, *Samia Cynthia ricini* and *Corcyra cephalonica* in the laboratory conditions. The predatory potential and numerical response of *E. furcellata* and *A. spinidens* on fall armyworm, *S. frugiperda* was studied (Fig.3). Peak population of *E. furcellata* was observed during the 38th and 39th standard meteorological week from V9 to V15 stages. Both the predators were easily amenable for mass production and can be effectively used in management of fall armyworm through augmentative techniques.

Fig. 3 *Eocanthecona furcellata*

1.1.9 Natural parasitism of *Trichogramma chilonis* on *Spodoptera frugiperda* infesting maize and sorghum

A total of 1035 eggs were collected from the maize field from 15 day after sowing to till harvesting of crop. The natural parasitisation of eggs of fall armyworm by *Trichogramma chilonis* ranged from 17.90 to 44. 50 % in maize (Fig. 4). A total sixteen populations of *T. chilonis* were collected from FAW eggs from the different locations in Karnataka. In Maharashtra, The natural prasitisation range between 7 to 18% in maize. Six populations of *T. chilonis* on FAW were collected from Maharashtra on FAW eggs in maize and sorghum.

Fig 4. Fall armyworm eggs parasitized by *Trichogramma chilonis*

Trichogramma chilonis

1.1.10 Egg parasitoids of *Spodoptera frugiperda*

Field parasitism by egg parasitoids, *Trichogramma chilonis* and *Telenomus remus* was studied in maize. The percent parasitisation by both the parasitoidswas 33.5%, however greater parasitisation of eggs of *S. frugiperda* was recorded by *T. chilonis* compared to *T. remus* in maize.

1.1.11 Evaluation of indigenous and exotic Trichogrammatids against *Spodoptera frugiperda*

Six strains of Trichogrammatids *viz.*, *Trichogramma pretiosum* (thelytoky), *T. pretiosum* (thelytoky-France), *T. pretiosum* (arrhenotoky-Germany), *Trichogramma chilonis* (collected on FAW), *T. chilonis* (laboratory) and *Trichogrammatoidea armigera* were evaluated against fall armywormin the laboratory. Results showed that *T. pretiosum*(thelytoky) and *T. chilonis* (collected on FAW) parasitised 17.60 ±0.74 and 25.90 ± 1.88 eggs of *S. frugiperda*, respectively.

1.1.12 Evaluation of entomopathogenic bacteria against *S. Frugiperda*

Attempts were made to identify and develop indigenously isolated *Bt*for FAW management. Extensive surveys were conducted in the southern states of Karnataka, Tamil Nadu and Andhra Pradesh to collect the infected larvae. Initially there was no *Bt* infected larvae present as farmers used pesticides. However subsequent collections yielded few infections and *Bt*was isolated, purified as per standard protocols. The *Bt*isolate was tentatively identified as NBAIR-BT25 (GenBank MN327970) and the culture was also certified by ICAR-NBAIM, Mau (MN203620.1). *In vitro* studies showed that *B.thuringiensis* NBAIR-BT25 incited 100% mortality at 48h after treatment. The LC50 was worked out to be 44.72 µg/ml.

1.1.13 Field evaluation of liquid formulation of ICARNBAIRBT25 against fall armyworm

Field evaluation of *B. thuringiensis* NBAIR-BT25 was carried out against *S. frugiperda* in maize during *rabi* season in 2018 &*kharif* in 2019 at Bengaluru and Chikkaballapur in Karnataka. There was 69.4% reduction in pest damage after two sprays at farmer’s field in Chikkaballapur. At NBAIR research farm, NBAIR-BT25 recorded 81% decrease in pest based on larval mortality.

Area coverage

Bacillus thuringiensis (ICAR-NBAIRBT1) isolate was evaluated in different maize growing areas of the country covering an area of 40 hectares in Karnataka and AndhraPradesh.

1.1.14 Evaluation of indigenous EPN species against *Spodoptera frugiperda*

Efficacy of five indigenous EPNs, *Heterorhabditis indica*, *H. bacteriophora*, *Steinernema carpocapsae*, *S. abbasi* and *S. siamkayai* was tested against larvaland pupal stages *S. frugiperda*under laboratoryconditions. The results revealed that both thirdand fourth instar larval stages of *S. frugiperda* were susceptible to all five EPNs species tested andthird-instar larval stages were more susceptiblethan fourth-instar larvae. When a dose of 600 IJslarva–1 was applied, the greatest mortality of third instarlarvae was observed for *H. indica*(100%), *H. bacteriophora*(87%), *S. carpocapsae*(100%) and *S. abbasi*(93%), and the lowest was observed for *S. siamkayai*(66.7%). In case of fourth-instar larvae, the greatest mortality was observed for *H. indica*(100%), *S. carpocapsae*(96%) and *H. bacteriophora*(75%) and the lowest was observed for *S. siamkayai*(40%). The mortality percentage in third and fourth instar larvae of FAW increased significantly with the increase in the IJ concentrations of all EPN species. When pupalstages of *S. frugiperda*treated with 600 IJs pupa-1 at the greatest mortality was observed *H. indica* (85%), *H. bacteriophora* (60%), *S. carpocapsae* (65%) and *S. abbasi* (35%), and the lowest was observed for *S. siamkayai* (15%). The mortality percentage in pupal stages of *S. Frugiperda* in creased significantly with the increase in the IJ concentrations only for *H. indica* and *S. carpocapse.*

1.1.15 Evaluation of entomopathogens biopesticides for the management of sucking pest *Thrips palmi* in watermelon var. Arkamanik and suppression of watermelon bud necrosis tospovirus under field conditions

Effective use of entomopathogens biopesticides under field conditions viz., *Metarhizium anisopliae* strain NBAIR-MaCB, *Pseudomonas fluorescens* strain NBAIR-PFDWD and *Bacillus albus* strain NBAIR-BATP either individually or in consortia form effectively manage *Thrips palmi* on watermelon compared to untreated control. These biopesticides is on par with the chemical control imidacloprid but the yield was at appreciable level in *B. albus*, followed by *P. fluorescens,* chemical check and *M. anisopliae*. Consortia of *B. albus* with *P. fluorescens* is very effective in *T. palmi* management compared to other consortia.

Management of *T. palmi* is in correlation with the suppression of watermelon bud necrosis tospovirus in watermelon. Figure 1 shows the representative image of biopesticides treated watermelon and control treatment shows the typical symptoms of watermelon bud necrosis tospovirus in watermelon. So, this biopesticides experiment clearly indicated the suppression of *T. palmi* and watermelon bud necrosis tospovirus in watermelon under field conditions.

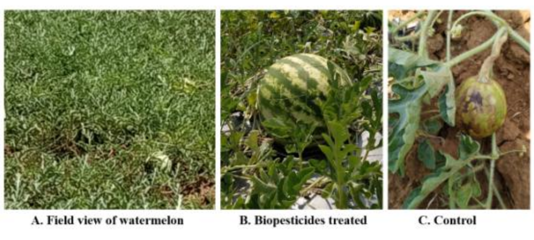


Fig. 5. Representative image to show field evaluation of entomopathogens biopesticides against *Thrips palmi* on watermelon

1.1.16 Evaluation of entomopathogens biopesticides for the management of sucking pest *Thrips hawaiiensis* in export quality of *Gerbera jamesonii* var. Faith under polyhouse conditions

Severe infestation of *Thrips hawaiiensis* was observed in export quality of *Gerbera jamesonii*var Faith under polyhouse conditions. Export quality flowers was severely affected by *T. hawaiiensis* as seen in representative image from control plots. Application of *P. fluorescens* strain NBAIR-PFDWD and *B. albus* strain NBAIR-BATP and its consortia effectively reduced the *T. hawaiiensis* from the count of 45 per plant to 6 per plant within three days after application of biopesticides. After four applications of biopesticides at the weekly intervals thrips population were significantly reduced and quality of the flowers was retained to the appreciable level under polyhouse conditions.

A. Polyhouse view of Gerbera sp. **B. Biopesticides treated** **C. Control**

Fig. 6. Representative image to show polyhouseevaluation of entomopathogensbiopesticides against *Thrips hawaiiensis* on *Gerbera jamesonii* var. Faith under polyhouse conditions

1.1.17 Field efficacy of EPN formulations for the management of FAW in maize

- Field trial on doses, efficacy in combination synthetic insecticides and formulations of EPN against FAW (Kharif 2019-20) indicated dose dependent control of FAW larvae with an optimum dose of 4-6kg/ha either in the form of WP or granular formulation of *Heterorhabditis indica* NBAII Hi101; split doses and combination of *H. indica* with emamectinbenozoate at split doses could protect the crop upto 80-88% (Fig. 7 a,b,c). Another field trial in Pachora, Maharashtra in black cotton soils indicated application of WP formulation of EPN to plant root zone in combination with whorl application in the first fortnight followed by split dose 30 days later prevented secondary infestation of field populations of FAW.

Fig. 7 a. Maize treated with wettable powder of *Heterorhabditis indica* NBAII Hi101 (Red arrow shows damaged leaf at the 3-4 leaves from top; yellow arrow shows healthy and undamaged cobs).

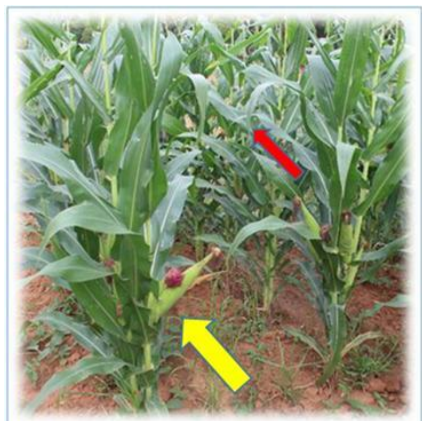


Fig 7 b. Maize treated with granular formulation of *Heterorhabditis indica* NBAII Hi101 (Red arrow shows damaged leaf at the 3-4 leaves from top; yellow arrow shows healthy and undamaged cobs).

Fig 7 c. Maize treated emamectin benzoate as chemical check. (Red arrow shows damaged leaf at the 3-4 leaves from top; yellow arrow shows healthy and undamaged cobs).

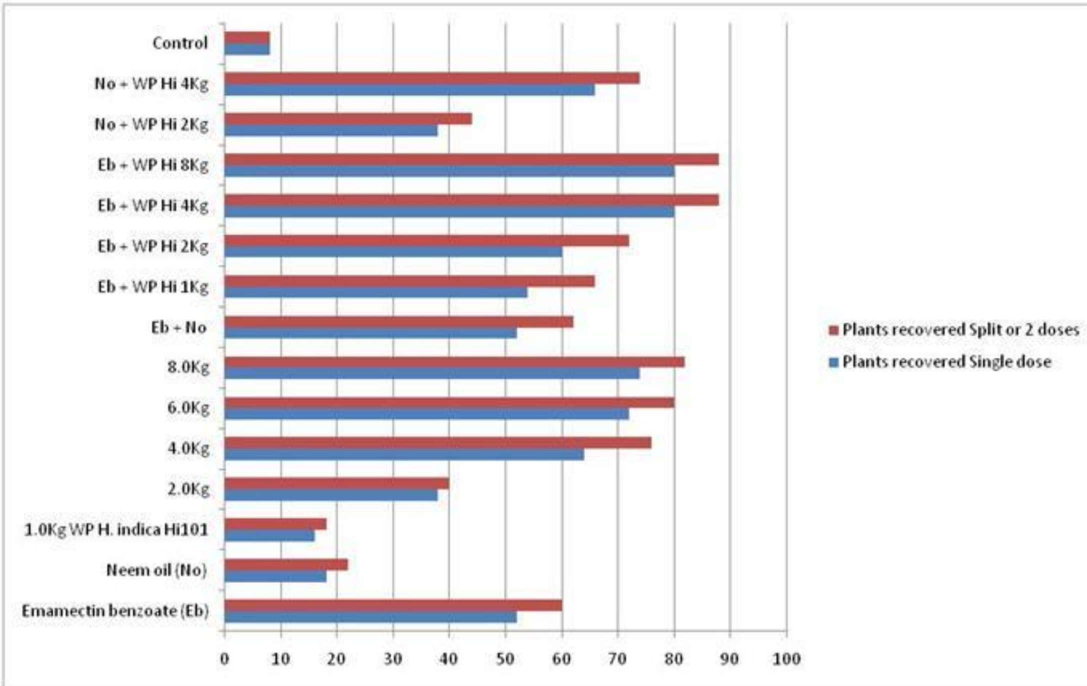


Fig. 8. Field evaluation of WP *H. indica* combinations with insecticides and their dosages (2019-20).

1.2 Reports from different centres

1.2.1 YSPUHF, Solan

Biodiversity of biocontrol agents from various agro-ecological zones of HP on fruits and vegetables

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Rekongpeo, Pooh, Bajaura,Mandi, Ghumarwin, Palampur, Solan,Sarahan, Naina Tikkar Kufri, Theog, Chhella, Kotkhai, Powari, Kangosh, Hurling, Kaja of districtsBilaspur, Mandi, Kullu, Solan, Sirmaur, Shimla,Kangra, Kinnaur and Lahaul & Spiti.	Aphids, mites, whiteflies and scale insects occurring on apple, apricot, peach, plum, almond, tomato, cucumber, brinjal, okra,cabbage, cauliflower, maize, capsicum, and wild flora	*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 *Hyselia sanscrita*
Nauni,Nainatikkar andSarahan, Rekongpeo, Powari, Kangosh, Hurling and Kaja	Aphids and whiteflies occurring on Apple, peach and cucumber	*Chrysoperla zastrowi sillemi*
Nauni, Solan, Nainatikkar, Sarahan,Rekongpeo, Bajaura, Powari, Kangosh, Hurling, Kaja	Different flowering plants	*Episyrphus balteatus, Eupeodes frequens, Melanostoma univitatum, Betasyrphus serarius, Sphaerophoria indiana, Ischiodon scutellaris, Metasyrphus confrator*
Nauni, Bajaura and surroundings	Phytophagous coccinellids such as *Coccinella septempunctata, Hippodamyia variegata* on vegetable and fruit crops	*Dinocalpus coccinellae*
Nauni, Rekongpeo and surroundings	Cauliflower and cabbage	Parasitoids of diamondback moth, *Diadegma semiclausum* and *Diadromus collaris*
Nauni and surroundings, Rekongpeo	Peach leaf curl aphid and thrips	Anthacorid predators, *Orius* sp and *Anthocoris* sp
Nauni, Nainatikkar, Sarahan, Mandi, Bajaura	Tomato leafminer	*Nesidiocoris tenuis, Neochrysocharis formosa*
Nauni	Vegetable leaf eating beetles	Shield bug, *Zicrona caerulea*

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 at Nauni.

I.2.2 IGKV, Raipur

Table 7. Coccinellid and reduvid predators from various crop ecosystems of Raipur

S.No.	Name of the natural enemy	
1.	***Menochilus sexmaculatus* (F.) from cowpea**	
2.	***Coccinella transversalis* (F.) from cowpea**	
3.	***Illeis cincta* (F.) from okra (New Record)**	
4.	***Coranus* sp.**	
5	***Rhynocoris fuscipes***	

6	***Scadra* sp.**	
7	***Acanthaspis siva***	

1.2.3. PJTSAU, Rajendranagar, Hyderabad

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Khammam, Adilabad, Warangal, and Nalgonda, Rangareddy, districts	Mealy bugs, *viz.*, *Paracoccus marginatus*, *Maconellicoccus hirsutus*, *Phenacoccus solenopsis*, and *Ferrisia virgata* and *Amrasca biguttula biguttula* on cotton	*Coccinella septumpunctata*, *Cryptolaemus montrouzieri*, *Chrysoperla* sp.

1.2.4. UBKV, Pundibari

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Pundibari, District – Coochbehar	Tea mosquito bug (*Helopeltis* sp.), Tea looper (*Hyposidra talaca*), Tea jassid (*Empoasca flavescens*), Tea aphid (*Toxoptera aurantii*) and Red spider mite (*Oligonychus coffeae*) on tea	*Calosoma* (Ground beetle), *Chrysoperla*, Dragon Fly, *Forficula* (Earwig), *Rhynocoris*, *Mantis* and *Coccinella*, *Cotesia* sp., *Ichneumon* sp. and *Trichogramma* sp.

Pundibari, District – Coochbehar,	Stem Borers, Green Leafhoppers, Brown Planthoppers, Gundhi Bugs, Gall Midge, Hispa, Leaf folder, Caseworm on rice	*Coccinella*, *Micraspis*, *Cyrtorhinus* and Spiders, *Trichogramma, Tetrastichus, Telenomus, Chelonus, Bracon* and *Platygaster* spp.
Pundibari, District – Coochbehar	Mustard Aphid, Leaf Miner and Diamond back moth on cole crops	*Eupeodes* (Hover fly), *Coccinella* (*C. Septempunctata* and *C. transversalis*) *Cheilomenes*, *Chrysoperla* and Spiders

1.2.5. TNAU, Coimbatore

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Coimbatore, Tirupur, Erode, Theni, Thajavur, Cuddalore, Kanyakumari, Tiruvarur, Tirunelveli and Dindigul	Natural enemies of rugose spiralling whitefly, *Aleurodicus rugioperculatus*	The parasitisation by *Encarsia guadeloupae* ranged between 25.00 and 72.00 per cent on coconut gardens and a predator *Mallada boninensis* was seen in all the ccoconut gardens (Table-1). Besides *E. guadeloupae* and*M. boninensis*, Many predators *viz.*, *Cybocephalus* spp., *Cryptolaemus montrouzieri* Muls., *Chilocorus nigrita*(Fabricius), *Cheilomenes sexmaculata* (Fab.), *Curinus coeruleus* (Mulsant), *Mallada astur* (Banks),*Chrysoperla zastrowi sillemi* (Esben – Petersen), praying mantis and spiders were also recorded as natural enemies of *A. rugioperculatus* in Tamil Nadu.
Coimbatore district *viz.*, Pichanoor, Patchapalayam, Thekarai and Thudiyalur.	Natural enemies of *Tuta absoluta* on tomato	Nil
Coimbatore, Erode, Tiruppur, Salem, Karur, Villupuram, Karur, Cuddalore and Namakkal	Papaya mealybug	*Acerophagus papaya* and *Cryptolaemus montrouzieri* have been found in all papaya and cassava fields while *Pseudleptomastix Mexicana* was seen in Cassava fields at Kalkurichi, Namakkal District
Different agro-ecological zones of Tamil Nadu	Different crops and pests	The natural enemies *viz.*, *Trichogramma* sp., *Cryptolaemus montrouzieri*, *Chrysoperla zastrowi sillemi* on papaya mealybug, *Trichogramma chilotrae* and *Chelonus sp* on maize fall army worm,

		Mallada boniensis on coconut trees infested with rugose spiralling whitefly, *C. montrouzieri*, and *Chrysoperla zastrowi sillemi* on mealybug, scales, whiteflies, psyllids infesting the crops namely tapioca, papaya, brinjal, bhendi, curry leaf and coconut. *Dipha aphidivora* and *Micromus igorotus* on sugarcane woolly aphid.

1.2.6 OUAT, Bhubaneswar

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
OUAT, Bhubaneswar	Paddy (Var. Swarna)	*Araneus* sp., *Pardosa* sp., *Argiope catenulata, Tetragnatha* sp., ?*Larinia* sp., *T. javanica, Oxyopes ?bharatae,*

1.2.7. MPKV, Pune

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
Pune	maize, soybean, sugarcane, tomato and brinjal	*Chrysoperla zastrowi sillemi*, *Mallada boninensis, Coccinella septempunctata* L. and *Menochilus sexmaculata*
Pune	*S. litura* on soybean and cabbage	*Metarhizium rileyi* from the diseased cadavers,
Pune	FAW on maize	Sofr NPV from the diseased cadavers
Pune	S. litura and H. armigera on soybean, cabbage, pigeoppea, capsicum, tomato	SpliNPV, HearNPV
Pune	Mango hoppers	*M. anisopliae*
Pune	Sugarcane woolly aphid	The natural enemies like *D. aphidivora* (1.00 to 2.00 larvae/leaf), *M. igorotus* (1.00-3.00 grubs/leaf), syrphid *Eupoderes confrater* (0.60-1.00 larvae/leaf) and spider (0.60-1.00/leaf) were observed during April, 2019 to February, 2020. The parasitoid, *Encarsia flavoscutellum* found distributed and well established in almost all sugarcane fields and suppressed the SWA incidence in Western Maharashtra.
Pune	Papaya mealybug	The encyrtid parasitoid, *Acerophagus*

		papayae was found parasitizing the mealy bugs in almost all the papaya orchards surveyed. It was ranged from 0.00 to 2.5 adults / leaf and it is density dependent.

1.2.8. MPUAT, Udaipur

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
Udaipur district [Vishma, Hyla (Sayara), Veerpura, Pilader (Jaisamand), Dabok, Mavali, Fatehanagar and Vallabhnagar	maize,gram and tomato	*Cheilomenes sexmaculata*, *Coccinella septempuctata*, *Chrysoperla carnea*, *Brumoides suturalis*, rove beetles, syrphid flies, Cotesia flavipes, Campolites chrloidae,

1.2.9. IIVR, Varanasi

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
IIVR, Experimental farm, Varanasi	Tuta absoluta on tomato	*Nesidiocoris tenuis* (maximum 3.7 bugs / apical twigs)

1.2.10. IIRR, Hyderabad

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
ICAR - Indian Institute of Rice Research, Hyderabad and Nalgonda district of Telangana,	Rice	*Pardosa pseudoannulata*, *Oxyopes salticus*, *Araeneus inustus*, *Tetragnatha javana*, *Tetragnatha maxillosa*, *Tetragnatha nitens*, *Plexippus* sp., *Bianor* sp., *Argiope catalunata*, *Olios* sp., and *Thomisus* sp. The wolf spider *Pardosa*(1.25/ trap) was the most abundant in pitfall traps while *Tetragnatha* spp., (3.14) were dominant in sweep nets.

1.2.11. IIMR, Hyderabad

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
IIMR, Hyderabad	Shoot flies on barnyard, proso, little and kodo millets	Egg parasitoid Trichogrammatoidea simmondsi (20 %); Larval parasitoid, *Neotrichoporoides nyemitawus* (18.0 %) and pupal parasitoid , Spalangia endius (10%) were found parasitizing shoot flies across species and millets.

1.2.12. CISH, Lucknow

Biodiversity of bio-control agents from mango ecosystem was observed during reproductive phase of the crop at the Institute experimental farm. Among the natural enemies, spider population was elevated during 20th SMW with 0.4 / tree. Coccienellids inhabitants were found as high as 3.45 adults/ tree at some point in 15th SMW. Coccinellids *viz*., *Coccinella septempunctata* Linn. *Cheilomenes sexmaculata* Fab. *Chilocorus rubidus* Hopeand *Scymnus* sp. were observed feeding on mango hoppers; amongst most abundant and spectacular was *Coccinella septempunctata.* Peak population of Hoverflies were observed through 19th SMW, registering with 4.8/tree, and peak Chrysopid population was noticed during 17th SMW which was recorded 1.7 adults /tree (Table 8).

Table 8. Co-existing predator population and their dynamics with the pest population in mango ecosystem during 2019

SMW	Hopper (No./ panicle/ sweep)	Thrips (No./trap)	Spider (No./tree)	Coccinellids (No./tree)	Hoverflies (No./tree)	Chrysopids (No./tree)
10	0.80	0.00	0.20	0.00	0.00	0.00
11	4.65	0.00	0.25	0.0	0.00	0.00
12	3.80	0.00	0.20	0.00	0.00	0.00
13	4.45	0.00	0.20	0.30	0.00	0.00
14	3.95	8.25	0.25	0.30	0.80	0.00
15	13.50	8.55	0.30	3.45	2.40	0.00
16	6.60	0.50	0.20	2.20	3.50	0.80
17	6.45	55.60	0.35	0.00	2.60	1.70
18	9.15	21.00	0.25	0.00	4.50	0.50
19	8.35	21.75	0.25	0.00	4.80	0.00
20	3.10	52.20	0.40	0.00	1.80	0.00
21	7.75	50.40	0.35	0.00	1.50	0.00
22	8.60	26.50	0.30	0.00	0.25	0.00

23	1.70	24.00	0.35	0.00	0.00	0.00
24	3.95	14.55	0.35	0.00	0.00	0.00
25	2.10	16.70	0.30	0.00	0.00	0.00

Reduviid predators are the largest terrestrial bugs considered to be potential bio-control agents. This predator belongs to the genus *Sycanus* sp., an assassin bug, was observed in mango ecosystem. The predators are potentially predating on the larvae of mango leaf webber and mango semiloopers in field conditions. In laboratory studies it was found that single adult bug can predate 2-3 rice moth larvae/ hour.

1.2.13. NCIPM, New Delhi

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
Fazilka, Muktsar, Bathinda and Mansa districts of Punjab, Sirsa and Hisar districts of Haryana	Cotton	Among natural enemies predators Chrysopid and spiders were the dominant. Population of Coccinelid beetles was not found in most of the fields. Maximum population (mean of all locations) of Chrysopids (egg/larvae per plant) was observed in the month of July (2.22±0.52) followed by June (1.97±0.61), Aug (1.94±0.43), Oct (1.48±0.14) and 0.97±0.18. Among all locations Chrysopid population (mean of the season) was maximum in Muktsar (2.07±0.91) followed by Sirsa (1.71±0.75), Sriganganagar (1.64±0.43), Hanumangarh (1.63±0.36) and Fazilka (1.53±0.44). Spider (adults/spiderlings per plant) population (mean of all locations) was maximum in the month of Oct (0.87±0.19) followed by Sep (0.75±0.21) and Aug (0.44±0.15) July (0.34±0.21). In the month of June Spider population was not found in cotton fields. Among all locations spider population (mean of the season)was maximum in Sriganganagar (0.55±0.47) followed by Fazilka (0.53±0.37), Sirsa (0.50±0.29) Hanumangarh (0.45±0.45) and Muktsar (0.36±0.26).In the beginning of the season spider population was absent but it starts build up from July onwards and reached maximum at the end of the

		season. Population of Chrysopids were present in large numbers from the beginning of the season and continue throughout the season.
Fazilka, Muktsar, Bathinda and Mansa districts of Punjab, Sirsa and Hisar districts of Haryana	Cotton whitefly	Mean (average of the season) parasitization (per cent) of whitefly nymphs by *Encarsia* spp or other parasitoids was recorded maximum in Muktsar (33.85, Range 25.00 – 57.14) followed by Sirsa (29.650 Range 12.50-40.90), Fazilka (29.28 range 18.11-39.42), Sriganganagar (26.57; range 12.33-38.46) and Hanumangarh (25.40 range 14.71-37.93).Overall average of all locations indicates that parasitisation fluctuated between 2.34 to 27.83 per cent which was maximum in August and minimum in October.The study clearly indicated that the heavy parasitization of whitefly by *Encarsia* and other species of parasitoids and natural control by predators 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.

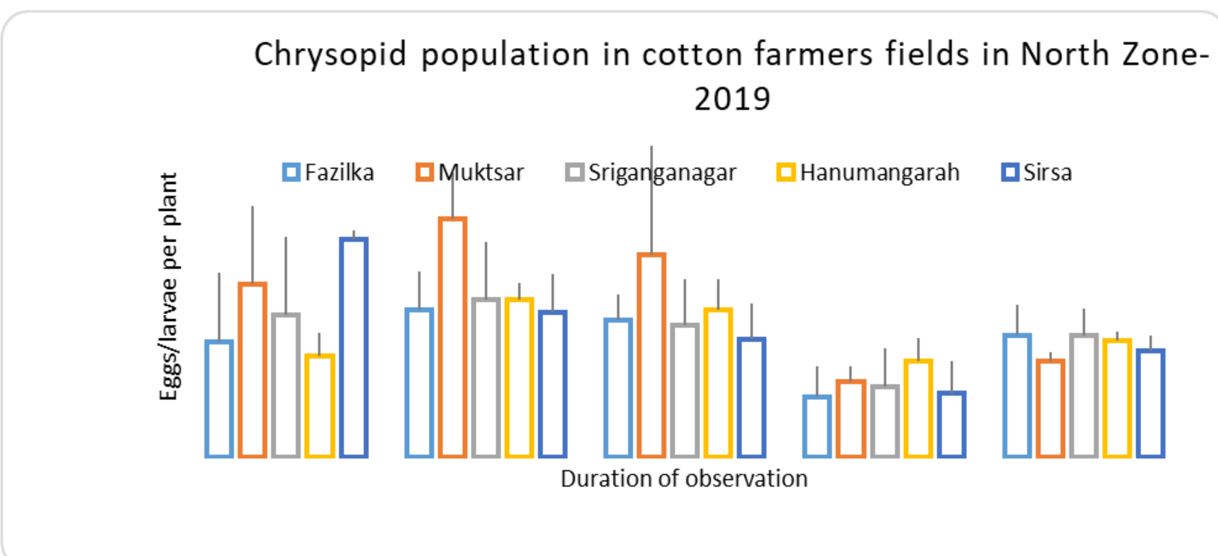


Fig 9. Chrysopid population in cotton

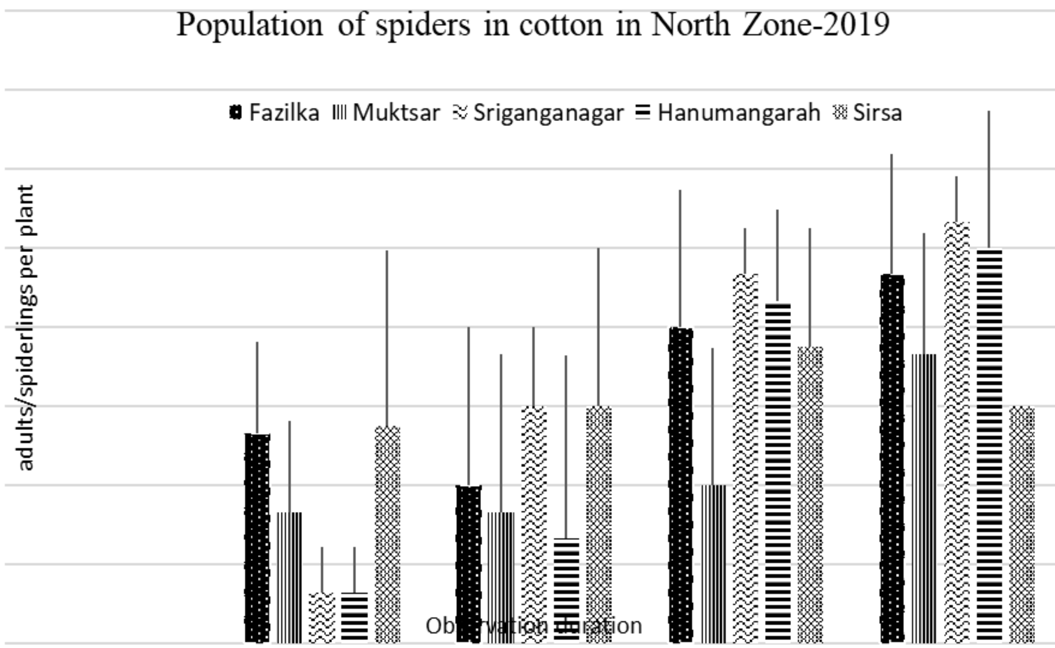


Fig 10. Spider diversity in cotton

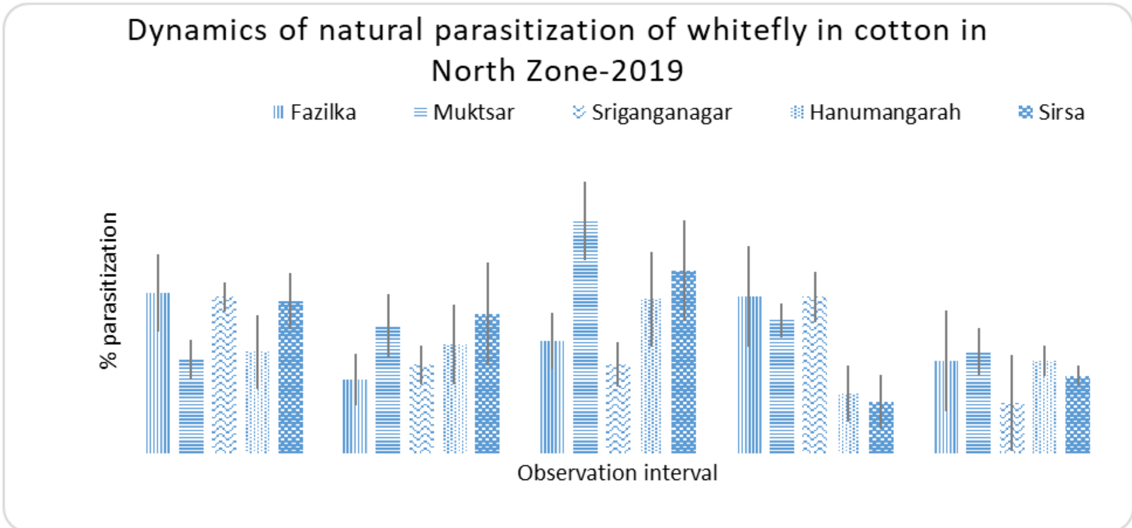


Fig 11. Parasitization of whitefly nymphs by *Encarsia spp* in cotton in different districts in north zone

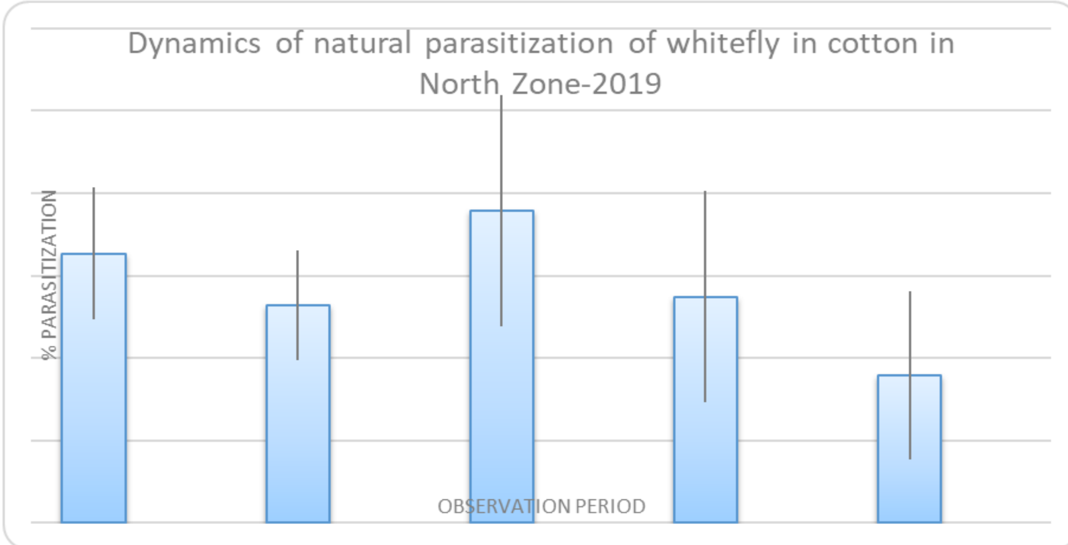


Fig 12. Parasitization of whitefly nymphs by *Encarsia spp* in cotton in north zone

Fig 13. *Encarsia spp pupae and* Adult (parasitoids of whitefly)

1.2.14. AAU, Anand

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
Middle Gujarat	Cotton, okra, maize, rice, tomato	*Trichogramma chilonis* was the major *Trichogrammatid* recorded. *Trichogrammatoidea bactrae* was observed in cotton field during 2nd and 4th installation. Geographical population of green lacewing was collected. *Chrysoperla zastrowi sillemi* (Esben-Petersen) was found in all the populations. *Cheilomenes sexmaculatus* Fabricius was found to be the predominant coccinellid species. The spiders belonging to five families namely Araneidae, Oxyopidae, Salticidae, Tetragnathidae and Thomisidae were recorded. Out of 86 specimens, 29 turned to be *Agriope* sp. and 31 were *Neoscona theisi*.
Various locations of Gujarat	Soil samples from different crop eco-systems	Four strains of *Metarhizium* sp. and six EPN isolates were recovered from soil sampleshave been isolated and identified. During the survey of invasive pest *Spodopetra frugiperda,* NPV infected larvae were collected. NPV occlusion bodies (OBs) were isolated and pathogenicity of the virus was confirmed. Further studies on *Sf*NPV are under progress.

1.2.15. DRYSRHU, Ambajipeta, AP

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
Various places in AP	Rugose whitefly *Aleurodicus rugioperculatus* in coconut	Nil population of parasitoid *E. guadeloupae* and low population of predators spiders (0.25/ per four leaf lets) and predator *Dichochrysa astur* (0.50/ per four leaf lets) was recorded under natural conditions

1.2.16. AAU, Jorhat

Site of collections	**Crop eco-system surveyed and the host insects**	**Biocontrol agents observed**
Neul Gaon, Dangdhara, Uttar garumora, Ahom Gaon and Dhekor gora cipahikhola of Jorhat Dt.	Rice	Spiders: Highest number of spider population (0.8 to1.4 spider/ m^2) was recorded in rice fields. Altoghether, 138 numbers of spiders from 6 different families (Lycosidae, Oxyopidae, Tetragnathidae, Araneidae, Uloboridae and Salticidae,) were collected from different rice fields. The predominant spider was *Lycosa pseudoannulata* (48) followed by *Oxopes javanus* (32) and *Tetragnatha* sp.(28) and they were active throughout the cropping season. It was observed that out of different predators and parasitoids, spiders were the dominant one and occupied major status in rice ecosystem followed by the pest insects
	Vegetables	In vegetative and reproductive growth stage of rice crop, more number of odonates(dragonfly and demselfly), was observed. Out of 56 numbers of collected species of odonates, the most dominant damselfly and dragonfly species were *Agrionemisfemina* (22) and *Brachythemis contaminate* (18)in all rice growing areas. Eighty two numbers of coccinellids predators were recorded from August to Nov' 2019 from rice field and the major predators were *Micraspis discolor, Micrapsis crocea, Harmonia octomaculata and Chilomenes sexmaculatus.* However, *M. discolor* was more compared to other predators collected from rice fieldand it was the most predominant in rice ecosystem. Apart from these, other predators and parasitoids (emerged from eggs and larvae) associated with rice crop was low in their abundance

Table 9. Natural enemies (Class: Arachnida) of the rice ecosystem

Species	Family	Collected Species (Total)	Period of activity	Relative abundance (%)
Lycosa pseudoannulata	Lycosidae	48	Throughout the cropping season	34.78 (+++)
Oxyopes javanus	Oxyopidae	32	Throughout the cropping season	23.19(+++)
O.shweta	Oxyopidae	4	Throughout the cropping season	2.89 (+)
O. lineaptis	Oxyopidae	1	Throughout the cropping season	0.73(+)
Tetragnatha sp.	Tetragnathidae	28	Throughout the cropping season	20.28(+++)
Argiope catenualata	Araneidae	17	August-Sept--October	12.31(++)
Neoscona thesi	Araneidae	2	August-Sept--October	1.49 (+)
Araneus sp.	Araneidae	1	August-Sept--October	0.73(+)
N. bengalensis	Araneidae	2	August-Sept--October	1.44(+)
Uluborus sp.	Uluboridae	2	Oct --Nov.	2.17(+)
Telamonia sp	Salticidae	1	Oct--Nov	1.44(+)

Table 11. Natural enemies (Class: Insecta) of the Rice ecosystem

Arthropod groups	Common name	Scientific name	Relative abundance
Order:Odonata			
Coenagrionidae	Damselfly	*Agrionemis femina*	+++
Libellulidae	Dragonfly	*Brachythemis contaminate*	+++
Order: Coleoptera			
Anthicidae	Lady beetle	*Micrapsis discolor*	+++
	Lady beetle	*M. crocea*	++
	Lady beetle	*Harmonia octomaculata*	++
	Lady beetle	*Chilomenes sexmaculatus*	+
Order: Hemiptera			
Miridae	Plant bug	*Cyrtorhinus lividipennis*	+
Order:Diptera			
Tachinidae	Tachinid fly	*Strumiopsis inferens*	+
Order:Hymenoptera			
Bracoinidae	Braconid wasp	*Cotesia* (*Apanteles*) *angustibasis*	++
Eulophidae	Eulophid wasp	*Tetrastichus schoenobii*	+
Trichogrammatidae	Trichogrammatid	*Trichogramma japonicum*	+++
	Trichogrammatid	*Trichogramma chilonis*	++

Order:Dermaptera			
Carcinophoridae	Earwig	*Euborella stali*	+

Table 12 : Seasonal abundance of predatory spiders

Period of observation	Visual count/m^2	*Sweep net/catch	Pitfall traps
2nd wk. of August	2.0	0.8	--------
1st wk. of September	0.9	0.6	---------
2nd wk. of September	1.3	0.7	0.4
1st wk. of October	1.4	0.9	0.5
2nd wk. of October	0.8	0.8	0.4
1st wk. of November	1.3	-------	0.5
2nd wk.of November	1.0	------	0.3
1st wk. of December	0.7	------	-----
2nd wk. of December	0.3	--------	-------

*Sweep net was not used from first week of November, 2019 due to reproductive growth phases of the crop.

1.2.17. CAU, Phasighat

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Arunachal Pradesh	Different agro-ecologies	Five species of spider and one species of lady bird beetle recorded

Fig 14. Spider diversity in Arunachal Pradesh

1.2.18. PAU, Ludhiana

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Fazilka, Bathinda, Mansa and Muktsar districts in Punjab	Cotton whitefly	Sixteen species of natural enemies were recorded including 7 species of insect predators; 2 species of parasitoids and 7 species of spiders. Among predators, *Coccinella septempunctata*, *Cheilomenes sexmaculata*, *Brumoides suturalis*, *Serangium parcesetosum*, *Chrysoperlazastrowi sillemi*, *Zanchius breviceps*, *Geocoris* sp. and spiders (*Neosconatheisi* Walckenaer, *Argiope* sp., *Oxyopes* sp., *Thomisus* sp., *Runcinia* sp., *Hyllus* sp. and *Chrysilla* sp.) were recorded. Out of these, *Chrysoperla* was the predominant species. Out of 11378 nymphs observed, 855 were found to be parasitized. The mean parasitization of whitefly by *Encarsia* spp. in different cotton growing areas of Punjab was 7.51 per cent (range = 0.90 to 24.1%).
Fazilka and Abohar of Punjab	Rice	A total of five species belong to three families, Tetragnathidae, Salticidae and Araneidae were recorded. Among these, *Tetragnatha maxillosa* waspredominant species (76.7%).
Different regions of Punjab	Soil samples (31)	Two *Bacillus* like entomopathogenic bacteria isolated

1.2.19. CPCRI, KAsargod

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
CPCRI Regional station, Kayamkulam	Coconut Rugose spiraling whitefly (*Aleurodicus rugioperculatus*), Bondar's nesting whitefly (*Paraleyrodes bondari*)	*Encarsia guadeloupae* on *A. rugioperculatus*. Percentage parasitism by *E. guadeloupae* on RSW colonies decreased from 48% in July 2019 to 22% in February 2020 which encouraged the buildup of RSW colonies in 2020 favoured by weather factors.
	Coconut scale insect, *Aspidiotus destructor*	More than 50% of the hard scales were found parasitized by the aphelinid parasitoid, *Aphytis* sp. and the population

		of the parasitoid was considerably higher in the pest inflicted garden. Besides, three lady beetles, *viz.*, *Chilocorus nigritus*, *Sasajiscymnus* sp., and *Pharoscymnus horni* and their grubs were recorded feeding voraciously on scales. *C. nigritus* was absolutely black, *Sasaji scymnus* sp. was brown in color and the grubs resemble mealy bugs whereas *P. horni* with characteristic red patches on elytron was observed for the first time in palm system

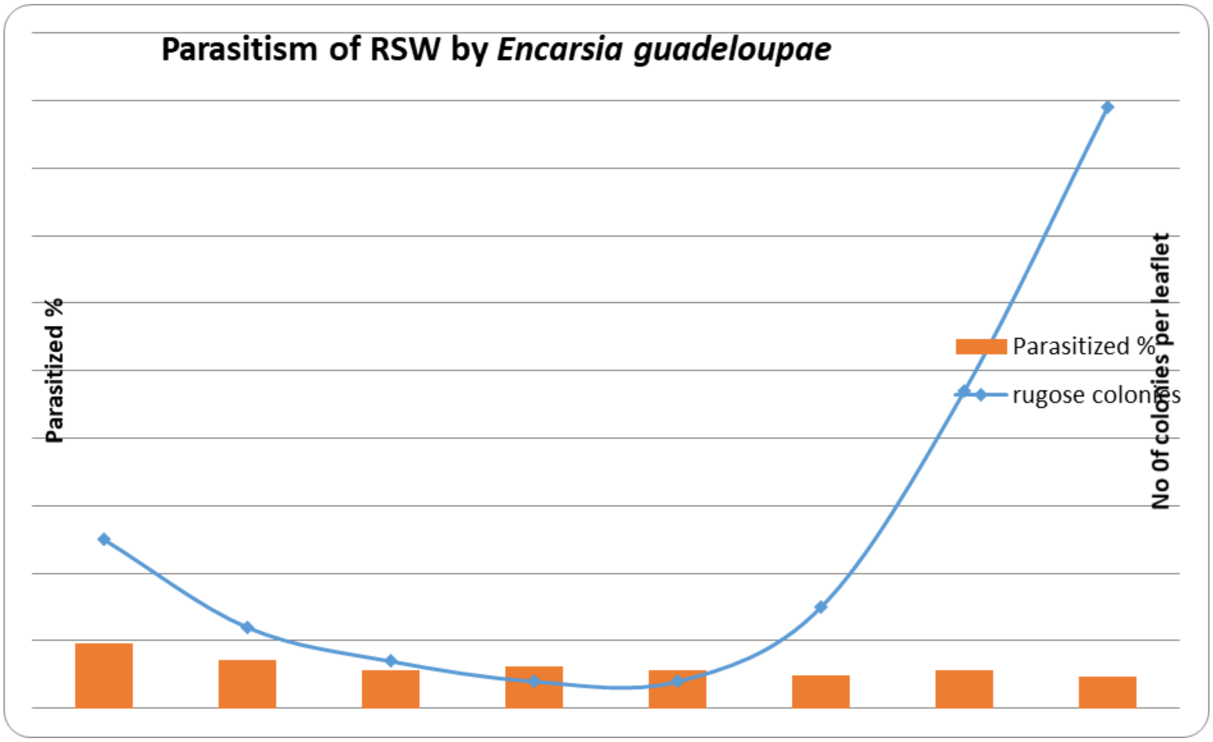


Fig 15. Parasitism of RSW by *Encarsia guadeloupae*

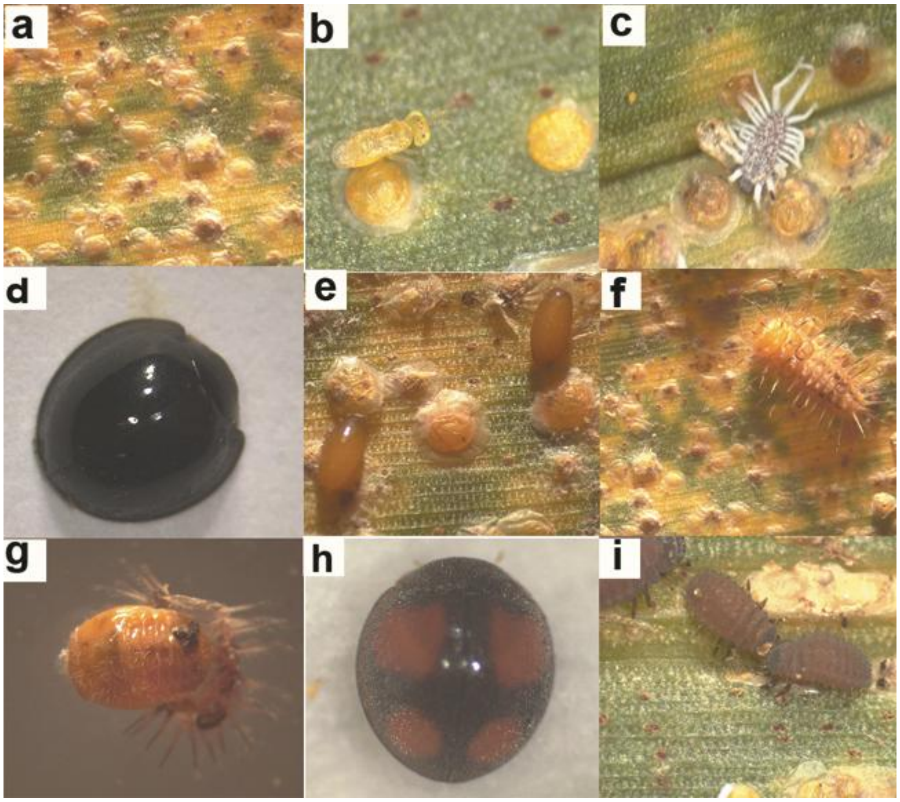


Fig 16. Coconut scale insect and natural enemies a-Damage by scale insects; b-*Aphytis* sp.; c-Grub of *Sasajiscymnus* sp.; d-*Chilocorus nigritus;* e-Eggs of *C. nigritus*; f-grub of *C. nigritus*; g-Pupa of *C. nigritus*: h-*Pharoscymnus horni*; i-Grubs of *P. horni.*

1.2.20. UAS, Raichur

The following naturan enemies (Table 13) were observed Non *Bt* cotton BGDS-1063 (Non *Bt*) Hybrid during the crop season of 2019-20

Table 13. Incidence of natural enemies in Non *Bt* cotton BGDS-1063 (Non *Bt*) Hybrid **during 2019-20**

Month	Natural enemies			
	Spiders / plant	**Coccenellids / plant**	**Syphids /plant**	***Aenasius arizonensis* (No./ 2.5 cm apical shoot length per plant**
July	0.0	0.0	0.0	0.0
August	0.07	0.29	0.0	0.0
September	0.42	1.16	0.24	0.0
October	1.28	1.46	0.54	0.0
November	1.1	0.61	0.04	0.92
December	0.62	0.19	1.14	3.64
January	0.14	0.06	1.28	9.32
February	0.03	0.0	0.77	14.46

1.2.21. KAU, Vellayani

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Thrissur and Palakkad	Rice	165 spiders collected
Thrissur and Palghat	Coconut rugose spiralling whitefly	28.64 to 80.18 % parasitization at Palakkad and 35.72 to 62.10 % Thrissur

II SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS

II.1. Surveillance

II. 1.1 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 in 2-3 districts.

Conducted 21 field visits in Visakhapatnam, Vizianagaram and Srikakulam districts of Andhra Pradesh. Monitored moderate to severe incidence of fall armyworm in maize, low to moderate incidence of leaf folder and stem borer in rice; moderate to severe incidence of BPH, WBPH in rice; moderate to severe incidence of early shoot borer in sugarcane. Noticed severe outbreak of rugose spiralling whitefly in coconut and also in guava. Observed severe outbreak of looper, *Perixera illepidaria* in mango and severe incidence of minor pests i.e., lepidopteran larvae damaging mango inflorescence and mango fruit borer (Table 13). Molecular identification of egg parasitoid, *Telenomus* sp from fall army worm eggs on sugarcane at NBAIR, Bengaluru was in progress.

Mango looper, lepidopteran larvae damaging mango inflorescence and mango fruit borer specimens were submitted to NBAIR, Bengaluru for molecular identification during March, 2020.

Fig 17. Looper damage in mango

Table 13 . Crop pest outbreak during 2019-20:

S.No	Month	Date	Locations	Crop	Problems noticed & Level of incidence
1.	June2019	1.06.2019	Anakapalle, Visakhapatnam district	Maize	Fall army worm- moderate incidence (5-10%)
			Tumpala, Anakapalle mandal, Visakhapatnam district	Maize	Fall army worm - moderate to Severe incidence (12-25%)
2.	July2019	23.7.2019	Kothavalasa, Vizianagaram district	Paddy	Stem borer - Low incidence (<2% DH)
			S.Kota, Vizianagaram district	Maize	Fall army worm - low incidence (2-4%)
			Anakapalle, Visakhapatnam district	Maize	Fall army worm - low incidence (1-4%)
			Araku, Visakhapatnam district	Maize	Fall army worm - low incidence (<5%)
3.	August2019	7.08.2019	Somalingapuram, Merakamudidam mandal, Vizianagaram district	Paddy	Leaf thrips – Low incidence
				Maize	Fall army worm – Low to moderate incidence – 4-8%
			M. Ravivalasa, Merakamudidam mandal, Vizianagaram district	Maize	Fall army worm – Low to moderate incidence – 2-10%
			Bantupalli,Merakamudidam mandal, Vizianagaram district	Maize	Fall army worm – Low to moderate incidence – 5-8%
			Vedurlavalasa, Cheepurupalli mandal, Vizianagaram district	Maize	Fall army worm – Low incidence – 2-5%
4.	September 2019	25.09.2019	Kudipi,Nelimarla mandal, Vizianagaram	Maize	Fall army worm - moderate incidence - 6 to 10%

			district		
			Suvvanipeta ,Nelimarla mandal, Vizianagaram district	Maize	Fall army worm - moderate incidence- 5 to 10%
			Kella,Gurla mandal, Vizianagaram district	Maize	Fall army worm - moderate incidence- 5 to 12%
			Valllapuram, Gurla mandal, Vizianagaram district	Maize	Fall army worm - low to moderate incidence- 4 to 15%
5.	October 2019	9.10.2019	Voppangi, Ranasthalam mandal, Srikakulam district	Paddy	Leaf folder – moderate incidence - 5-7% BPH, WBPH - moderate to severe incidence -20-50 hoppers/hill Sheath blight – low incidence - < 1%
			Narayanapuram, Ranasthalam mandal, Srikakulam district	Paddy	Leaf folder – moderate incidence - 5-7% BPH, WBPH- moderate to severe incidence -20-40 hoppers/hill Sheath blight – low incidence - < 2%
			Pathivadapalem, Ranasthalam mandal, Srikakulam district	Paddy	Leaf folder – moderate incidence - 3-7% BPH, WBPH- moderate to severe incidence -15-40 hoppers/hill
		10.10.2019	Kumili, Pusapatirega mandal, Vizianagaram district	Paddy	Leaf folder –low incidence: 2-4% BPH, WBPH- moderate to severe incidence -20-40 hoppers/hill Sheath blight:low incidence < 2%
			Gantyada, Vizianagaram district	Paddy	Leaf folder –low incidence - 1-5%BPH, WBPH- moderate to severe incidence -20-

					40 hoppers/hill Sheath blight – low incidence - < 2%
6.	November 2019	16.11.19	Srikakulam, Srikakulam district	Maize Coconut	Fall army worm – moderate to severe incidence – 12-27% Rugose whitefly- moderate to Severe infestation – 26- 68%
			Ranasthalam, Srikakulam district	Maize Coconut	Fall army worm – moderate to severe incidence – 12-27% Rugose whitefly- Severe infestation – 52-79%
7.	December 2019	9.12.2020	Pusapatirega, Denkada mandal, Vizianagaram district	Maize Paddy	Fall army worm – moderate incidence – 7-12% Stem borer – low incidence - <2 %
		21.12.2019	Patharlapalli, Ranasthalam mandal, Srikakulam district	Maize Coconut	Fall army worm – moderate to severe incidence – 12-27% Rugose whitefly- moderate to Severe infestation – 26- 68%
			Kumili, Pusapatirega mandal,Chollangipeta, Denkada mandal,Vizianagaram district	Maize Coconut	Fall army worm – moderate to severe incidence – 5-17% Rugose whitefly- moderate to Severe infestation – 33- 70%
		28.12.19	Venkataraopeta, Patharlapalli, Ranasthalam mandal	Coconut	Rugose whitefly- low to Severe infestation – 12-62%
			Amadalavalasa, Naira,Amadalavalasa mandal,Srikakulam district	Coconut	Rugose whitefly- moderate to Severe infestation – 47-82%
8.	January2020	6.01.2020	Venakatraopeta, Ranasthalam mandal, Srikakulam district	Coconut	Rugose whitefly- low to severe infestation – 12- 42%

		7.01.2020	Kondaguddi, Pusapatirega mandal, Vizianagaram district	Maize	Fall army worm – low to moderate infestation- <5% - 12%
		18.01.2020	Gurla, Kella,Cheepurupalli mandals, Vizianagaram district	Maize Coconut	Fall army worm – Low to moderate infestation - <5 % -18% Rugose spiraling whitefly – low to moderate infestation – 6- 20%
		30.01.2020	Cheepurupalli, Garividi mandals, Vizianagaram district	Maize	Fall army worm – Low to moderate infestation - 4 % -14%
9.	February 2020	4.2.2020	Venkataraopeta, Pathasundarapalem ,Ranasthalam mandal, Srikakulam district	Coconut	Rugose spiraling whitefly – low to moderate infestation – 5- 22% Noticed establishment of *Encarsia* parasitoid on RSW
		6.2.2020	Koyyam, Etcherla mandal, Srikakulam district	Coconut	Rugose spiraling whitefly – low to moderate infestation – 30-89%
		7.2.2020	Patharlapalli, Neliwada, Ranasthalam mandal, Srikakulam district	Coconut	Rugose spiraling whitefly – Severe infestation – 20-62%
		25.02.2020	Chinthapalli, Visakhapatnam dist	Maize	Fall army worm – low incidence- <5%
		27.02.2020	Penasam,Gantyada mandal, Vizianagaram district	Mango	Mango looper outbreak- severe infestation –90-100% Fruit borer- Severe infestation- 40-50%
			Challavanithota, Kumili, Pusapatirega mandal, Vizianagaram dist	Coconut	Rugose spiraling whitefly – Severe infestation – 30-56%
10.	March2020	12.03.2020	Bondapalli, Logisa, Gajapathinagaram mandal,	Mango	Mango looper outbreak- severe infestation –100%

			Vizianagaram dist		Fruit borer- Severe infestation- 30-60%
		13.03.2020	Venkatapuram, Patharlapalli, Srikakulam dist, Denkada, Vizianagaram dist	Coconut Guava	Rugose spiraling whitefly – low to moderate infestation – 5- 22%. Noticed establishment of *Encarsia* parasitoid on RSW in coconut Rugose spiraling whitefly – Severe infestation – 55- 72%

Natural epizootics of entomopathogenic fungus, *Nomuraea rileyi* on fall armyworm, *Spodoptera frugiperda* infesting maize was observed during October, 2019 to February, 2020 with infection ranging from 3.1 per cent to 38.02 per cent. The epizootics of *N.*rileyi recorded during congenial weather conditions prevailing during November, 2019.

Nomuraea rileyi was isolated from cadavers of S. frugiperda collected from maize in the Regional agricultural research station, Anakapalle. rDNA-ITS sequence of N. rileyi isolate AKP-Nr-1 showed considerable homology *and* the sequence was submitted to NCBI and accession number was retrieved. N. rileyi culture was submitted for safe deposition at NBAIM, Mau.

Molecular based identification of *Nomuraea rileyi* on maize fall army worm Nomuraea rileyi (Akp-Nr-1) GenBank Accession No.: MN960559

Fig 18. Natural parasitization of Fall army worm eggs by *Trichogramma chilonis* in sugarcane

II.1.2 AAU-Anand

Monitoring and record of incidence of papaya mealybug and its natural enemies onpapaya and other alternate hosts

The intensity of papaya mealybug infestation was ranged between Nil to Very low. The parasitoid *viz*., *Acerophagus papayae* was noticed parasitizing mealybug.

Table 14. Survey and monitoring of papaya mealybug *Paracoccus marginatus*

Sr. No.	Date of survey	Location Detail /GPS location	Crop plants infested	Non hosts crop and weeds infested	Chemical pesticides if any used with dose	Existing natural enemies in 25 randomly selected plants	Grade/ Infestation (%)
1.	20.11.19	Hasmukhbhai Patel Dhundhakuva Ta- Borsad Dist- Anand 22.45 52 63 72.88 29 16	Papaya	-	-	-	0
2.	20.11.19	Bhupendrabhai Dahyabhai Patel Dhundhakuva Ta- Borsad Dist- Anand 22.45 53 28 72.88 29 38	Papaya	-	-	*A. papayae*	1 (<5%)
3.	20.11.19	Shaileshbhai Vaghjibhai Patel Dhundhakuva Ta- Borsad Dist- Anand 22.45 53 17 72.88 29 19	Papaya	-	-	-	0
4.	20.11.19	Gajendrabhai Bhikhabhai Patel Dhundhakuva Ta- Borsad Dist- Anand 22.45 79 56 72.86 30 47	Papaya	-	-	*A. papayae*	1 (<5%)
5.	20.11.19	Atulbhai	Papaya	-	-	-	0

		Ramjibhai Patel Sandeshar Ta- Petlad, Dist- Anand 22.51 57 89 72.87 45 04					
6.	17.12.19	Rasikbhai Mangalbhai Talpada Bhavanipura Ta- Petlad Dist- Anand 22.49 60 78 72.82 66 43	Papaya	-	-	-	0
7.	17.12.19	Harshadbhai Gordhanbhai Patel Bhavanipura Ta- Petlad Dist- Anand 22.49 61 06 72.82 64 99	Papaya	-	-	-	0
8.	17.12.19	Navgan Bharwad Bhavanipura Ta- Petlad Dist- Anand 22.49 62 36 72.82 64 77	Papaya	-	-	*A. papayae*	1 (<5%)
9.	17.12.19	Arunbhai Ishwarbhai Patel Kavitha Ta- Petlad Dist- Anand 22.45 83 92 72.86 52 20	Papaya	-	-	-	0
10.	17.12.19	Sanjaybhai Chimanbhai Patel Ashi Ta- Petlad Dist: Anand 22.46 57 17 72.86 79 22	Papaya	-	-	-	0

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

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

Table 15. Survey details on Tomato pinworm *Tuta absoluta*

Date	Name of the farmer	Place	Host crop, non host crops and weed plants.	Natural enemies
03.01.20	Kanubhai Ambalal Patel	Village- Runaj, Ta.- Sojitra, Dist.- Anand	Tomato (Nil)	Nil
	Kanjibhai Gotabhai Parmar	Village- Malataj, Ta.- Sojitra, Dist.- Anand		
	Bhanubhai G. Parmar	Village- Malataj, Ta.- Sojitra, Dist.- Anand		
	Pareshbhai Chhaganbhai Talpada	Village- Karamsad, Ta.- Anand, Dist.- Anand		
	Babubhai Vaghajibhai Talpada	Village- Karamsad, Ta.- Anand, Dist.- Anand		
28.12.19 12.01.20	Patel Nehalbhai Divyeshbhai	Village-Vaghrota, Ta.- Prantij, Dist.- Sabarkantha	Tomato (Nil)	Nil
	Patel Mahendrabhai Ranchhodbhai	Village-Himatnagar, Ta.- Himatnagar, Dist.- Sabarkantha		
	Patel Jagdishbhai	Village-Chandrala (Magodi farm), Ta.- Dehgam, Dist.- Gandhinagar		
	Patel Pankajbhai Haribhai	Village-Maniyor, Ta.-Idar, Dist.- Sabarkantha		
	Patel Pravinbhai Davabhai	Village-Maniyor, Ta.-Idar, Dist.- Sabarkantha		

II.1.3 AAU-Jorhat

Survey, Surveillance and quantification of natural enemy complex including spiders in *kharif* rice and vegetables of Jorhat district

Field surveys were carried out in 5 numbers of farmers' fields located at Neul Gaon, Dangdhara, Uttar garumora, Ahom Gaon and Dhekor gora cipahikhola during 2019- 20 to record the occurrence of natural enemy complex of insect pests associated with *kharif*rice and vegetables (brinjal, tomato, cucurbits, cole crops, okra, papaya, chilli) of Jorhat districts.

Visual counts per m^2 were adopted to record the number of spiders and coccinellids from rice ecosystem. Similarly, for dragonfly and damselfly, visual as well as catch /unit efforts was adopted. 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, if any. In rice and vegetables, sentinel cards containing 100 numbers of *Corcyra* eggs were also placed to record the parasitization by Trichogrammatids.The spiders and coccinellids collected from different rice and vegetable fields were preserved in 70% alcohol.

Highest number of spider population (0.8 to1.4 spider/ m^2) was recorded in rice fields. Al toghether, 138 numbers of spiders from 6 different families (Lycosidae, Oxyopidae, Tetragnathidae, Araneidae, Uloboridae and Salticidae,) were collected from different rice fields. The predominant spider was *Lycosa pseudoannulata* (48) followed by *Oxopes javanus* (32) and *Tetragnatha* sp. (28) and they were active throughout the cropping season **(**Table 16). It was observed that out f different predators and parasitoids, spiders were the dominant one and occupied major status in rice ecosystem followed by the insects belonging to the order Coleoptera, Odonata, Hemiptera and diptera in descending order.

Table 16. Natural enemies (Class: Arachnida) of the rice ecosystem

Species	Family	Collected Species (Total)	Period of activity	Relative abundance (%)
Lycosa pseudoannulata	Lycosidae	48	Throughout the cropping season	34.78 (+++)
Oxyopes javanus	Oxyopidae	32	Throughout the cropping season	23.19(+++)
O.shweta	Oxyopidae	4	Throughout the cropping season	2.89 (+)
O. lineaptis	Oxyopidae	1	Throughout the cropping season	0.73(+)
Tetragnatha sp.	Tetragnathidae	28	Throughout the cropping season	20.28(+++)
Argiope catenualata	Araneidae	17	August-Sept--October	12.31(++)
Neoscona theisi	Araneidae	2	August-Sept--October	1.49 (+)
Araneus sp.	Araneidae	1	August-Sept--October	0.73(+)
N. bengalensis	Araneidae	2	August-Sept--October	1.44(+)
Uluborus sp.	Uluboridae	2	Oct --Nov.	2.17(+)

Telamonia sp	Salticidae	1	Oct--Nov	1.44(+)

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

Moreover, in vegetative and reproductive growth stage of rice crop, more number of odonates(dragonfly and damselfly), was observed. Out of 56 numbers of collected species of odonates,the most dominant damselfly and dragonfly species were *Agrionemisfemina* (22) and *Brachythemis contaminate* (18)in all rice growing areas. Eighty two numbers of coccinellids predators were recorded from August to Nov' 2019 from rice field and the major predators were *Micraspis discolor*, *Micrapsis crocea, Harmonia octomaculata and Chilomenes sexmaculatus.* However, *M. discolor* was more compared to other predators collected from rice fieldand it was the most predominant in rice ecosystem. Apart from these, other predators and parasitoids (emerged from eggs and larvae) associated with rice crop was low in their abundance(Table 17).

Table 17. Natural enemies of the Rice ecosystem

Arthropod groups	Common name	Scientific name	Relative abundance
Order:Odonata			
Coenagrionidae	Damselfly	*Agrionemis femina*	+++
Libellulidae	Dragonfly	*Brachythemis contaminata*	+++
Order: Coleoptera			
Anthicidae	Lady beetle	*Micrapsis discolor*	+++
	Lady beetle	*M. crocea*	++
	Lady beetle	*Harmonia octomaculata*	++
	Lady beetle	*Chilomenes sexmaculatus*	+
Order: Hemiptera			
Miridae	Plant bug	*Cyrtorhinus lividipennis*	+
Order: Diptera			
Tachinidae	Tachinid fly	*Sturmiopsis inferens*	+
Order: Hymenoptera			
Braconidae	Braconid wasp	*Cotesia* (*Apanteles*) *angustibasis*	++
Eulophidae	Eulophid wasp	*Tetrastichus schoenobii*	+
Trichogrammatidae	Trichogrammatid	*Trichogramma japonicum*	+++
	Trichogrammatid	*Trichogramma chilonis*	++
Order:Dermaptera			
Carcinophoridae	Earwig	*Euborella stali*	+

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

In vegetable ecosystem, survey carried out during May to October'2019 at different vegetable growing areas of Jorhat district against papaya, chilli/ bhut jolokia, tomato, brinjal, okra, cucurbits, cole crops and potato and recorded 183 numbers of different types of predators like *Spalgius epius (*20*),* Chysopids(28), *Coccinella septempunctata (45), C. transversalis (*32*), Serangium parcesetosum (*3),*Harmonia dimidiata (*10*), Cheilomenes sexmaculata (*24), *Brumoides suturalis* (18) and *Cryptolaemus* sp. (3) was recorded from different *rabi* and kharif vegetables during 2019-20.

Besides, the parasitoids viz., *Cotesia glomerata*, parasitizing larvae of *Pieris brassicae*, *Campoletis chlorideae* (larval) *Trichogramma chilonis* (egg), *Bracon* sp. (Larval) parasitizing *Helicoverpa armigera*, *Diaeretiella sp* from aphid, *Encarsia* sp. from whitefly and *Phanerotoma* sp. from brinjal were also recorded.

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

The seasonal abundance of spider was recorded, covering an area of 1 hectare at ICR farm, AAU, Jorhat under unsprayed condition (Table 18). 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 visual count (1mx1m), pitfall traps and sweep net methods at 15 days interval starting from 2nd week of August (30 DAT) to till maturity of crop. For sweep net method, 10 catches per unit effort was made randomly from each block to collect the spiders from the field. Similarly, 10 numbers of pitfall traps were 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 were:

General collections (Visual methods) = 97 numbers
Sweep net methods = 38 numbers
Pitfall traps = 21 numbers

Table 18. Seasonal abundance of predatory spiders (Av)

Period of observation	Visual count/m^2	*Sweep net/catch	Pitfall traps
2nd wk. of August	2.0	0.8	--------
1st wk. of September	0.9	0.6	---------
2nd wk. of September	1.3	0.7	0.4
1st wk. of October	1.4	0.9	0.5
2nd wk. of October	0.8	0.8	0.4
1st wk. of November	1.3	-------	0.5
2nd wk.of November	1.0	------	0.3
1st wk. of December	0.7	------	-----
2nd wk. of December	0.3	--------	-------

*Sweep net was not used from first week of November, 2019 due to reproductive growth phases of the crop.

II. 1.4 CAU, Pasighat

Incidence of insects and diseases in Litchi

Mite incidence was recorded in litchi at East Siang district of Arunachal Pradesh. Incidence of blight disease (20%) was recorded.

Fig 19. Mite infestation in Litchi

Moderate incidence of fall armyworm was recorded at Ruksin in East Siang district of Arunachal Pradesh.

Fig 20. Fall armyworm damage in maize

II.1.5 IIVR, Varanasi

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

For record of natural enemies associated with American Pin Worm (*Tuta absoluta*), the tomato fruit damage by the *T. absoluta* was monitored at weekly intervals in and around Varanasi including the experimental farm of the institute. The larvae collected from the infested plants were reared individually for emergence of parasitoids, if any. The tomato fruit damage was started by this pin worm during the last week of November (48^{th} SMW) onwards and continued till last week of March, 2020 (13^{th} SMW). The maximum fruit damage (5.56%) was recorded during the first week of January, 2020(1^{st} SMW) whereas lowest (0.60% fruit damage) was observed during the third week of March, 2020 (12^{th} SMW). As regards to parasitoids, no parasitoids were noted to be associated with the pest in the region. However, a polyphagous predator, namely *Nesidiocoris tenuis* was observed in abundance (maximum 3.7 bugs / apical twigs) feeding on early instar larvae. Besides, it also feeds on soft-bodied insects like whitefly, jassids and aphids in tomato field.

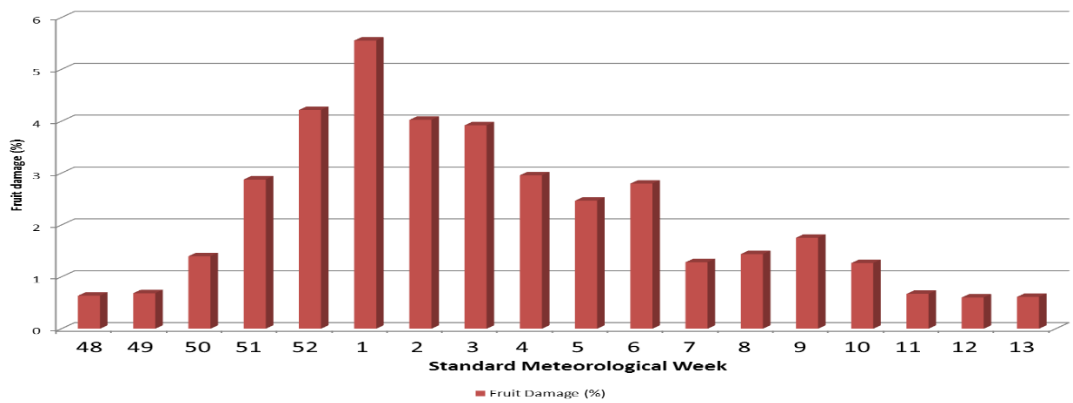


Fig. 21. Periodical incidence of *Tuta absoluta* infesting tomato

II.1.6. KAU, Thrissur

Neither any outbreaks of pests nor any alien pest species were reported across the state during the period under report.

II.1.7. MPKV, Pune

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

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

The sugarcane fields surveyed during the period from April, 2019 to February, 2020. The data regarding effect of natural enemies on incidence of sugarcane woolly aphids presented in Table indicated that, the SWA incidence was observed along riverside and canal areas with natural enemies in sugarcane fields. The pest incidence was relatively low during this year. The SWA incidence was observed in Mulshi, Haveli, Indapur, Baramati, Daund Tahasils of Pune district, Kopargaon, Sangamner, Rahuri in Ahmednagar District, Karad, Wai, Phaltan and Jawali tehsils in Satara district,Walwa, Shirala, Palus Kadegaon area in Sangali district, Kagal, Panhala, Hatkangale and Radhanagari tehsils of Kolhapur district, Madha, Malashiras, and Pandharpur tehsils of Solapur districtalong with its predator *Micromus igorotus, Dipha aphidivora*, *Eupoderes confractor* and a parasitoid, *Encarsia flavoscutellum*. The predatory population was recorded from July onwards. *Micromus igorotus*was noticed during August to November, 2019. These predators were predominant and well established in the sugarcane growing areas of Western Maharashtra. Moreover, the parasitoid, *Encarsia flavoscutellum* which was brought from Assam and release in Maharashtra is well established which was also observed in most of the sugarcane growing areas of western Maharashtra.

It is seen from the data in Table 19 that the SWA incidence was relatively less in Pune and Solapur districts during this year, 2019-20. However, the natural enemies were noticed soon after the pest incidence. The average SWA incidence and pest intensity ratings were 1.91 per cent and 2.00, respectively. The natural enemies recorded in the SWA infested fields were mainly the predators like *D. aphidivora* (1.00 to 2.00 larvae/leaf), *M. igorotus* (1.00-3.00 grubs/leaf), syrphid *Eupoderes confrator* (0.60-1.00 larvae/leaf) and spider (0.60-1.00/leaf) duringApril, 2019 to February, 2020. The parasitoid *Encarsia flavoscutellum* (1.00-2.00 /leaf) found distributed and well established in almost all sugarcane fields and suppressed the SWA incidence in Western Maharashtra.

Table 19. 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. confrater***	
Pune	1.50	2.00	1.2	3.00	1.50	1.00	1.00
Satara	2.00	2.00	1.5	1.00	2.00	0.60	0.60
Sangli	2.00	2.00	1.5	2.5	2.00	0.60	0.60
Kolhapur	2.5	2.00	2.0	3.00	2.00	1.00	0.60
Ahmednagar	1.5	2.00	1.0	1.00	2.00	0.60	1.00
Solapur	2.0	2.00	1.0	1.00	2.00	1.00	1.50
Average Range	**1.91 1-2.5**	**2.00 2.00**	**1.36 1.00-2.00**	**1.91 1.00-3.00**	**1.91 1.00-2.0**	**0.80 0.60-1.00**	**0.80 0.60-1.00**

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

Survey and record of incidence of pin worm, *Tuta absoluta* on tomato

The activity of adult pin worm mothswas monitored by installing pheromone traps. The Survey and surveillance of natural enemies of pin worm, *Tuta absoluta* on tomato was conducted during April, 2019 to February, 2020.The survey and surveillance of natural enemies of pin worm, *T.absoluta* on tomatoindicated no infestation of *T. absoluta* in Pune, Satara, Sangli, Solapur and Kolhapur and Ahmednagar district of Maharashtra state.

Monitoring the incidence of papaya mealybugs (PMB) and its natural enemies on papaya and other alternate hosts

The papaya orchards were surveyed for the incidence of papaya mealybugs (PMB) in various agro-ecological zones of western Maharashtra and recorded its associated natural enemies as well as alternate host plants. The intensity rating of mealybug was recorded in 1-5 scale from 5 plants per orchard. Besides, the natural enemies in mealybug colonies and alternate hosts of PMB in the vicinity of papaya orchards were also recorded.

The data presented in Table revealed that the negligible incidence of PMB was noticed to the extent of 1.0 to 2.00 per cent in all districts of Western Maharashtra. It was relatively very low with 1.0 pest intensity rating during this year. The pest incidence was maximum (2.00 %) in Shahada (Nandurbar) followed by Shirpur (Dhule) and Chopada tehsil of Jalgaon district (1.00 %). 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.

Table 20 . Survey and record of papaya mealybugs in Western Maharashtra

District surveyed	**PMB incidence (%)**	**Pest intensity rating**	***A. papayae* population/leaf**
Pune	1.00	1.0	1.20
Ahmednagar	1.00	1.0	0.00
Jalgaon	1.00	1.0	1.20
Dhule	1.00	1.0	2.00
Nandurbar	2.00	1.0	2.50
Solapur	1.00	1.0	1.20
Kolhapur	1.00	1.0	1.20
Satara	1.00	1.0	0.00
Sangli	1.00	1.0	0.00
Average	**1.10**	**1.0**	**1.16**
Range	**1.0 – 2.0**	**1.0**	**0 – 2.5**

1-5 scale (1= very low; 2=low; 3=medium; 4=high; 5= very high population)

Natural enemies recorded in papaya mealybug colonies:

i. Encyrtid parasitoid, *Acerophagus papayae* N. & S.
ii. *Spalgius epius*
iii. *Coccinella septempunctata*
iv. *Scymnus* sp.
v. *Menochilus sexmaculatus*
vi. Anthocorids
vii. *Mallada* sp.
viii. *Brumoides* sp.
ix. Spiders

Alternate hosts of papaya mealy bug in Maharashtra:

During survey, the papaya mealybug was observed on following plants/weeds as alternate hosts in the vicinity of papaya orchards.

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

Monitoring the diversity and outbreaks for invasive mealybug on cotton

There was very meagre incidence of invasive mealy bug(0.0 to 0.8/plant) throughout season on cotton crop in Ahmednagar, Solapur, Dhule, Nandurbar and Jalgaon districts.

Crop Pest Outbreak Report(CPOR)

The field crops, 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 districts as well as fruits and vegetables market areas around Pune were visited for record of pest species *viz.*, coconut leaf beetle (*Brontispa longissima*), spiraling white fly (*Aleurodicus dugessi*), mealy bug species (*Phenacoccus manihoti*, *Paracoccus marginatus, Phenacoccus madeirensis*, *Pseudococcus jackbeardsleyi*),American pin worm (*Tuta absoluta*)on tomato and other alien invasive pests. The pest infested fruits and vegetablesamples 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, *Pseudococcus jackbeardsleyi* and*Paracoccus marginatus* were recordedon custard apple and papaya respectively, in Pune and Dhule and Jalgaon districts. The encyrtid parasitoid, *Acerophagus papayae* N & S, predatory larvae of *Spalgis epius*, coccinellids, anthocorids, chrysopids, syrphids and spiders were recorded in Pune region. Amongst the target pests, *Tuta absoluta* was not recorded in surveyed area of Western Maharashtra during April, 2019 to February, 2020 on tomato crop.

New Alien pest, Fall Army Worm (FAW), *Spodoptera frugiperda* was reported in all maize growing areas of Western Maharashtra. The FAW infestation was ranged between 20 to 30 per cent in maize crop. The pest extended its host range and it was also reported on sorghum and bajra crops in Pune, Solapur, Satara and Sangli districts. The FAW infestation on maize with intercrop was ranged between 10 to 15 per cent. FAW is reported for the first time on Cotton crop at Susare Village of Pathardi tehsil in Ahmednagar district. Similarly, it is also reported on sugarcane crop at Susare village.

II. 1.8 MPUAT, Udaipur

Survey and surveillance of Pin worm, *Tuta absoluta* on Tomato

Surveys were conducted to record the incidence of the tomato pin worm, *T. absoluta* from November, 2019 to February, 2020 at 8 locations of districts Udaipur which is the major tomato growing area of Rajasthan. The incidence of *T. absoluta* was also recorded under both open and protected conditions at Dabok, Mavli, Pilader and Veerpura villages of Udaipur district (Rajasthan) on tomato. Among all these locations the infestation ranged from 6 to 25 per cent. Whenever no control measures were taken, 55-65 per cent infestation was recorded in tomato crop. Survey reveals that the pest is more severe under protected conditions than in open field conditions and prefers tomato over other host plants. (Table 20).

Fig 22. Damage caused by *Tuta absoluta*

Table 20.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	30.11.2019	Low	10-15	6-8
Dabok, Mavli & nearby villages	5.12.2019	Low	15-20	10-15
Pilader, Jaisamand & nearby villages	12.12.2019	Low	20-25	8-10
Pilader, Jaisamand & nearby villages	15.01.2020	Moderate	50-55	15-25

Survey and surveillance of Fall Army Worm, *Spodoptera frugiperda* on maize

Surveys were conducted to record the incidence of fall army worm, *S. frugiperda* from July, 2019 to February, 2020. The survey indicated that the incidence of fall army worm was noticed to be moderate to severe in Udaipur, Chittorgarh, Banswara and Dungarpur districts of Southern Rajasthan with an average incidence range of 30-40 per cent (Table 21).

Fig 25. FAW Infested plants and field view

Table 21. 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 (%)**
Villages of Girwa, Mavli, Bhinder, Badgaon block of Udaipur	15.07.2019	Low to Moderate	15-20	20-25
Villages of Chittorgarh, Badsadri, Nimbahera block of Chittorgarh	16.07.2019	Low to Moderate	15-20	30-60
Piladar, (Jaisamand)	08.08.2019	Low	30-35	10-15

Table 22. Monitoring of FAW, *Spodoptera frugiperda* by pheromone traps at RCA Farm

Date of installation of pheromone trap	**Number of traps/acre**	**No. of adults trapped (week)**	**Trap-1**	**Trap-2**	**Trap-3**	**Trap-4**	**Total trapped adults**
12/08/2019	04	I	01	00	01	01	03
		II	03	03	02	02	10
		III	03	02	04	05	14
		IV	02	02	02	03	09
		V	01	00	01	01	03
		VI	00	01	01	00	02
11/12/2019	04	I	06	01	08	07	22
		II	00	00	15	00	15
		III	00	02	04	00	06
		IV	08	01	01	00	10
		V	00	02	12	04	18
		VI	01	01	12	03	17
		VII	03	02	22	02	29
		VIII	01	09	05	00	15
		IX	07	08	23	01	39
		X	11	12	16	02	41

Crop Pest Outbreak Report

Surveys undertaken during July, 2019 to February, 2020 covering Udaipur, Chittorgarh, Bhilwara, Banswara and Dungarpur districts of Rajasthan coincided with maximum vegetative stage of maize crop and was moderately infested by fall armyworm. In tomato, tomato pinworm, *T. absoluta* in Rajasthan was more infested under protected condition from Udaipur and Banswara districts in a survey undertaken during November 2019 to February, 2020.

The swarm of Locust was first spotted in month of December, 2019 in Udaipur region, mainly Kotra block. It has damaged many hectares of mustard and wheat crops and eaten up plants in the large forest area. A swarm of locusts perhaps got separated from a larger herd in Gujarat and flew into the bordering villages of Kotra block. It has so far stationed at Dedhmariya, Phulwariya, Maldar, Mahudi and Khajuria village. Earlier, locust swarm spotted in Jaisalmer, Barmer, Jodhpur, Jalore, Sirohi, Pali, Bikaner and Ganganagar districts of Rajasthan. Among these districts, in Jalore, Barmer, Jaisalmer district, this pest caused significant damage to cumin, castor and isbagol crops.

Fig 24. Locust swarm in Kotra block of Udaipur district

II. 1.9 OUAT, Bhubaneswar

Survey was made in every month starting from Sept, 2019 in Odisha for the outbreak of insect pests in different crops(Table 23).

Table 23. Month wise outbreak of insect pests in Odisha during 2019-20

Month and year	Crop	Pest	Level of infestation	Site	Remarks
September 2019	Maize (*Zea mays*)	Fall armyworm (*Spodoptera frugiperda*)	Mild to Moderate	Gajapati,Nuapada,Raygada districts of Odisha.	Emamectin benzoate5%SG(200gm/ha) or Chloran traniliprole 18.5% SC 200ml/ha
October 2019	Paddy (*Oryza sativa*)	Yellow stem borer (*Scirpophaga	moderate	Nimapara areas of puri district &Salepur of	Flubendiamide 20% SG125gm/ha OR Chloran

		incertulas)		Cuttack district.	traniliprole 18.5% SC 200ml/ha
November 2019	Maize(*Zea mays*)	Fall army worm (*Spodoptera frugiperda)*	Moderate Moderate	AICRP on Maize field, OUAT, Bhubaneswar Nawarangapur district,Odisha	Thiamethoxam 12.6% +Lambda cyhalothrin 9.5% EC @ 250 ml/ha
December 2019	Mustard (*Brassica juncea)*	Mustard saw fly(*Athalia lugens*)	Moderate	Sundargarh district	Ethofenprox 10% EC 500 ml/ha
January 2020	Mustard	Mustard aphid *(Lipaphis erysimi*)	Moderate	Puri District of Odisha	Imidacloprid 17.8% SL 140ml/ha
February 2020	Brinjal (*Solanum melongena*)	Brinjal fruit and shoot borer(*Leucin odes orbonalis*)	Moderate	OUAT Research farm, Bhubaneswar. Malipada and Kateni village near by Bhubaneswar	Novaluon 10%EC 500ml/ha
March 2020	Brinjal (*Solanum melongena*)	Brinjal fruit and shoot borer(*Leucin odes orbonalis*)	Moderate	Village Barabahali of Ghasipura Block of Keonjhar district	Spinetoram 11.7 % SC 500ml/ha

Fig 25. Damage symptoms by Fall Armyworm

Fig 26. Shoot and fruit borer infestation in brinjal

II.1.10 PJTSAU, Hyderabad

The trial was carried out with a periodicity of one month in collaboration with District Agricultural Advisory & Training Centres (DAATTCs) and Krishi Vigyan Kendras (KVKs) of University. The survey and surveillance of the pests was also done with close interaction with state Agriculture department officials and local farmers.

All the thirty-three districts of Telangana were covered. In addition to regular visits, In case of pest outbreak of Fall Army Worm (FAW) and Rugose Spiraling Whitefly (RSW), the affected areas were specifically visited.

S. No.	Name of the Pest	Districts	Specific areas	Remarks
1.	Grasshopper, *Heiroglyphus nigroplectus*	Siddipet (Thoguta Mandal)	Ghanapur, Govardhangiri, Gudikandula, Vardarajupet	The incidence was there for less than a week between 9-12 September 2019
2.	Fall Army Worm (FAW), *Spodoptera frugiperda*	Nagarkurnool & Khammam	Palem, Wyra	Sporadic incidence
3.	Rugose Spiraling Whitefly (RSW),	Khammam & Bhadradri Kothagudem	Bethupalli, Pakalgudem, Ganeshpadi	Moderate to Severe incidence in coconut & Oil palm

The information on Specific site & date visited (District, Mandal & village), Variety grown, Major insects and diseases noticed, Age of crop in severely damaged fields, the plant protection measures already taken up by the farmers/state department were documented duly following the prescribed protocols.

Status of Pink Boll worm (PBW) in Telangana:

It has been observed that in many cotton growing areas of Telangana, the incidence of PBW was hovering around ETL only. Most of the crop season, the incidence of PBW was below ETL. The incidence of PBW is sporadic & moderate in early sown/early flowered crop but the incidence was near nil at several mandals across the cotton growing districts of the state.

Status of Fall Armyworm (FAW) in maize crop in Telangana:

Fall Army Worm (FAW) incidence of was noticed from low to moderate during *Kharif* 2019-20, in many maize growing districts of Telangana *viz*., Karimnanagar, Siddipet, Sangareddy & Mahbubnagar. The rating of the incidence was low to moderate during *Kharif* 2019-20, in many maize growing districts of the state while it was found to be medium to high in Nagarkurnool and Khammam districts as compared to other districts of the state.

In all the districts where FAW was reported the infestation was seen from August 2019 onwards and was spreading in both area and intensity till the management practices were adopted. The infestation was found to be less in the areas where the crop management practices were taken up in time.

Status of Grasshopper damage in maize in Telangana

Area and crops surveyed:

- The outbreak was reported on maize in Thogunta mandal of Siddipet district
- The crops cultivated in four villages *viz.*,Govardhanagiri, Gudikandula, Ghanapur and Varadarajupalli were examined for incidence and damage by the pest.
- The crops surveyed for assessing incidence extent of damage were mainly maize and paddy while other crops such as redgram, cotton etc. were also examined.

Incidence, symptoms, assessment and impact of Damage:

- A typical feeding symptom by swarm of grass hoppers is observed in maize where no foliage on the plant is left except midribs of the leaves.
- Huge presence and feeding of swarm of grasshoppers were noticed in maize even during afternoon hours resulting in to extensive damage to the crop.
- The populations were found cutting the newly formed cobs also indicating the severe status of the damage.
- The swarm forming nature by grasshoppers was clearly visible as the populations were moving in groups by ravaging a field and shifting to another field.
- Nearly total damage was noticed in infested fields.

Report of host range as per observed incidence:

- In all the surveyed areas, the pest was found feeding only on maize crop.
- Only peripheral incidence was noticed in paddy fields at village Govardhanagiri despite huge incidence in damage in the adjoining maize fields indicating preference for maize in comparison with other crops existing in the same vicinity.
- Crops such as redgram, cotton etc. were found to be not being damaged by the hoppers.
- However, huge numbers of population were found resting without any damage on non-host plants/trees such as guava, *Hibiscus*, redgram, and other avenue plants.

Preliminary identification characters of the hoppers observed in the field:

- Medium to large in size with green frontal surface of the head capsule extending later into brownish colour.
- Wings slightly lengthier than thorax with typical segmentation on pronotum
- Femur of the hind leg is cream coloured and well developed while tebia is found to be sky blue in colour.
- The above colour patterns are found to be more distinct in adults as compared to nymphs.
- Always found in groups (in swarms) while feeding on host crop (maize) and while resting (on other non-host crops).

Confirmatory identification of the hoppers by NBAIR:

Molecular characterization of *Hieroglyphus nigrorepletus*:

The sample was received from Telangana State Agricultural university (PJTSAU) from three different locations and sent to ICAR-National Bureau of Agricultural Insect Resources, Bangalore, India, for the Molecular identification of the Grasshopper species. Further, DNA barcodingbased identification was employed to determine the identity by amplifying COX1 mitochondrial gene. DNA was extracted from the single leg of all three samples using Qiagen DNeasy® kit, following the manufacturer's protocols. The extracts were subjected to polymerase chain reaction (PCR) amplification of a 658bp.

Based on the DNA sequencing data, our three sequences matched 100% with GenBank accession numbers (JF838481, JF838480, JF838479, JF838477) and **identity was determined as *Hieroglyphus nigrorepletus***.

Initiatives taken by PJTSAU for creation of awareness on management:

- After assessing the extensive damage, immediate management approaches were suggested to farmers to restrict the further spread

    - Spraying chloripyriphos @ 2.5ml/lit or malathion @ 2ml/lit two times with an interval of one week between sprays.
    - Cleaning of vegetation/grasses on bunds on community basis to avoid the buildup of initial populations.
    - Spraying of *Metarhizium anisopliae* @ 5ml/lit both in the field as well as on the resting populations on non host trees and plants.
    - Arrangement of light traps on community basis with provision of water traps filled with water mixed with insecticide/kerosene.

- Alert messages were sent by university through print and electronic media.
- Assessment of damage levels, preference of host crops/plants, management approaches to avoid scope of further spread was done by technical team.
- To give scientific validity to such apprehensions the samples of pest were collected from Govardhanagiri, Gudikandula, Ghanapur, Varadarajupalli villages of Thogunta mandal for further taxonomic identification and confirmation.
- The collected samples were segregated and processed at PJTSAU Bio ControlLaboratory as per Standard Operating Procedures (SOPs) and the samples were made ready for further analysis.
- One set of collected samples were packed as per SOPs and sent for DNA Bar-Coding studies at National Bureau of Agricultural Insect Resources (NBAIR)
- The immediate management approaches to tackle the problem is being communicated to all the extension functionaries of university and state Department of Agriculture for checking the spread in other areas of the state.

Status of Rugose spiralling whitefly (RSW) in Telangana

Recently, during January-March, 2020, the incidence of Rugose Spiraling Whitefly (RSW) was noticed in oil palm in Khammam district. The limited area under coconut in Khammam district was also found to be infested by RSW. The bio agents were supplied by PJTSAU and spraying of Azadirachtin 1500 ppm was recommended under Bio suppression of RSW in Telangana.The following are the observations on Rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin in Telangana during the survey conducted during February 2020.

Area covered under survey undertaken for RSW infestations:

S. No.	Village	Mandal	District	Crop	Age	Area
1.	Bethupalli	Sathupalli	Khammam	Coconut	1 Year	1 Acre
2.	Pakalgudem	Sathupalli	Khammam	Oil palm	13 Year	4 Hectares
3.	Ganeshpadi	Dammapeta	Khammam	Guava	14 months	3Acre
4.	Bethupalli	Sathupalli	Khammam	Maize	2 months	2 Hectares
5.	Bethupalli	Sathupalli	Khammam	Banana	8 months	2 Hectares
6.	Pakalagudem	Sathupalli	Khammam	Cocoa	4 Year	4 Hectares
					Total area covered	12 Hectares & 4 Acres

Extent of Damage by RSW in surveyed areas:

S. No.	Crop	Infestation levels*	Impact on Yield
1.	Coconut	> 60 Per cent	Yet to be worked out
2.	Oil palm	35-40 Per cent	Yet to be worked out
3.	Guava	10 Per cent	Yet to be worked out
4.	Maize	Only egg stages	Not completing lifecycle – No Pest status
5.	Banana	15-20 Per cent	Yet to be worked out
6.	Cocoa	5-10 Per cent	Yet to be worked out

Yield impact correlation studies are yet to be taken up by DoH & SKLTSHU

Action Plan:

- Planning and execution of massive awareness programmes at village level by the staff of Department of Horticulture & TSOILFED on Rugose Spiralling White fly management approaches.
- Employing of audio equipped local autos with recorded message on management practices of RSW to the farmers of Oil palm, Coconut and other fruit crops infested by RSW.
- Purchase of Turbo sprayers by DoH, T.S, Hyd., for application of management inputs of RSW.
- Distribution of the revised pamphlets / leaflets / brochures/ posters in Telugu highlighting the management approaches of RSW

- Awareness creation on farm level production of *Isaria fumosorosea* by scientists from IIOPR, Pedavegi, PJTSAU, SKLTSHU & CIPMC Hyderabad in collaboration with Director of Horticulture, T.S, Hyd., TSOILFED.
- Addressing letters from Government of Telangana to Plant Protection Advisor (PPA) GoI for recent advisory on management of RSW by keeping in view of label claim issues.
- Involving of Biological control laboratory at HRS, Aswaraopet of SKLTSHU for mass production of *Isaria fumosorosea* by procuring quality inoculum cultures from AICRP on Biological control, PJTSAU Hyderabad.
- Training of staff of HRS, Aswaraopet of SKLTSHU at PJTSAU Centre - AICRP on Biological control, PJTSAU Hyderabad on mass production and quality assessment of *Isaria fumosorosea*.

II. 1.11 PAU Ludhiana

The crops were regularly monitored in collaboration with crop entomologists, Department of Entomology, PAU, Ludhiana and Extension specialists of PAU Krishi Vigyan Kendras (KVKs) and Farm Advisory Service Centres (FASC). No major outbreak of any pest was recorded. The damage of invasive pest, fall armyworm *Spodoptera frugiperda* was recorded on maize and fodder maize crops. The status of insect pests and natural enemies recorded in different crops in Punjab is given in Table 24.

Sugarcane: Low to moderate incidence of lepidopteran borers (*C. infuscatellus*, *S. excerptalis* and *C. auricillius*) was recorded from April to June, 2019. The population of *Pyrilla perpusilla* was also recorded during months of August and September, 2019. The natural enemies in sugarcane included *Cotesia* sp., *Fulgorecia melanoleuca Trichogramma chilonis* and *T. japonicum* was observed in sugarcane fields.

Cotton: The population of sucking pests (*Bemisia tabaci*, *Thrips tabaci*, *Amrasca bigutulla*) was recorded, though the population remained low to moderate throughout the season.

Maize: The incidence of maize stem borer, *C. partellus* was observed in low to moderate proportions during June and July, 2019. In Punjab, the first incidence of fall armyworm was recorded on August 15, 2019 at Maize Research Area, ICAR-Indian Institute of Maize, Research, Ladhowal (Ludhiana) and at farmer's field on August 17, 2019 in Hoshiarpur district. Most of the available maize grain crop was at maturity stage and low to moderate population of FAW was recorded on late sown crop. In fodder maize, wherein staggered sowing of the crop was there, the population of fall armyworm was recorded (up to 30%) during September and October months. No FAW incidence was recorded on any other crop. During 2020-21, the maize crop will be monitored for FAW incidence in collaboration with concerned Maize Scientists and Extension Specialist of PAU, during spring and ensuing *kharif* season regularly. Besides maize, its incidence will also be monitored on other crops in Punjab.

Rice: The incidence of stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* and brown planthopper, *Nilaparvata lugens* was recorded to be low during August to October, 2019. Spiders, dragonflies, damselflies, *Trichogramma* spp. and *Stenobracon* sp. were among the natural enemies observed in paddy fields.

Wheat: Low to moderate damage of pink stem borer, *Sesamia inferens* in the month of December, 2019 only, as no population of this pest was observed in the remaining crop season. Aphid population also remained low and was recorded in the month of March, 2020. *Coccinella septempunctata* was the predatory beetle recorded on the wheat crop.

Mustard: Low population of mustard aphid, *Lipaphis erysimi* was recorded during March, 2020. Among natural enemies, grubs and adults of *C. septempunctata* population was also recorded on the crop.

Locust Status: On the basis of surveys conducted for locust occurrence during the months of January and February, 2020, low population of Desert Locust, *Schistocerca gregaria* was recorded in Fazilka, Ferozepur and Bathinda districts of Punjab, bordering Rajasthan and Pakistan. But at all locations, the pest was timely managed by the Department of Agriculture, Punjab with the help of District Administration. However, it was observed that fresh breeding may take place in the coming months, requiring continuous monitoring.

Table 24. Status of insect pests and natural enemies on different crops during 2019-20

Crop	Insect pests	Status	Natural enemies recorded
Sugarcane	*Chilo infuscatellus*	Low (April to June)	*Cotesia* sp, *Trichogramma chilonis, T. japonicum, Fulgorecia melanoleuca*
	Scirpophaga excerptalis	Low (April to June)	
	Chilo auricillius	Low to moderate (July to November)	
	Pyrilla perpusilla	Low to moderate (August to October)	
Cotton	*Bemisia tabaci*	Low to moderate (June to September)	*Chrysoperla* sp. (eggs and grubs), Spiders
	Thrips tabaci	Low to moderate (May-June)	
	Amrasca bigutulla	Low (July-August)	
Maize	*Chilo partellus*	Low to moderate (June-July)	Spiders, *T. chilonis, Coccinella septempunctata*
	Spodoptera frugiperda	Low to moderate (August to October)	
Rice	*Scirpophaga incertulas*	Low (August)	Spiders, dragonflies, damselflies, *Trichogramma* spp, *Stenobracon*
	Cnaphalocrocis medinalis	Low (August-September)	
	Nilaparvata lugens	Low (September-October)	
Wheat	*Sesamia inferens*	Low to moderate (December)	*Coccinella septempunctata*
	Rhopalosiphum maidis, R. padi, Sitobion miscanthi, S. avenae	Low (March)	
Mustard	*Schistocerca gregaria*	Low (January-February)	*C. septempunctata*

	Lipaphis erysimi	Low (March)	

II.1.12 SKUAST, Jammu

Crop Pest Outbreak since the inception of this centre, June, 2019

S. No.	Month	Date	Locations	Crop	Problems noticed & Level of incidence
1.	June 2019	04/07/19	Bassi Kala, Mandal/Taluk: Bari Brahmna District: Samba	Sorghum, Maize Mango Cucurbits Guava Citrus	Stem borer – Moderate Scale - Severe on Malta, but nil on Dasheri Mealy bug – Low Fruitflies – Severe Hoppers – Moderate Anthracnose – 10–15% Powdery Mildew – 5–10% Fruitflies – Severe Bitter Gourd – Downy Mildew – 25 – 30% Pumpkin - Alternaria leaf blight - 20 – 25% Bottle gourd – Viral diseases - 15 – 20% Round gourd and summer squash – Wilt – 45 – 50% Scale, Mealy bug – low Guava wilt – 5-10% Leaf miner – Moderate Citrus greening – 5-10%
			DeraGanotra Mandal/Taluk: Patti District:- Samba	Sorghum, Maize Mango	Stem borer – Moderate Turticum leaf blight – 5-10% Fruitflies – Severe Hoppers – Moderate

					Anthracnose – 10 – 15%
2.	July 2019	16/07/19	Painthi Mandal/Taluk: Samba District: Samba	Pear, Mango, Peach, Guava	Scarabid beetles (identified as Flower chafer beetle; *Oxycetoniaversicolor*, Cowboy beetle; *Chondropyga dorsalis* (*Diaphoniadorsalis*),Green June beetle (*Cotinisnitida*), May beetle or June Beetles or June bugs (*Phyllophaga*spp.), Japanese beetle (*Popilia japonica*) - Severe Anthracnose – 5 to 10%
		14/07/19	Samla, District:- Samba	Cucurbits and Okra	Scarabid beetles (identified as Flower chafer beetle; *Oxycetoniaversicolor* (Fabricius) and Cowboy beetle; *Chondropyga dorsalis*(*Diaphoniadorsalis*) - Severe
3.	August 2019	29/08/19	Rajpura, District:- Samba	Okra Brinjal	Fruit and Shoot borer, hoppers, whiteflies – Severe Yellow vein mosaic – 25-35% Fruit and Shoot borer - Severe
			Palura, Mawa, Chaliyari, Chachwal, BadiChak District:- Samba	Rice Maize	Leaf folder – Low Brown leaf spot - less than 5% Stem borer – Low Turcicum leaf blight – 10-15%
4.	September2019	04/09/19	Tarore, Sarore District: Samba	Maize	Stem borer – Low Turcicum leaf blight – 20-25%

		06/09/19	KharaMadana, Khaner Mandal/Taluk**:** Purmandal District: Samba	Maize	Stem borer – Low Turcicum leaf blight – 40-45%
		11/09/19	Barori**,** District: Samba	Mungbean Urdbean	Hairy Caterpillar, *Spodopteralitura*, Whiteflies – Severe Yellow Mosaic – 20-25%
		16/09/19	BalloreMandal/Taluk: Samba District: Samba	Rice	Grasshoppers – Moderate Brown spot of rice – 25-30%
		25/09/19	Nazwal, Mandal/Taluk: Sarore, Bari Brahmana District: Samba	Cauliflower	Seedling blight of cauliflower - 25-30%
5.	October, 2019	25/10/19	Karan Bagh, GadiGarh Mandal/Taluk: District: Jammu	Mango Guava	Mango hoppers – Low Anthracnose – 15% Brown spot with necrosis – 75% affected leaves
		31/10/19	DeoliMandal/Taluk: Bishnah District: Samba	Rice	Grasshoppers – Low Brown spot of rice – 30-40%
6.	November2019	19/11/19	Khoulpur, Govindgarh, Rajpura, Raipur Mandal/Taluk: Ramgarh, Rajpura District: Samba	Cruciferous vegetable crops	*Pieris brassicae* - Moderate
7.	December, 2019	-	Bari Brahmana, Samba	Wheat, Mustard, Chickpea	- Nil -
8.	January, 2020	30/02/2020	Samba, Sumb, Painthi Mandal/Taluk: Samba District: Samba	Chickpea	Gram pod borer – Low Wilt – 15-20%
9.	February, 2020	28/02/2020	Dhiansar, Sarore, Murarichak, Palli, Dolian, Kartholi, MeenCharkan,	Wheat	Wheat aphid - Low to Moderate Yellow rust – 10-15%

			Ismailpur, Bari Khud, Badori, Patti, Ranjari, Raya, Suchani, Baguna **Mandal/Taluk:**Bishnah, Bari Brahmana **District:** Samba	Gobhi, Sarson, Mustard	Mustard aphid - Moderate to Severe White Rust – 15-20%

Fig 27. Maize stem borer damage

Fig 28. Symptoms of Turcicum leaf blight

Fig 29. Turcicum blight incidence on maize cob

Fig 30. Death of the central shoot due to Turcicum leaf blight

Fig 31. Group of beetles infesting pear fruit Infested fallen fruits

Fig 32. Fallen Scarab beetles after insecticidal spray

Fig 33. Brown spot of rice **Fig 34. White Rust of Mustard**

Fig 35. Wheat aphid **Fig 36. Wheat Yellow Rust**

II.1.13 TNAU, Coimbatore

Survey and surveillance of natural enemiesof tomato pinworm, *Tuta absoluta*

Survey was conducted to assess the occurrence of tomato pinworm, *Tuta absoluta* in tomato growing areas of Coimbatore district *viz.*, Pichanoor, Patchapalayam, Thekarai and Thudiyalur. In Thekarai, the leaf damage was 12.0 per cent whereas no fruit damage was observed. In Patchapalayam, the fruit damage was 3.00 per cent. In Pichanoor, 12.00 and 4.00 per cent leaf and fruit damages were observed respectively.

Monitoring and record of incidence of papaya mealy bug and its natural enemies

The infestation of papaya mealybug, *Paracoccus marginatus* was noted in crops like papaya, tapioca, mulberry, guava, and cotton. The incidence of papaya mealybug was recorded in Coimbatore, Erode, Tirupur, Salem, Karur, Villupuram, Karur, Cuddalore and Namakkal districts of Tamil Nadu. A maximum of 7.50 per cent infested papaya trees were observed in Erode District. Cassava fields in Salem and Namakkal Districts had the infestation level of 2.00 to 20.00 per cent. The papaya mealy bug natural enemies *viz.*, *Acerophagus papayae* and *Cryptolaemus montrouzieri* have been found in all papaya and cassava fields while *Pseudleptomastix Mexicana* was seen in Cassava fields at Kalkurichi, Namakkal District.

Monitoring and record of incidence of fall armyworm and its natural enemies

The natural enemies *viz.*, *Trichogramma* sp., *Cryptolaemus montrouzieri*, *Chrysoperla zastrowi sillemi*and parasitoids of papaya mealybug were collected. The egg parasitoid of maize fall army wormwas identified as *Trichogramma chilotrae*. The activity of *Chelonus* sp was observed on maize fall army worm eggs in field conditions. Staphylinids and spiders were also observed in maize fields.

Other predators *viz.*,*C. montrouzieri*, and *Chrysoperla zastrowi sillemi* were seen on mealybug, scales, whiteflies, psyllids infesting the crops namely tapioca, papaya, brinjal, bhendi, curry leaf and coconut.

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

The incidence of sugarcane woolly aphid was observed in Kanjikovil, Erode District during December 2019. The natural enemies *viz.,Dipha aphidivora*, *Micromus igorotus* and *Encarsia* sp. Were found in the woolly aphid colonies.

Surveillance for pest outbreak and alien invasive pests

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

Woolly whitefly in guava

In guava orchard (11°07'N, 76°59' E) in Coimbatore, woolly whitefly (*Aleurothrixus floccosus*) (Maskell) (Hemiptera: Aleyrodidae), was observed during October 2019. Predators *viz., Cryptolaemus montrouzieri* and *Mallada desjardinsi* were found feeding on the woolly whitefly.

Bondar's Nesting Whitefly in coconut

Bondar's Nesting Whitefly *Paraleyrodes bondari* (Hemiptera: Aleyrodidae) was observed in coconut gardens in Coimbatore, Erode and Tirupur Districts since October 2019. *Mallada boninensis* was found feeding onBondar's Nesting Whitefly.

II. 1.14 UAS, Raichur

During 2019-20 roving survey were conducted in north eastern Karnataka and the incidence of fall armyworm and its natural enemies were collected and submitted the parasitoids for identification to ICAR- NBAIR, Bengaluru. Roving survey conducted in six districts of North Eastern Karnataka indicated that FAW incidence was negligible in rabi Jowar (M 35-1). On Maize the number of egg patches per plant and number of larvae were highest compared to rabi jowar. We have also collected the parasitoids and they were submitted to ICAR- NBAIR, Bengaluru for identification and in Koppal district the natural epizootic of *Metarhizium rileyi* was noticed (Table 25).

Table 25 . Incidence of fall armyworm, *Spodoptera frugiperda* in North Eastern Karnataka during 2019-20

Districts	Crop	No. of egg patches/plant	No. of larvae/plant	Parasitisation (%)	Mycosis (%)
Bidar					
	Maize	1.36	1.28	-	1.50
	Jowar	1.14	0.46	-	-
Kalaburgi					
	Maize	1.18	1.36	-	-
	Jowar	1.06	0.54	-	-
Yadagir					

	Maize	1.24	1.28	2.00	3.50
	Jowar	1.18	0.72	-	-
Raichur					
	Maize	1.42	1.44	2.00	4.50
	Jowar	1.36	0.66	-	-
Ballari					
	Maize	1.34	1.24	-	-
	Jowar	1.28	0.76	-	-
Koppal					
	Maize	1.64	1.32	3.50	10.50
	Jowar	1.36	0.64	-	-

II. 1.15 YSPUHF, Solan

Surveillance for alien invasive pests *Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis, Tuta absoluta* and others

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 *Tuta 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 from May to October, 2019 at 17 locations of districts Solan, Sirmour, Mandi, Kullu, Bilaspur, Shimla, Kangra, Kinnaur and Lahaul & Spiti of Himachal Pradesh (Table 26). The pest was recorded at at nine locations namely Nauni, Dharja, Nainatikkar, Mangarh, Sarahan, Mandi, Bajaura, Ghumarwin and Bajaura. At these locations 22 to 77 per cent of the tomato plants were infested with *T. absoluta* with the number of mines/leaf/infested plant varying from 0-5 and fruit damage varying from 0-3 per cent at different locations. The pest was also monitored on potato and brinjal, but no incidence of the pest was recorded on these crops except Nauni where the pest was found on potato, however the incidence was negligible. 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 26. 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	40-64	0-2	1-2
2	Dharja	Solan	35 - 57	1-3	1-3
3	Nainatikkar	Sirmaur	31 - 46	0-3	1-2
4	Sarahan	Sirmaur	22 - 68	0-4	0-2
5	Mangarh	Sirmaur	24 - 59	1-3	0-2
6	Mandi	Mandi	44-67	0-5	1-3

7	Bajaura	Kullu	41-66	0-4	0-3
8	Ghumarwin	Bilaspur	28-49	0-5	0-1
9	Duttnagar (Rampur)	Shimla	Nil	Nil	Nil
10	Kufri	Shimla	Nil	Nil	Nil
11	Theog	Shimla	Nil	Nil	Nil
12	Palampur	Kangra	56-77	1-4	0-2
13	Rekongpeo	Kinnaur	Nil	Nil	Nil
14	Powari	Kinnaur	Nil	Nil	Nil
15	Kangosh	Kinnaur	Nil	Nil	Nil
16	Hurling	Kinnaur	Nil	Nil	Nil
17	Kaja	Lahaul & Spiti	Nil	Nil	Nil

Monitoring and record of incidence of papaya mealybug and its natural enemies onpapaya and other alternate hosts

The intensity of papaya mealybug infestation was ranged between nil to very low.The parasitoid *viz*., *Acerophagus papayae* was noticed parasitizing mealybug.

III. BIOLOGICAL CONTROL OF PLANT DISEASES USING ANTAGONISTIC ORGANISMS

PAU, Ludhiana

III.1. Evaluation of microbial antagonists for the management of foot rot of kinnow caused by *Phytophthora* spp.

The experiment to evaluate the microbial antagonists against foot rot of citrus was conducted at Gangian (District Hoshiarpur) during 2019. There were six treatments:

1. *Pseudomonas fluorescens* (NBAIR-PFDWD) (Talc formulation)
2. *Pseudomonas fluorescens* Commercial (Talc formulation)
3. *Trichoderma viride* Commercial (Talc formulation)
4. *Trichoderma harzianum* Commercial (Liquid formulation)
5. Chemical control (Curzate M-8 @ 25g/10 litre water/ tree)
6. Untreated control.

There were four replications per treatment and three trees per replication. The Kinnow trees showing symptoms of foot rot were selected and treated with different antagonist formulations. The treatments were given as soil application @ 2.5 kg completely dried FYM enriched with 100 g of formulation /tree). The trees were recorded for initial lesion size on trunk and final lesion size was recorded in December 2019. The per cent recovery in final lesion size over untreated control was worked out. The observation of number of foot rot infected plant and yield parameter were recorded.

The number of foot rot infected plants selected initially per treatment were non-significant. The per cent recovery in final lesion size was highest in chemical control (45.5%) over untreated control followed by NBAIR-PFDWD *Pseudomonas fluorescens* and *Trichoderma* *harzianum* with 24.59 and 21.94 percent recovery, respectively. The mean number of fruits per plant was maximum (504.0) in chemical treatment (Curzate M8) followed byNBAIR-PFDWD *Pseudomonas fluorescens*(482.0). However, minimum number (382.0) of fruits was recorded in untreated control. The yield per tree was 99.5kg and 109.5kg in *Pseudomonas fluorescens*NBAIR-PFDWD and chemical control, respectively.

It may be concluded that NBAIR-PFDWD *Pseudomonas fluorescens*was found to be significantly better than other bio-formulations for the management of foot root disease in Kinnow and also recorded higher yield.

Table 27: Evaluation of microbial antagonists against foot rot disease in *Kinnow* during 2019

Treatments	Initial lesion size (cm)	Final lesion size(cm)	Percent recovery in final lesion size over control
Pseudomonas fluorescens NBAIR-PFDWD (Talc)	143.75	128.00[b]	24.59
Pseudomonas fluorescens commercial (Talc)	146.75	135.00[c]	20.47
Trichoderma harzianum commercial (liquid)	149.00	132.50[c]	21.94
Trichoderma viride (Talc)	147.50	133.00[c]	21.64
Curzate M-8	148.00	92.50[a]	45.50
Untreated control	150.00	169.75[d]	-
CD (p=0.05)	3.40	3.50	
CV(%)	11.53	10.70	

Table 28. Evaluation of microbial antagonists against foot rot disease in *Kinnow* on yield during 2019

Treatments	No. of foot rot infected plants initially	Number of fruits per tree	Yield/tree (Kg)
*Pseudomonas fluorescens*NBAIR-PFDWD (Talc)	12	482	99.5[b]
Pseudomonas fluorescens commercial (Talc)	12	463	93.5[c]
Trichoderma harzianum commercial (liquid)	11	445	92.5[c]
Trichoderma viride commercial(Talc)	12	428	89.75[c]
Curzate M-8	12	504	109.5 [a]
Untreated control	12	382	70.25[d]
CD (p=0.05)	NS	11.8	5.41
CV (%)		12.74	13.88

DRYSRHU, AMBAJIPETA

III. 2 *In vivo* evaluation of effective bio control agents against *Phytophthora* Pod rot management in cocoa

a. Pod Rot:

Layout: RBD
Treatments: 4
T_1- Spraying of *Trichoderma reesei* spore suspension (2 × 10^6 cfu/ml) (2-3 sprays at 15 days intervals during monsoon period)
T_2 – Soil application of 50 g of *T. reesei* along with 5kg Neem cake (once before onset of monsoon)
T_3 – Spraying of copper oxychloride (3g/litre of water) (2-3 sprays at 15 days intervals during monsoon period)
T_4- Untreated Control
Replications: 6
Location: Avidi village, Kothapet Mandal, East Godavari district
Observations to be recorded: Number of healthy pods, Number of infected pods, Percent reduction of the infected pods & Yield.

b. Stem Canker

Layout: RBD
Treatments: 5
T_1- Chiseling of canker area on the stem and application of *T. reesei*paste formulation (2 × 10^6 cfu/ml) on the chiselled area. Need based application at quarterly intervals
T2 - Chiseling of canker area on the stem and application of *T. reesei* coir pith cake (one cake per each canker spot) Need based application at quarterly intervals
T_3 - Soil application of 50 g of *T. reesei* along with 5kg Neem cake (once)
T_4- Chiseling of canker area on the stem and application Copper oxychloride paste formulation based on the lesion size
T_5- Untreated Control
Replications: 5
Location: HRS, Ambajipeta, Ambajipeta Mandal, East Godavari district
Observations to be recorded: Percent reduction in canker lesion size and Yield data

Results: Pod Rot

The experiment was carried at Avidi village of East Godavari district. Based on the experiment results it was found that T_3 - Spraying of copper oxychloride (3g/litre of water) @ 2 sprays at 15 days interval during monsoon season resulted in reduction in pod rot from 39.3 percent to 83.3% and T_1 - Spraying of *T. reesei* spore suspension (2 × 10^6 cfu/ml) @ 2 sprays at 15 days interval during monsoon season led to reduction in pod rot from 32.5 percent to 81.8 % on par with each other, where as in control pod rot percent increased from 35.2% to 30.8% . In T_2- Soil application of 50 g of *T. reesei* along with 5kg Neem cake (once before onset of monsoon) had resulted in reduction in pod rot from 45.5 to 53.3 per cent. Non significant differences were observed among the treatments with regards to percent reduction of infected pods.

Table 29 : Evaluation of bio control agents against *Phytophthora* Pod rot in cocoa

TreatmentNo.	Treatment details	Pre treatment data			Post treatment data		
		Number of healthy pods	**Number of infected pods**	**Percent reduction of infected pods**	**Number of healthy pods**	**Number of infected pods**	**Percent reduction of infected pods**
T_1	Spraying of *T. reesei* spore suspension (2×10^6 cfu/ml)	37	12	32.5	11	9	81.8
T_2	Soil application of 50 g of *T.reesei* along with 5kg Neem cake	22	10	45.5	15	8	53.3
T_3	Spraying of copper oxychloride (3g/litre of water)	28	11	39.3	12	10	83.3
T_4	Untreated Control	37	13	35.2	13	4	30.8
	SEm			2.01			1.83
	CD			NS			NS

b. Stem Canker

Results:

Based on the results found thatT_{2-} Chiseling of canker area on the stem and application of *T. reesei* coir pith cake (one cake per each canker spot) led to reduction in lesion size by 40.6 cm followed by T_{1-} Chiseling of canker area on the stem and application of *T. reesei* paste formulation (2×10^6cfu/ml) on the chiseled area with 32.4 cm reduction. The chemical treatment T_{4-} Chiseling of canker area on the stem and application Copper oxychloride paste formulation however resulted in 30.9 cm. There was an increase in lesion length in control. Non-significant differences were observed among the treatments with regard to lesion length among the treatments.

Table 30. Evaluation of bio control agents against stem canker in cocoa

Treatment. No.	Treatment details	Pretreatment data	Post treatment data	
		Lesion length (cm)	Lesion length (cm)	Reduction in lesion size (cm)
T_1	Chiseling of canker area on the stem and application of *T. reesei* Paste formulation (2 × 10^6 cfu/ml) on the chiselled area.	63.8	31.4	32.4
T_2	Chiseling of canker area on the stem and application of *T. reesei* coir pith cake (one cake per each canker spot)	108.4	67.8	40.6
T_3	Soil application of 50 g of *T. reesei* along with 5kg Neem cake	48.6	34.6	14.0
T_4	Chiseling of canker area on the stem and application Copper oxychloride paste formulation based on the lesion size	147.5	116.6	30.9
T_5	Untreated Control	89.8	97.8	
	SEm	7.17	5.15	
	CD	NS	NS	

<u>AAU, Anand</u>

III. 3 Demonstration of *Trichoderma* sp. for the management of *Fusarium* wilt in pigeon pea

Objective: To demonstrate the use of *Trichoderma* sp. for the management of *Fusarium* wilt in pigeonpea
Year of commencement: *Kharif* 2018-19
Location: Farmer's field, Sankheda taluka, Vadodara district
Area: 1 ha

Variety	:	Local variety (Daftari)
Treatments	:	T1: Seed treatment – *T. harzianum* @ 10g/ kg seeds Soil application of *T. harzianum* @ 10 kg/ha multiplied in 250 kg FYM 10 days prior to its application and apply at the time of sowing T2: Farmer's practice
Replications	:	Each block was divided into 8 equal sized units and each unit was considered as replication (each unit= one replication)
Observations	:	Disease incidence (%) Plant stand (%) at 30, 45, 60, 75, 90 DAS Yield (q/ha)

The demonstration experiment is under progress at farmer's field, Manjrol (Sankheda)Vadodara district. Results of this demonstration experiment will be presented in annual biocontrol workshop.

GBPUAT, Pantnagar

III.4. Evaluation of bio-agent consortium in glasshouse (pot experiments) and in field for crop health management in chickpea

Experimental Details of Glasshouse

Variety	:	PG-186
Layout	:	CRD
Pot Size	:	2 kg
Treatment	:	11
Replication	:	03
Seed biopriming	:	29.08.19
Sowing	:	30.08.19
Treatments	:	1. Th-17 + Psf-173 2. Th-17+ Psf-2 3. Th-17 + Th-14 4. Th-14+ Psf-2 5. Th-17 (positive control) 6. Th-14 (positive control) 7. Psf-2 (positive control) 8. Psf-173 (positive control) 9. PBAT-3 (Standard check) 10. Carbendazim (chemical check) 11. Control
Mode of application		❖ Spoil inoculationwith *Fusarium* (5g inoculum/pot) one week before sowing followed by bioagents along with vermicompost (10g/100g) per pot. ❖ Three foliar sprays cum drench with bioagents 1st at 30 days after sowing and 2nd and 3rd at 45 days interval

A glasshouse experiment was conducted at Plant Pathology Department, Pantnagar during Rabi 2019-20 to test the efficacy of bio-agents consortium plant growth parameters.Soil was pre inoculated with*Fusarium* (5g inoculum/pot) one week before sowing. The bio-agents were applied asseed bio-priming (10g /kg seed), soil application (10 gformulation with 100 g vermicompost) and as three foliar sprays (10g /lit). The experiment was laid out in a completely randomized design in three replications (pot size 2kg).

45 DAS: Th17, Th17+Psf2, Psf2 and Control

45DAS: Carbendazim Psf173 PBAT3 Th14 & Control

View of experiment of bioagent consortium in glasshouse in Chickpea

Fig 37. Evaluation of bio-agents consortia in glasshouse

Mixed formulations showed better performance than individual isolates with respect to their effect on seed germination. In mixed formulation treatments maximum germination percentage was observed by PBAT-3 (84.29%) followed by Th14+Psf2 (83.00%), Th17+Psf173 (82.58%), Th17+Psf2 (81.92%), carbendazim (81.00%) and Th17+Th14 (80.93%). However minimum germination percentage was recorded in control (66.00%). Maximum root length was observed with PBAT-3 (21.70 cm) followed by Th17+Psf173 (19.96 cm),Th17+Th14 (19.37 cm) and carbendazim (17.53 cm) which were significantly different from each other including control (14.26 cm). Maximum shoot length was observed with Th17+Psf2 (42.90 cm) which was statistically at par with PBAT-3 (41.80 cm) followed by Th17+Psf173 (40.00 cm), carbendazim (38.60 cm). Minimum shoot length was observed in control (34.86 cm). Maximum fresh weight was observed with Th17+Psf173 (0.28 gm) which was statistically at par with PBAT-3 (0.27 gm) but significantly better than control (0.15 gm). Maximum shoot weight was observed with PBAT-3 (2.84 gm) which was significantly different from Th17+Psf173 (2.62 gm), Th17+Psf2 (2.60 gm) and Th17+Th14 (2.57 gm) including Control (1.74 gm). Maximum dry root weight was observed with Th17+Psf173 & Th17+Psf2 (0.18 gm) which did not differ significantly from Th17+Th14, Th-17 & PBAT-3 (0.17 gm) but proved better than control (0.13 gm). Significantly maximum shoot dry weight was observed with Th17+Psf173 (0.85 gm), which was statistically at par with PBAT-3 (0.84 gm) but was better than Control (0.43 gm) (Table 31).

Table 31. Efficacy of bioagent consortia under glass house condition

Treatments	Germination % (15 DAS)	Plant Length(cm)		Fresh Weight (gm)		Dry Weight (gm)	
		Root	Shoot	Root	Shoot	Root	Shoot
Th17+Psf173	82.58	19.96	40.00	0.28	2.62	0.18	0.85
Th17+Psf2	81.92	17.43	42.90	0.21	2.60	0.18	0.78
Th17+Th14	80.93	19.37	38.46	0.21	2.57	0.17	0.73
Th14+Psf2	83.00	17.13	37.43	0.23	2.22	0.16	0.76
Th-17	70.50	15.80	37.53	0.18	2.04	0.17	0.75
Th-14	73.21	16.51	35.70	0.18	2.17	0.16	0.74
Psf-2	79.31	15.61	36.33	0.19	1.97	0.16	0.67
Psf-173	71.26	15.68	35.73	0.18	1.93	0.16	0.72
PBAT-3	84.29	21.70	41.80	0.27	2.84	0.17	0.84
Carbendazim	81.00	17.53	38.60	0.19	1.96	0.16	0.66
Control	66.00	14.26	34.86	0.15	1.74	0.13	0.43
C.D.		0.96	1.59	0.02	0.18	0.01	0.02
C.V.		3.27	2.45	4.44	4.80	3.16	1.32

*05 counted seeds were sown in each pot

Experimental Detail of Field

Variety	:	PG-186
Layout		RBD
Plot size	:	3X2 m^2
Treatment	:	11
Replication	:	03

Seed biopriming	:	01.12.2019
Sowing	:	02.12.2019
Harvesting	:	Contd.
Treatments	:	1.Th-17 + Psf-173 2. Th-17+ Psf-2 3. Th-17 + Th-14 4. Th-14+ Psf-2 5. Th-17 (positive control) 6. Th-14 (positive control) 7. Psf-2 (positive control) 8. Psf-173 (positive control) 9. Th-14 + Psf-173 (Standard check) 10. Carbendazim 11.Control (Negative control)
Methodology		❖ Seed bio-priming @ 10g/kg seed ❖ Field application of bioagents along with vermicompost (50g/500g) per plot. ❖ Three foliar sprays cum drench (10 gm/l) with bioagents 1st at 30 days after sowing and 2nd and 3rd at 45 days interval

Plant mortality and mature plant wilt under Field: Maximum percentage of seed germination was observed with PBAT-3 (86.08 %), while minimum percentage of seed germination was recorded in control (69.24 %). Maximum plant stand, 60 DAS and 120 DAS respectively was recorded with consortium Th17+Psf173 (208.74 and 205.38) followed by PBAT-3 (205.50 and 203.83), carbendazim (204.20 and 201.53), Th-14 (204.17 and 201.50), which did not differ significantly from each other but were better thancontrol (167.48 and 163.48)
Minimum number of mature plant wilt at 120 DAS was observed with consortium Th17+Psf173 (3.24), while maximum in control (6.10) after 120 days of sowing (Table 32).

Table 32: Efficacy of promising bio-agents against seed and plant mortality and mature wilt of chickpea in field

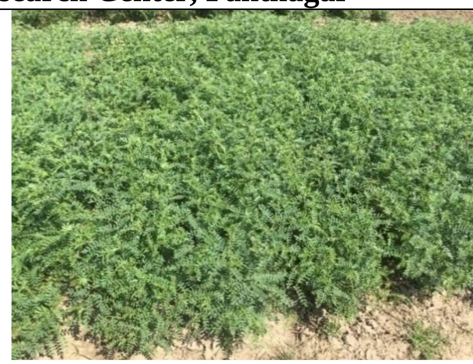
Treatment	Plant Stand (15 DAS)	Germination (15 DAS)	Healthy Plant Stand		Mature plant wilt (120 DAS)	Total plant stand (120 DAS)	Wilted plant
			60 DAS	120 DAS			
	(No.)	(%)	(No.)	(No.)	(No.)	(No.)	(%)
Th17+Psf173	211.61	84.64	208.74	205.38	3.24	208.62	1.50
Th17+Psf2	206.85	82.74	200.92	199.25	4.22	203.47	2.04
Th17+Th14	210.23	84.09	202.20	199.53	4.38	203.91	2.08
Th14+Psf2	210.49	84.19	203.33	199.00	4.05	203.05	1.92
Th-17	205.81	82.32	199.37	196.71	5.12	201.83	2.48
Th-14	207.76	83.10	204.17	201.50	5.14	206.64	2.47
Psf-2	206.20	82.48	199.56	198.56	5.45	204.01	2.64
Psf-173	204.24	81.69	198.83	197.83	5.16	202.99	2.52

PBAT-3	215.07	86.08	205.50	203.83	3.27	207.10	1.52
Carbendazim	209.37	83.74	204.20	201.53	4.16	205.69	1.98
Control	173.10	69.24	167.48	163.48	6.10	169.58	3.52
CD (0.05)	4.64	-	5.02	5.84	0.33	-	-
CV (%)	1.31	-	1.46	1.73	4.31	-	-

*250 counted seeds were sown in each plot

Field view of chickpea trial at Crop Research Center, Pantnagar

Control



PBAT 3 (Th14+ Psf173)

Wilting symptoms in chickpea plant

Field Observation

Fig 38. Evaluation of bio-agent consortium in field for crop health management in chickpea at Crop Research Centre

III. 7 Large scale field demonstration of bio-control technologies

Rice (var. Pant Dhan 4, Sharbati, Narendra 359, &PR 113)

Large scale field demonstrations of bio-control technologies were conducted at the end of 90farmersfrom 10 villages namely, Dumkabangar, Jaggibangar, Haripur, Dhanpur, Radheypur, Umapati, Nathupur, Devlamalla, Kuwarpur and Devlatalla of Haldwani block, District Nainital, covering an area of 126.0 ha. The farmers' acreage ranged from 0.3 - 3.5 ha. Seven quintals PBAT-3 (Th-14 + Psf-173)was distributed to the farmers to conduct field trials.Polysheet(2x10m to each farmer) was distributed for nursery soil solarization.Neem oiland pheromone traps using *Scirpophaga incertulas* lures were distributed for the control of stem borer in rice. Knapsack sprayers for bioagents application and other safety items like hand gloves and mask were also distributed to them.

A total of 14 visits at different locations were made to provide inputs, technical knowledge, monitoring, data and trainings.

Bio- control technologies adopted by the farmers were as under:

i. Soil solarization of nursery beds before sowing seeds.
ii. Seed treatment with Bioagent (10 g/kg seed).
iii. Seedling root dip treatment (10 g/lit water) for 30 min. prior to transplanting.
iv. Four foliar sprays with PBAT-3 (10 g/lit water) at 15 days interval.
v. Three sprays of Neem oil @ 3ml/l at 10 days interval.
vi. Installation of Pheramone traps for shoot borer @ 9 traps/ ha.

Sheath blight (*Rhizoctonia solani*), Bacterial leaf blight (*Xanthomonas oryzae*) and False smut (*Ustilaginoidea virens*) diseases were observed at all the locations. (Table 33)

Table 33. Occurrence of rice diseases at farmer's fields

Disease	Cause	PBAT-3	Conventional Practices
		Disease severity (%)	Disease severity (%)
Sheath blight	*Rhizoctonia solani*	0	1-2
False smut	*Ustilaginoidea virens*	2-3	10-12
Bacterial blight	*Xanthomonas campestris* pv. *oryzae*	5-7	10-15

An average yield of 65.0 q/hawas recorded by the farmers adopting bio-control technologies along with need- based organic practices as compared to an average yield of 50.0 q/ha by the farmers adopting conventional practices for the management of insect pests and diseases. Maximum yield of 88 q/ha was obtained where the farmers used PBAT-3 along with pheromone traps & spray of neem oil. (Table 34)

Table 34. Cost-benefit ratio with biocontrol practices and with conventional practices

Management Practices	Cost of production per ha	Yield	Selling price	Total selling price	Net Profit	Cost benefit ratio
	(Rs.)	(q/ha)	(Rs.)	(Rs.)	(Rs.)	
Biocontrol Practices	32,500.00	65.0	1815.00	1,17,975.00	85,475.00	1: 2.63
Conventional practices	36,500.00	50.0	1815.00	90,750.00	54,250.00	1: 1.49

RARS, Kumarakom

III. 8. Screening of promising fungal and bacterial isolates for management of anthracnose disease in cowpea (KAU)

Variety	:	Lola (KAU variety)
Layout	:	Randomized Block Design.
Plot size		8x5 m
Treatments	:	T1: *Pichia guilliermondi* (Y-12) @ 2x10^8 spores/ml – 10ml/lt T2: *Hanseniaspora uvarum*(Y-73)2x10^8 spores/ml – 10ml/lt T3: *Trichoderma harzianum* (Th-3) @ 2x10^8 spores/g – 10g/lt T4: *Trichoderma viride* (KAU strain) @ 2x10^8 spores/g – 10g/lt T5: *Pseudomonas fluorescens* (KAU strain) @ 1x10^8 spores/g -20g/L T6: Carbendazim @ 2g/kg (seed treatment) and 2g/L spray T7: Untreated control
Replications		Four
Mode of application	:	Seed treatment with bioagents (10g or 10 ml/kg) followed by foliar spray @15, 30 and 45 DAS
Observations	:	Disease incidence, Yield (kg/plot)

Table 34. Efficacy of fungal and bacterial isolates on anthracnose disease of yard long bean (RARS, Kumarakom, 2019- 2020)

Treatment	Percent Disease Index*	Percent reduction over control	Yield (kg/plot)
T1: *Pichia guilliermondi* (Y-12) @ 2x10^8 spores/ml – 10ml/lt	65.49 (54.09)	10.61	14.90
T2: *Hanseniaspora uvarum*.(Y-73)2x10^8 spores/ml – 10ml/lt	32.12 (34.47)	56.16	16.01
T3: *Trichoderma harzianum* (Th-3) @ 2x10^8 spores/g – 10g/lt	23.91 (29.25)	67.36	17.48
T4: *Trichoderma viride* (KAU strain) @ 2x10^8 spores/g – 10g/lt	24.17 (29.07)	67.01	16.36
T5: *Pseudomonas fluorescens* (KAU	24.53	66.52	16.90

strain) @ 1x10^8 spores/g -20g/L	(28.98)		
T6: Carbendazim @ 2g/kg (seed treatment) and 2g/L spray	11.67 (19.47)	84.07	22.45
T7: Untreated control	73.26 (59.02)	-	11.44
CD (0.05)	8.66		NS
CV	16.04		25.42

*Values in parantheses are arcsine transformed

It is found that the fungal isolate *Trichoderma harzianum* (Th-3), *T. viride* (KAU strain) and *Pseudomonas fluorescens* (KAU strain) were effective in controlling yard long bean anthracnose to about 67 per cent. The next effective treatment was *Hanseniaspora uvarum*(Y-73). Higher yields were obtained in biocontrol agent treated plots but were not significant when compared to control.

BIOLOGICAL CONTROL OF CROP PESTS

CEREALS

1. RICE

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

The experiment was undertaken with the treatment details mentioned hereunder

T1: *Steinernemacarpocapsae* (NBAIR strain) @1.2x10^9 IJs ha^{-1}
T2: *Heterorhabditisindica* (NBAIR strain) @1.2x10^9 IJs ha^{-1}
T3: *Bacillus thuringiensis* (NBAIR strain) 2g/l
T4: *Beauveriabassiana* (NBAIR strain) @10^8 spores/ml
T5: *Metarhizium anisopliae* (NBAIR strain) @10^8 spores/ml
T6: Flubendiamide 25g.a.i.ha^{-1}
T7: Untreated control

1.1.1 ANGRAU, Anakapalle

Rice leaf folder damage recorded low in chemical treatment, flubendiamide (1.17 rolled leaves/sq.m)followed by *B. thuringiensis*(1.67rolled leaves/sq.m); *H. indica* (2.17 rolled leaves/sq.m); *S. carpocapsae* (2.33 rolled leaves/sq.m) and high in control (6.16 rolled leaves/sq.m) (**Table 35).** Yellow stem borer damage as per cent dead heart and white ear recorded high in control (3.17 %DH, 15.33 % WE/sq. m) and low in flubendiamide (1.33 % DH, 3.33% WE/sq. m) followed by *B. thuringiensis* (1.17 %DH, 6.67 %WE/sq. m). Percent reduction in leaf folder and stem borer damages over untreated control was high in flubendiamide followed by *B. thuringiensis.* Grain yield recorded high in chemical treatment,flubendiamide 40SC @ 0. 1 ml/lt (3.65t/ha) followed by *B. thuringiensis* (NBAIR strain) (3.4 t/ha) and *B. bassiana* (3.27t/ha), *S. carpocapsae* (3.25 t/ha) and low in control (2.82 t/ha.

Table 35. Effect of entomopathogens on incidence of rice stem borer and leaf folder

Treatment	**aves /sq.m**					**% DH or WE/sq.m**			**Grain yield (t/ha)**	**Per cent increase in yield over control**
	Before 1st spray	**After 1st spray**	**After 2nd spray**	**Per cent reduction after 1st spray**	**Per cent reduction over control**	**After 2nd spray**	**At harvest**	**Per cent reduction over control**		
S. carpocapsae	5.17	4.16	2.33	54.93	63.19	1.0	10.33	32.62	3.25	15.25
H. indica	5.33	4.67	2.17	59.28	65.72	1.33	9.33	39.14	3.13	10.99
Bt (NBAIRstrain)	3.0	2.66	1.67	44.33	73.62	1.17	6.67	56.49	3.4	20.57
B. bassiana	4.16	4.0	3.33	19.95	63.19	1.5	8.17	46.71	3.27	15.96
M. anisopliae	4.0	3.0	2.67	33.25	57.82	1.67	9.67	36.92	3.1	9.93
Flubendiamide 40 SC @ 0.1 ml/lt	5.0	3.20	1.17	76.66	81.52	1.33	3.33	78.28	3.65	29.43
Untreated control	5.16	4.33	6.16	22.67 (increase)		3.17	15.33		2.82	
CD(0.05)	NS	NS	2.36			1.23	8.74		NS	
CV%	22.12	23.00	30.21			15.10	13.02		13.9	

1.1.2 KAU, Thrissur

The experiment was evaluated at RARS, Pattambi during November, 2019 to February, 2020. The treatments were imposed at 10, 25 and 45 DAT. Mean number of dead hearts and rolled leaves as well as mean yield per plot were recorded. Stem borer infestation remained low during the vegetative growth stage. However, during twenty-one days after the third spray, *B. thuringiensis*,*H. indica, S. carpocapsae* and *B. bassiana*,recorded 1.66, 3.00, 4.00and 4.66deadhearts/ m^2respectively and were on par with each other and significantly superior to the untreated control. Plots treated with*B. thuringiensis*, *H. indica*, and *B. bassiana*had significant lower number of dead hearts (3.66, 5.00 and 8.33/ m^2 respectively) was recorded at28 days after the third spray(**Table 36**). The entomopathogenic bacterium, *B. thuriengiensis* consistently recorded the lowest number of dead hearts throughout the study. However, both *H. indica*and *B. bassiana*were equally effective in preventing stem borer damage, suggesting viable alternatives for insecticides in managing stem borer in rice.

The leaf folder infestation remained at low during the study with no significant variation among the treatments. Significant variation among the treatments was observed only at 28 days after the third spray. The lowest mean number of 1.66/m^2 rolled leaves was recorded in plots treated with flubendiamide, which was on par with both *H. indica* as well as *M anisopliae* with mean values of 2.66 and 3.33 rolled leaves /m^2. The pooled analysis of the two years(2018-19 and 19-20) data showed that the plots treated with bioagents namely,*B.thuringiensis*, *B. bassiana* and *H.indica* have consistently recorded low stem borer and leaf folder damages that are comparable or less than the insecticide check.

Table 36. Effect of entomopathogens on incidence of Dead Hearts/ White ear heads in rice

Treatment	Mean number of dead hearts/ white ear heads/m^2											Yield (kg/m^2)
	Pre count	7DAS1	14DAS1	7DAS2	14DAS2	7DAS3	14DAS3	21DAS3	28DAS3	35DAS3	42DAS3	
T1:*S.carpocapsae*	0	0 (0.70)	1.33 (1.17)	1.33 (1.17)	1.00 (1.17)	0 (0.70)	2.00 (1.55)^{bc}	4.00 (1.80)^{c}	11.00 (3.27)^{bc}	17.66 (4.18)	17.66 (4.16)	0.29
T2: *H. indica*	0	0.33 (0.87)	2.33 (1.54)	2.33 (1.54)	2.00 (1.48)	0.66 (1.05)	1.00 (1.17)^{c}	3.00 (1.66)^{c}	5.00 (2.16)^{cd}	13.66 (3.29)	14.33 (3.56)	0.25
T3: *Bt*	0	0 (0.70)	1.66 (1.46)	1.66 (1.46)	2.33 (1.65)	1.00 (1.17)	0.33 (0.87)^{c}	1.66 (1.27)^{c}	3.66 (1.82)^{d}	12.00 (3.36)	13.00 (3.56)	0.22
T4: *B.bassiana*	0	0 (0.70)	2.00 (1.46)	2.00 (1.46)	0 (0.70)	0 (0.70)	1.00 (1.22)^{c}	4.66 (2.14)^{bc}	8.33 (2.87)^{bcd}	18.33 (4.14)	19.00 (4.30)	0.21
T5: *M.anisopliae*	0	0 (0.70)	1.33 (1.26)	1.33 (1.26)	1.00 (1.17)	1.33 (1.26)	5.33 (2.35)^{a}	16.00 (3.88)^{a}	16.00 (3.94)^{ab}	39.66 (6.05)	27.00 (5.10)	0.32
T6:Flubendiamide	0	0 (0.70)	0.33 (0.87)	0.33 (0.87)	0 (0.70)	0.33 (0.87)	4.00 (2.12)^{ab}	15.66 (3.89)^{a}	21.66 (4.64)^{a}	25.66 (5.02)	24.66 (4.94)	0.16
T7: Control	0	0 (0.70)	1.33 (1.28)	1.33 (1.28)	0.66 (0.99)	0 (0.70)	5.00 (2.28)^{a}	11.66 (3.35)^{ab}	17.00 (4.01)^{ab}	31.66 (5.45)	30.33 (5.31)	0.16
CD@ 5%		NS	NS	NS	NS	NS	0.688	1.465	1.314	NS	NS	NS

*Figures in the parenthesis are √x+1 transformed values

1.2 Management of plant hoppers through BIPM approach in organic basmati rice (PAU) / rice (ANGRAU, PDKV)

The experiment was undertaken with the treatment details mentioned hereunder

T1: BIPM

- Recommended variety
- Optimum time of transplanting
- Green manuring and FYM
- Optimum plant spacing
- Alleyways of 30 cm after 2 m
- Water management: Alternate wetting and drying
- Erection of straw bundles (spiders) @ 20/ha
- Increasing floral diversity through flowers on bunds –Marigold, Balsam
- One spray each of neem (Azadirachtin 50000 ppm @ 200 ml/ ha) and *B. bassiana/M. anisopliae* @ 2.5 kg/ha)

T2: Farmers practice

T3: Untreated control

1.2.1 PAU, Ludhiana

The planthoppers' population in BIPM and control plots observed at Kheri Kalan village (Barnala) during September-October 2019 are shown in **Fig 39**.The population of planthoppers in BIPM and control plots was 1.93 and 3.00 per hill resulting in a reduction of 35.8 per cent over control. Basmati yield was 32.00 q/ha in BIPM as compared to 30.50 q/ha in untreated control with an increase of 4.92 per cent (**Table 37).**

Table 37. Mean population of planthoppers and spiders in BIPM and control treatments in organic *basmati* rice during 2019

Treatments	*Plant hoppers population / hill	Per cent reduction over control	Spider population / hill	Basmati yield (q/ha)	Per cent increase over control
BIPM	1.93	35.83	0.96	32.00	4.92
Untreated control	3.00	-	0.68	30.50	-

* Mean of eight observations

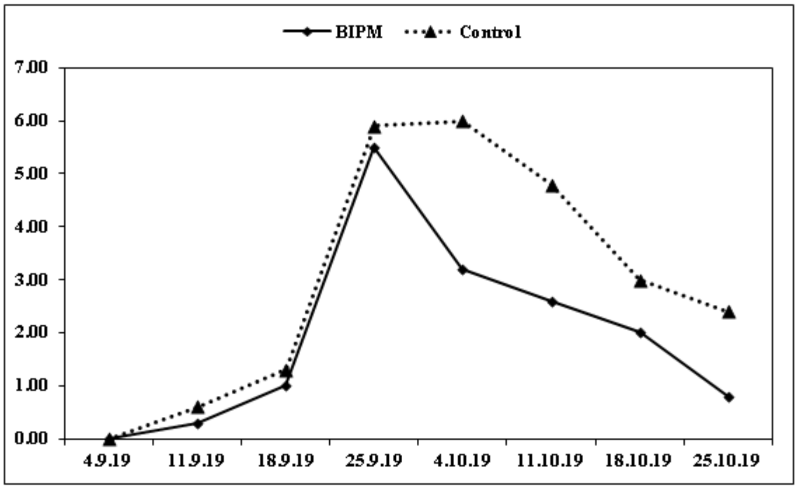


Fig 39. Population of planthoppers in BIPM and control treatments during *Kharif*, 2019

1.2.2 ANGRAU, Anakapalle

Hopper population was low in BIPM plot (0.48 hoppers/hill) and farmers practice plot (0.78 hoppers/hill) compared to control plot (3.5 hoppers /hill) (**Table 38**). Reduction in hopper population after first spray was high in BIPM plot (83.6 %) and farmers practice plot (77.38%) and increase in hopper population was recorded in control(20.14 %). Grain yield recorded high in BIPM practice i.e., *B. bassiana* (5g/lt), *M. anisopliae* (5 g/lt)as (3.85 t/ha) compared to farmer's practice i.e., monocrotophos (1.6 ml/lt) and acephate (1.5 g/lt) as (3.63 t/ha) and untreated control (3.52 t/ha). Percent yield increase in BIPM practice over control was 52.77%.

Table 38. Management of plant hoppers through BIPM approach in rice

Treatment	Number of hoppers/hill			Per cent reduction in hopper population		Grain yield (t/ha)	Percent increase in yield over control
	Before first spray	After first spray	After second spray	After 1st spray	After 2nd spray		
T1-BIPM	81.28	13.33	0.48	83.6	96.4	3.85	52.77
T2- Farmers' practice*	39.78	9.0	0.78	77.38	91.33	3.63	44.05
T3- Control	43.2	51.9	33.5	20.14 (increase)	22.45	2.52	
CD(0.05)	NS	4.15	1.74			NS	
CV%	14.95	19.33	17.24			16.12	

*Two sprayings-monocrotophos @ 2.2 ml/lt followed by acephate @1.5 g/lt.

1.2.3 PDKV, Akola

The experiment conducted with the variety PKV HMT during July 2019 revealedsignificant differences among the treatments. The population of GLHwas significantly low in BIPM plot recording 2.37 GLH/hill at 114 DAT. The data on brown planthopper revealed that BIPM treatment was significantly mosteffective in reducing BPH population recording 12.30 and 7.45 BPH/ hill at 114 DAT and pooled mean respectively.The data on yield also recorded significant differences among the treatments.Maximum yield of 25.44 q/ha was recorded in farmers' practice followed by BIPM recording 23.24 q/ha, both being at par with each other and significantly superior over untreated control (Table 39).

Table 39 Effect of different treatments on peak and pooled mean incidence of GLH and planthoppers and yield of rice crop (*Kharif* 2019)

Treatment	Incidence of GLH, WBPH and BPH (No./hill)						Yield (q/ha)
	GLH		WBPH		BPH		
	Peak 114DAT	Pooled Mean	Peak 114DAT	Pooled Mean	Peak 114DAT	Pooled Mean	
BIPM	2.37 (1.70)	1.29 (1.34)	2.30 (1.67)	1.56 (1.44)	12.30 (3.58)	7.45 (2.82)	23.24
Farmers' practice#	2.61 (1.76)	1.20 (1.30)	2.68 (1.78)	1.47 (1.40)	14.67 (3.89)	6.95 (2.73)	25.44
Control	2.57 (1.75)	1.36 (1.36)	2.72 (1.79)	1.68 (1.48)	17.21 (4.21)	8.63 (3.02)	19.67
'f' test	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**
SE (M)	0.01	0.01	0.01	0.01	0.04	0.01	0.74
CD at 5%	0.04	0.02	0.04	0.02	0.11	0.05	2.28
CV (%)	2.04	1.06	2.20	1.05	2.51	1.36	8.60

#-Thiamethoxam 25 WG @ 2 g/10 Lt. on 60DAT; Fipronil 5% SC @ 20 ml / 10 Lt. on 75 DAT
Figures in parentheses are corresponding values of square root (n+0.5) transformation

1.3 Large scale bio-intensive pest management on rice [ANGRAU, PAU, KAU, AAU-A, AAU-J)

The experiment was undertaken with the treatment details mentioned hereunder

T1: BIPM

- Seed bio-priming *P. fluorescens*@ 10g/kg of seeds.
- Seedling dip with *P. fluorescens* 2% solution.

- Spray of Azadirachtin 1500 ppm @ 3ml/litre at 45 and 65 DAT against foliar diseases and sucking pests.
- Installation of bird perches.
- Spray of *P. fluorescens* @ 1.5 kg/ha against foliar diseases
- Release of *T. japonicum*@ 1,00,000/ha (6 releases) at 10 days interval starting from 25 DAT for stem borer and leaf folder infestation.

T2: Farmers' practice
T3: Untreated control

1.3.1 ANGRAU, Anakapalle

Demonstration were conducted in 14 acres at farmers' fields of Narayanapuram, Srikakulam district and Kumili, Vasadi, Vizianagaram districts during *kharif*, 2019. Rice stem borer damage was low in BIPM package (1.78 % DH) compared to farmers practice (6.25 % DH and 7.12% WE) (Table 40). Leaf folder was low (1.44%) in BIPM plot and high in farmers practice (7.48%). Grain yield recorded high in BIPM plot (5.38 t/ha) than farmers practice plot (4.9 t/ha). Adoption of BIPM package in three locations resulted in 9.65 % increased yields (5.38t/ha) with high incremental ratio of 12.04 compared to farmers practice (4.9 t/ha) with low incremental ratio of 4.62 (Table 40).

Table 40. Pest and disease incidence in bio-intensive pest management of rice in farmers fields

Location	Stem borer damage (%DH & % WE)		Leaf folder damage (%)		Sheath blight (%)		Grain yield t/ha		Benefit cost ratio		Incremental benefit cost ratio	
	BIPM	FP*	BIPM	FP*	BIPM	FP*	BIPM	FP*	BIPM	FP*	BIPM	FP*
Kumili, Vizianagaram Dist. (5 ac.)	1.33 DH	5.17 DH 7.63 WE	1.16	8.64	3.3	4.12	5.06	4.68	2.53	1.40	10.35	3.29
Vasadi, Vizianagaram Dist. (5 ac)	1.89 DH	6.47 DH 6.22 WE	1.22	6.93	4.84	5.25	5.45	4.87	1.68	1.46	14.75	6.87
Narayanpuram, Srikakulam Dist. (4 ac)	2.13 DH	7.12 DH 7.5 WE	1.94	6.88	4.62	5.18	5.62	5.16	1.73	1.55	11.02	3.71
Average	1.78 DH	6.25 DH 7.12 WE	1.44	7.48	4.15	4.85	5.38	4.90	1.98	1.47	12.04	4.62

*Application of carbofuran 3G@10 kg/ha at 30 DAT against stem borer; Two sprayings with chlorpyriphos @2.5 ml/lt, acephate @ 1.5 g/lt against leaf folder; Two sprays with propiconazole @ 1ml/lt against sheath blight.

Table 41.Comparison of bio-intensive pest management with farmers practice in rice

Location	**Percent reduction in stem borer damage in BIPM over FP**	**Percent reduction in leaf folder damage in BIPM over FP**	**Percent reduction in sheath blight incidence in BIPM over FP**	**Percent increase in grain yield BIPM over FP**
Kumili, Vizianagaram Dist. (5 ac.)	89.6	86.11	19.9	8.12
Vasadi, Vizianagaram Dist. (5 ac)	85.11	82.4	7.81	11.91
Narayanpuram, Srikakulam Dist. (4 ac)	85.43	71.80	10.81	8.91
Average	86.71	80.1	14.43	9.65

1.3.2 PAU, Ludhiana

Large scale demonstrations on the bio-suppression of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *C. medinalis* were conducted in fields of Patiala, Sangrur, Kapurthala, Jalandhar, Gurdaspur, Amritsar, Ludhiana, Ferozepur and Fazilka districts in *basmati* rice (var. Pusa 1121) over an area of 248 acres. The augmentative releases of *T. chilonis* and *T. japonicum* each @ 1,00,000 parasitoids/ha are compared with the untreated control. The data were recorded on dead hearts due to stem borer and leaf damage due to leaf folder at vegetative state (45 and 60 DAT). White ear incidence was recorded a week prior to harvest. Grain yield was recorded on plot basis and economics was worked out.

Based on the mean of all locations (Table 42), mean dead heart incidence in biocontrol fields was 1.40 and 1.80 per cent at 45 and 60 DAT, respectively. The corresponding figures in untreated control were 3.00 and 4.20 per cent. The mean reduction of dead heart incidence in release fields was 55.24 per cent over control. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields as compared to untreated control. The mean incidence of white ears was significantly lower in biocontrol field (2.24 %) as against untreated control (4.47 %) resulting in a reduction of 49.89 per cent (**Table 43**). Grain yield in biocontrol field (28.70 q/ha) was significantly better as compared to 26.00 q/ha in untreated control, respectively. The yield increase in release fields was 10.38 per cent more than untreated control. It can be concluded that five releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha resulted in lowering incidence of rice insect pests and higher grain yield in organic *basmati* rice with an additional benefit of Rs. 7760/- per hectare.

Table 42. **Large scale demonstrations of biocontrol of rice pests in organic *basmati* rice during 2019**

Treatments	DH (%)				Leaffolder damaged leaves (%)			
	45 DAT	60 DAT	Mean	Per cent reduction over control	45 DAT	60 DAT	Mean	Per cent reduction over control
Biocontrol*	1.40[a]	1.80[a]	1.60[a]	55.24	1.80[a]	1.99[a]	1.90[a]	56.77
Untreated control	3.00[b]	4.20[b]	3.60[b]	-	4.00[b]	4.80[b]	4.40[b]	-

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

Table 43: Large scale demonstrations of biocontrol of rice pests and yield of organic *basmati* rice during 2019

Treatments	White ears incidence (%)	Per cent reduction over control	Paddy yield (q/ha)	Per cent increase over control	Net returns over control (Rs./ha)
Biocontrol*	2.24[a]	49.89	28.70[a]	10.38	7760.0
Untreated control	4.47[b]	-	26.00[b]	-	

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

1.3.3 KAU, Thrissur

Large scale validation of BIPM in rice was carried out over an area of 150 ha in Alathur panchayath of Palakkad district during November 2019 to March 2020. Adoption of BIPM practices led to substantial reduction in infestation by major pests. The dead heart as well as white ear symptoms in BIPM plots was approximately 75 per cent lower than in non BIPM plots.The population of natural enemies was also higher in BIPM plots. Greater parasitoid activity was also observed in BIPM plots. The yield obtained from BIPM plots, at 7619.5 kg/ha was approximately 58 per cent more than that obtained from non BIPM plots(4600 kg/ha). The cost of cultivation also was nearly nine per cent lower in the BIPM plots. The increased yield as well as reduced cost resulted in an increase in profit by Rs 82,910/ha. The cost benefit ratio, at 2.90 for BIPM fields compared quite favorably with 1.66 for non BIPM fields (Table 44).

Table 44 . Comparison between BIPM and non BIPM plots at Alathur Panchayath

Sl. No.	Particulars	BIPM plot (Mean no/m^2)	FP* (mean no/m^2)
1.	Dead hearts	1.125	5.0
2.	White ear heads	4.0	18.0
3.	Leaf roller damage	1.69	4.0
4.	Rice bug	7.38	15.0
5.	Spiders	18.93	15.0
6.	Other predators	26.5	19.0
7.	Parasitoids	21.31	9.0
8.	Yield (kg/ha)	7619.5	4800.00

9.	Returns per ha (@Rs. 26.95/kg)	Rs. 2,05,345/-	Rs. 1,29,360/-
10.	Cost of cultivation (Rs/ha)	Rs. 70,775/-	Rs. 77,700/-
11.	Net return per ha	Rs. 1,34,570/-	Rs. 51,660/-
12.	Benefit cost ratio	2.90	1.66

*Flubendiamide applied twice at 25 g.a.i ha^{-1}against lepidopteran insects; Imidacloprid/thiamethoxam @50g a.i ha^{-1}against rice bug.

1.3.4 AAU-Anand

Large scale demonstration on biointensive pest management in rice crop (var.Suryamoti) was carried in Farmer's field at Runaj, Sojitra taluk, Anand district(2 ha.) during *Kharif* 2019. The rice leaf folder, *C. medinalis*infestation was recorded during the experimental period. In BIPM package, the number of damaged leaves/10 hill was 7.62, 9.37 and 12.12 at 30, 45 and 60 DAT, respectively. Whereas in farmers practice the number of damaged leaves/10 hill was 7.37, 11.75 and 14.50 at 30, 45 and 60 DAT, respectively. Significantly lower damaged leaves were recorded at 45 and 60 DAT in BIPM package as compared to farmers' practice. With regard to the yield, the two treatments found at par with each other. It can be concluded that use of BIPM strategies resulted in lower incidence of rice leaf folder and higher grain yield(Table 45).

Table 45. Large scale demonstration of BIPM package in rice

Treatments	Leaf folder damaged leaves/10 hill			Grain yield (q/ha)
	30 DAT	45 DAT	60 DAT	
BIPM package	7.62 ± 2.13	9.37 ± 1.92	12.12 ± 1.72	36.80 ± 2.66
Farmers' practice	7. 37 ± 1.06	11.75 ± 2.31	14.50 ± 1.69	35.69 ± 2.63
t-test	NS	*	*	NS
P value	0.77	0.04	0.01	0.41

1.3.5 AAU- Jorhat

The trial was undertaken at Neul Gaon (Panchayat –Thekorgora), Jorhat district in 50 ha areaof rice variety Ranjit. Result of the experiment (Table 46) indicated that the mean dead heart incidence in BIPM package was 5.77 and 3.78 per cent at 45 and 60 DAT, respectively as against 4.34 and 2.82 per cent in farmers practice plot. Both the treatments were significantly superior to untreated control plots at 45 DAT (5.96%) and 60 DAT (6.78%). In case of WEH, the mean incidence was2.93% in BIPM package and was superior to farmer's practice plots (3.88%) at 100 DAT without any significant difference in between the treatments. Leaf folder damage in BIPM package was 3.78 and 3.22 per cent at 45 and 60 DAT, respectively as compared to 3.50 and 2.86 per cent farmers practice and 7.70 and 6.31 per cent in untreated control. Maximum yield of 4976.3 Kg/ha was registered in BIPM plots which was significantly higher compared to 4393.5 and 3357.0 Kg/ha in farmers practice and untreated control plots, respectively. The net returns over control in BIPM package were Rs. 76752.00 as compared to Rs. 61294.00 in farmers practice plot with cost: benefit ratio of 1:3.37 and 1:2.30, respectively (Table 47).

Table 46 Observation on incidence of Dead heart, WEH, LFDL and grain yield of rice in *kharif* 2019

Treatments	Dead heart (%)		WEH (%)	LFDL (%)		Grain yield (kg/ha)
	45DAT	60DAT	100DAT	45DAT	60DAT	
BIPM Package	5.77	3.78 [a]	2.93 [a]	3.78 [a]	3.22 [a]	4976.3 [a]
Farmers practice*	4.34	2.82 [a]	3.88 [a]	3.50 [a]	2.86 [a]	4393.5 [b]

Untreated control	5.96	6.78 [b]	6.35 [b]	7.70 [b]	6.31 [b]	3357.0 [c]
CD = 0.05	NS	1.25	2.17	1.46	1.96	205.88

*Four alternate spray with chlorpyrifos @ 2.5ml/litre and quinalphos @2.5ml/litre was applied at 30, 40 , 50 and 60 DAT.

Table 47. 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	4976.3	1619.3	99520.00	22768.00.00	76752.00	3.37
Farmers' practice	4393.5	1036.5	87870.00	26576.00	61294.00	2.30
Untreated control	3357.0	-	67140.00			

Rs. 20/kg of rice grain

1.4 (i) Evaluation of bio-agent consortium in glasshouse (pot experiments) and in field for crop health management in rice (GBPUAT, Pantnagar)
Experimental Details of Glasshouse

Variety	:	Rice: Pant Dhan-4
Layout	:	CRD
Pot size	:	2 kg
Treatment	:	11
Replication	:	03
Seed biopriming	:	22.08.2019
Sowing	:	23.08.2019
Treatments	:	1. Th-17 + Psf-173 2. Th-17+ Psf-2 3. Th-17 + Th-14 4. Th-14+ Psf-2 5. Th-17 (positive control) 6. Th-14 (positive control) 7. Psf-2 (positive control) 8. Psf-173 (positive control) 9. PBAT-3 (Standard check) 10. Carbendazim (Chemical check) 11. Control (Negative control)
Mode of application	:	❖ Soil was pre inoculated with *Rhizoctonia* (5g inoculum/pot) one week before sowing followed by application of bioagents along with vermicompost (10g/100g) per pot ❖ Three foliar sprays (10 gm/l) along with drenching (10 gm/l) with bioagents (1st at 30 days after sowing and 2nd and 3rd at 45 days interval)

To test the efficacy of potential bioagents and their consortia, a glasshouse experiment was conducted at Plant Pathology Department, Pantnagar. Soil was pre inoculated with*Rhizoctonia* (5g inoculum/pot) one week before sowing. The bio-agents were applied asseed bio-priming (10g /kg seed), soil application (10 gformulation with 100 g vermicompost) and as three foliar sprays (10g /lit). The experiment was laid in a completely randomized design in three replications (pot size 2kg).

***Rhizoctinia* inoculum**

Soil pre-inoculated with *Rhizoctinia*

Application of bioagent along with vermicompost

Sowing of bioprimed seeds in pot

View of experiment of bioagent consortium in glasshouse in Rice

45 DAS: Control & Th 17 (Single Treatment)

45 DAS: Control & Th17+Th14 (Consortium)

45 DAS: Control & Th14+Psf173 (Consortium)

Fig 40. Pictorial presentation of evaluation of bio-agents consortia in glasshouse

Mixed formulation showed better performance over individual isolates with respect to its effect on seed germination and plant growth. In mixed formulations treatments, highest germination percentage was observed in PBAT-3 (87.00 %) followed by, Th17+Psf-173 (84.66%), Carbedazim (81.83%) as compared to control (61.00%). Maximum root length was observed with PBAT-3 (22.08 cm) followed by Th14+Psf-2 (21.83 cm), Psf-173 (21.50 cm), which did not differ significantly with each other but was significantly better than the control (15.08 cm). Maximum shoot length was recorded with PBAT-3 (56.25 cm), which was statistically at par with Th17+Psf173 (56.08 cm), Th17+Psf2 (55.31 cm) but significantly different from other treatments including control (38.40 cm). Maximum root fresh weight was observed with PBAT-3 (0.94 gm) followed by Th17+Psf2 & Th14+Psf2 (0.93 gm) which did not differ significantly with each other but was superior over control (0.20 gm). Maximum shoot fresh weight was recorded with PBAT-3 (3.33 gm) which was statistically at par with Th17+Psf173 (3.32 gm), Th17+Psf2 (3.38 gm) but significantly better than the control (1.04 gm). Maximum dry weight was observed with PBAT-3 (0.84 gm) that was statistically at par with Th17+Psf2 (0.83 gm) but significantly better than control (0.15 gm). Maximum shoot dry weight was observed with Th17+Th14 (1.62 gm) followed by PBAT-3 (1.53 gm), Th14+Psf2 (1.14 gm) which was significantly different from each other including control (0.36 gm) (Table 48).

Table 48. Efficacy of promising bio-agents onplant growth of rice (var. Pant Dhan-4)

Treatments	**Seed Germination % (10 DAS)**	**Plant Length(cm)**		**Fresh Weight (gm)**		**Dry Weight (gm)**	
		Root	**Shoot**	**Root**	**Shoot**	**Root**	**Shoot**
Th17+Psf173	84.66	19.66	56.08	0.88	3.32	0.62	0.62
Th17+Psf2	72.16	20.23	55.31	0.93	3.38	0.83	0.64
Th17+Th14	77.66	18.00	53.75	0.88	2.36	0.61	1.62

Th14+Psf2	73.50	21.83	51.45	0.93	2.83	0.52	1.14
Th-17	77.66	18.25	53.66	0.29	2.34	0.53	0.56
Th-14	73.83	21.33	48.08	0.34	1.49	0.18	0.61
Psf-2	77.66	17.16	48.75	0.42	1.46	0.18	0.46
Psf-173	73.50	21.50	46.25	0.61	1.60	0.73	1.48
PBAT-3	87.00	22.08	56.25	0.94	3.33	0.84	1.53
Carbendazim	81.83	17.41	45.25	0.80	1.94	0.60	0.94
Control	61.00	15.08	38.40	0.20	1.04	0.15	0.36
C.D.		1.57	1.92	0.02	0.11	0.06	0.04
C.V.		4.76	2.24	1.73	2.89	6.34	2.52

*06 counted seeds were sown in each pot.

Experimental Detail of Field

Variety	:	Rice: Pant Dhan-4
Layout	:	RBD
Plot size	:	3x2 m^2
Treatment	:	11
Replication	:	03
Seed biopriming	:	06.06.2019
Nursery	:	07.06.2019
Transplanting **Harvesting**	: :	18.07.2019 15.10.2019
Fertilizer	:	$N_{120}P_{60}K_{40}$
Treatments	:	1. Th-17 + Psf-173 2. Th-17+ Psf-2 3. Th-17 + Th-14 4. Th-14+ Psf-2 5. Th-17 (positive control) 6. Th-14 (positive control) 7. Psf-2 (positive control) 8. Psf-173 (positive control) 9. PBAT-3 (Standard check) 10. Carbendazim (Chemical check) 11. Control (Negative control)
Mode of application	:	❖ Seed bio-priming with bio-agent (10g/kg seed)- 06.06.19 ❖ Application of ZnSo4 (0.5%)+Urea (2%) in nursery beds on 29.06.19 ❖ Application of 100g vermicompost mixed with 10g bioagent formulation (in each plot) in nursery beds on 05.07.19 ❖ Application of Urea as broadcasting 08.07.19 ❖ Seedling dip treatment (10g/lit) for 30 min. before transplanting-18.07.19 ❖ Application of 1kg vermicompost mixed with 20g bioagent formulation through broad casting on 18.08.18 (30 DAT) ❖ Foliar sprays of bio-agents 1stspray at 30 DAT, 2nd and 3rd (at 45 days interval) ❖ Spray of Neem oil @ 2%(3 sprays at 7 days interval) for the management of stem borer. ❖ Use of pheromone traps for stem borer management after 15 days of transplanting.

A field experiment was conducted at Crop Research Centre, Pantnagar to test efficacy offour potential bio-agents, their consortium along with one standard check (PBAT-3) and one chemical check (Carbendazim) on rice (var. Pant Dhan-4)for disease management and yield improvement. The bio-agents were applied asseed bio-priming (10g /kg seed), soil application (10 gformulation with 100 g vermicompost), seedling root dip treatment (10g /lit) and as three foliar sprays (10g /lit). For the management of stem borer need-based neem oil sprays and pheromone traps were used. The experiment was laid in a randomized block design in three replications with a plot size of 3 m x $2m^2$.

Rice Nursery at Crop Research Centre, Pantnagar

Root Dip Treatment of Rice Seedling with Bioagents before Transplanting

Transplanted Rice in field

Foliar spray of bioagent

Field view of Rice trial at Crop Research Center

Fig 41. Evaluation of consortia of fungal and bacterial isolates for crop health management of rice at Crop Research Centre, Pantnagar

Occurrence of Foliar diseases:

Two diseases viz. Sheath blight and Brown spot were observed in the experimental field during the cropping season. Minimum Sheath blight (*Rhizoctonia solani*) disease severity was recorded with PBAT-3 (30.30%) followed by Carbendazim (30.58 %), Th17+Psf-2 (31.00%) and Th17+Psf-173 (31.29), which did not differ significantlyfrom each other but were significantly better than control (37.30%). Minimum percentage of Brown spot (*Drechslera oryzae*) formerly known as *Helminthosporium oryzae* infected panicle/hill was observed with Carbendazim (42.26%) which was statistically at par with PBAT-3 (42.77%) and followed by Th17+Psf-173 (44.17%). However, maximum percentage of brown spot infected panicle/hill was recorded with control (57.10%). (Table 49)

Fig. 3: Sheath Blight of Rice **Brown Spot of Rice**

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

Treatment	**Sheath Blight**		**Brown Spot**	
	Disease Severity (%)	Disease Reduction (%)	Infected panicle /hill (%)	Disease Reduction (%)
Th17+Psf173	27.00 (31.29)	16.11	51.81 (46.01)	19.42
Th17+Psf2	26.56 (31.00)	16.89	48.58 (44.17)	22.64
Th17+Th14	31.57 (34.17)	8.39	51.99 (46.12)	19.22
Th14+Psf2	30.60 (33.57)	10.00	51.99 (46.12)	19.22
Th-17	32.42 (34.69)	6.99	51.99 (46.12)	19.22
Th-14	32.57 (34.78)	6.75	52.07 (46.16)	19.15
Psf-2	29.65 (32.95)	11.66	51.72 (45.96)	19.50
Psf-173	30.67 (33.61)	9.89	54.07 (47.31)	17.14
PBAT-3	25.48 (30.30)	18.76	46.14 (42.77)	25.09
Carbendazim	25.90 (30.58)	18.00	45.25 (42.26)	25.98
Control	36.76 (37.30)		70.53 (57.10)	
C.D.	1.33		0.89	
C.V.	2.35		1.12	

*Figures in parenthesis are angular transformed values

Plant vigour and Yield

Maximum plant height was recorded with Th17+Psf-173 (63.06 cm) followed by Th17+Psf-2 (63.00 cm), Th14+Psf-2 (63.20 cm) and Psf173 (61.95 cm) and was though at par with other treatments but was significantly superior than control (57.94 cm). Maximum number of tillers/plant was observed in Th17+Th14 (18.66 tillers/plant) which was statistically at par with Th -17 (16.86 tillers/plant), Th-14 (16.86 tillers/plant) and PBAT-3(17.66 tillers/plant) but significantly better than control (14.66 tillers/plant). Maximum yield was obtained with PBAT-3 (53.83 q/ha) followed by Th17+Psf-173 (53.50 q/ha), Th17+Psf2 & Th14+Psf-2 (53.33 q/ha) and was superior than control (41.00 q/ha). Maximum test weight of grain was recorded by Psf-173 (28.51 g) which though did not differ significantly with Th-17 +Psf-173 (28.18 g), Th14 + Psf-2 (28.50 g), Th17+Th14 (28.41 g) yet was better than control (21.41 g). (Table 48)

Table 48. Efficacy of promising bio-agents onplant growth and yield of rice (var. Pant Dhan-4)

Treatment	Plant height (120 DAT) (cm)	Tillers/hill (90 DAT) (no.)	Yield			
			Yield / plot (6 m^2) (kg)	Yield (q/ha)	Increase in yield (%)	Test wt (g) (1000 no)
Th17+Psf173	63.06	15.66	3.21	53.50	30.48	28.18
Th17+Psf2	63.00	16.33	3.20	53.33	30.07	28.29
Th17+Th14	61.33	18.66	3.10	51.66	26.00	28.41
Th14+Psf2	63.20	15.33	3.20	53.33	30.07	28.50
Th-17	61.44	16.86	3.03	50.50	23.17	27.80
Th-14	60.73	16.86	3.03	50.50	23.17	28.03
Psf-2	60.86	16.33	3.10	51.66	26.00	27.35
Psf-173	61.95	15.33	3.11	51.83	26.41	28.51
PBAT-3	60.01	17.66	3.23	53.83	31.29	28.13
Carbendazim	59.80	15.66	3.00	50.00	21.95	25.93
Control	57.94	14.66	2.46	41.00		21.41
C.D.	1.29	2.10	0.15			1.14
C.V.	1.23	7.55	2.90			2.44

1.5 Bio-intensive pest management on rice at the Institutional Research Farm of IGKV, Raipur. (IGKV, Raipur)

The experiment was undertaken with the treatment details mentioned hereunder

T1: BIPM
- Seed treatment with *T. harzianum* @15g/Kg
- Seedling dip with *P. florescens* 2% solution
- Spray of Azadirachtin1500ppm @3ml/litre at 45 & 65 DAT against foliar and sucking pests
- Erection of bird perches
- Spray of *P. florescens* @ 1.5 Kg/ha against foliar diseases
- Release of *T.japonicum*@ 1,00,000/ha (6 releases at 10 days interval starting from 25 DAT)

T2: Farmers practice
- Seed treatment with Bavistin @ 2gm/Kg
- Spray of Chlorcyper

T3: Control.

The result of the experiment with Swarna variety indicated that maximum % dead heart caused by stem borer was recorded in control (12.20) and minimum (8.50) in BIPM treatment. Similarly maximum white ear head was recorded in control (20.51) and minimumin BIPM **(Table 49).** The incidence of other rice pets like leaf folder, caseworm, hispa, and BPH were also low in BIPM treated plot compared with the control.Significant maximum grain yield (31.56 kg/plot) was obtained in BIPM treatment followed by farmer's practice (28.88 kg/plot) and control (25.25 kg/plot). 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 49. Observation on incidence of rice stem borer (Dead heart and WEH)

Treatments	Pre -treatment	Dead heart %	White ear head %
T1- BIPM	6.10 (10.21)	8.50 (16.93)	15.58 (23.234)
T2- FP	7.40 (12.57)	11.24 (19.574)	18.01 (25.09)
T3- Control	8.61 (13.59)	12.20 (20.40)	20.51 (26.91)
CD	NS	0.943	0.522
SEm$\pm$	1.549	0.308	0.171

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

The experiment was carried out during June 2019-September 2019 at Parasuvaikkal, Padasekhara Samithi, Parassala Block in an area of 0.50 hectare of rice variety Jyothi. Data recorded on the mean larval count revealed that the mean population per plot ranged from 18.75 to 25.50 per 10 hills/plot prior to treatment, while it was reduced to 0 to 5 after two sprayings. There was no leaf folders at 14 DAS in plots treated with chitin enriched oil formulation of *Beauveria*, KAU isolate, and a negligible count (0.5 larvae per 10 hills) in the chitin enriched oil formulation of NBAIR isolate of *Beauveria* (Bb5). Furthermore, all the biocontrol treatments were superior to chemical control in the long run. Hence, it is concluded that enriched formulations of *B. bassiana* can perform well in the field and the indigenous isolate ITCC 6063 is the best treatment for *C. medinalis*, when sprayed twice during the vegetative phase. Pooled analysis of data for two years 2018-19 and 2019-20 revealed that indigenous isolate of KAU-*B. bassiana* was invariably the superior treatment for the management of *C. medinalis*. Additionally, the chitin enriched oil formulation could enhance the virulence of the pathogen as it could bring about 82.69 per cent reduction in pest population compared to its conidial suspension which brought about 79.84 % reductions in larval count (Table 50).

Table 50. Effect of improved formulation of *Beauveria bassiana* in the management of *Cnaphalocrocis medinalis*; Pooled analysis of experiment of two years (2018-19 &2019-20)

Treatments	Mean larval count/ 10 hills/plot					Percentage reduction in pest
	Precount	First spraying		Second spraying		
		7DAS	14DAS	7DAS	14DAS	
Bb - KAU conidial suspension @10^8spores ml^{-1}	35.00	23.00	13.00	7.50	2.62	79.84
Bb - NBAIR conidial suspension @10^8spores ml^{-1}	35.00	30.5	20.00	12.87	8.25	36.53
Chitin enriched oil formulation of *Bb* (KAU)	32.87	19.37	11.50	5.37	2.25	82.69
Chitin enriched oil formulation of *Bb* (NBAIR)	38.25	29.87	19.12	12.25	7.75	40.38
Flubendiamide18.5 SC @ 0.5ml/L	30.12	23.00	15.12	10.50	6.75	48.07
Untreated check	27.50	22.37	19.62	16.87	13.00	-
CD@5%	0.51	0.61	0.40	0.39	0.56	

1.7 Comparative efficacy of entomopathogenic fungi against sucking pests of rice, *Leptocorisa acuta* (KAU, Vellayani)

The experiment was carried out during June-September, 2019 at Parasuvaikkal, Padasekhara Samithi, Parassala Block in an area of 40 cents, in rice variety Prathyasha. Analysis of data revealed that *L. saksenae*@ 10^7 spores ml^{-1}, indigenous isolate from Velayani was the best treatment to manage *L. acuta* population, when sprayed twice at the panicle initiation and milky stage of the crop. NBAIR isolate-Bb5 which ranked second could also control *L. acuta* and these treatments were superior to thiamethoxam. However, Ma 4 and Vl8 of NBAIR were in effective in managing *L. acuta* and were inferior to thiamethoxam. The pre count in experimental plot was 30to 35.5 bugs per 5 sweeps per plot while it was successfully reduced to 0 to 12.75 in the treatment plot (Table 51). Data on mean count of natural enemies which included the total count of spiders, coccinellids, scarbids and mirid, analyses revealed that the population did not vary among treatments.

Table 51. Effect of entomopathogenic fungi on population of rice bug

Treatments	No. of bugs/sweeps/plot						
	Pre count	First spraying			Second spraying		
		3DAS	7DAS	14DAS	3DAS	7 DAS	14 DAS
T1- *L. saksenae* @ 10^7 spores ml^{-1}	30.25 (5.50)	24.5[c] (4.94)	17.5[d] (4.18)	7.5[e] (2.73)	3.75 f (1.93)	0 e (0.70)	0[d] (0.70)
T2- *L. lecanii* @ 10^7 spores ml^{-1}	32.75 (5.72)	31.5[a] (5.61)	28.75[a] (5.36)	24.75 a (4.97)	20.25 b (4.50)	15.75 b (4.02)	12.75 b (3.63)
T3- *B. bassiana* Bb5 @ 10^8 spores ml^{-1}	32 (5.66)	27.25[b] (5.22)	20.25 c (4.49)	10.25 d (3.19)	5.50 e (2.34)	3.00 d (1.87)	0 d (0.70)
T4- *M. anisopliae* @ 10^8 spores ml^{-1}	30.75 (5.54)	28.5 b (5.33)	26.00 b (5.09)	21.25 b (4.60)	17.75 c (4.20)	15.5 b (3.99)	12.25 b (3.55)
T5- Thiamethoxam 0.2 g/L	31 (5.56)	28.25 b (5.31)	23.75 b (4.87)	17.25 c (4.15)	11.75 d (3.42)	10.25 c (3.27)	7.25 c (2.78)
T6- Untreated	33.5 (5.79)	32.5 a (5.70)	30.5 a (5.52)	26.0 a (5.09)	23.75 a (4.87)	20.75 a (4.60)	16.5 a (4.11)
CD @5%	NS	0.246	0.233	0.275	0.225	0.165	0.298

1.8 Large scale bio-intensive pest management on rice (ICAR-IIRR, Hyderabad)

The trial was undertaken in three locations, 1. IIRR research farm, Hyderabad, 2. Farmers field in Neelayagudem village, Miryalguda, Telangana (2.0ha)and 3.Farmers field inGanjam and Jajpur districts at Odisha(1.6 ha).At IIRR farm, results indicated that organic cultivation with *Trichoderma* or *Pseudomonas* and without application of fertilizers and insecticides significantly reduced incidence of stem borer damage. The white ear damage was significantly higher in farmers practice with insecticidal treatment. The yield however was highest in plots with recommended fertilizer application. However, the yield in organic practices with seed treatments (5980 and 5900 kg/ ha respectively) was also on par with farmers' practice (6340 kg/ha). The reduction in white ears in organic cultivation could be attributed to higher parasitisation of egg masses of stem borer observed (75.26 and 64.68%) as compared to 35.46 per cent in plots with insecticide application (**Table 52).** Due to low pest pressure from the trial undertaken in farmer's fields at

Neelayagudem village,the only major pest observed was leaf folder, with lesser damage recorded in the BIPM module with *Bacillus subtilis* seed treatment (4.37 %). The number of spiders observed per five hills was significantly higher in BIPM treatments with the highest number being recorded in the *B. subtilis* based module.

The incidence of stemborers, leaffolder and brown planthopper were significantly lower in the IPM fields at Odisha.Stem borer incidence was under ETL in the IPM fields (5.88 and 10.2% respectively) as compared to the significantly high incidence of 17.37 and 22.35 % in non IPM fields(Table 53). There was an outbreak of brown planthopper in these districts and reached high numbers due to intermittent rains. But the population in IPM fields were significantly lower than that of non IPM fields. InOdisha, due to farmers practice of using lesser inputs, the cost of inputs in IPM fields was slightly higher. Nevertheless, the B:C ratio was higher in IPM fields due to increased yields.

Table 52. Pest and natural enemy incidence in BIPM trial, *Kharif* 2019

Treatment	Damage by Stem borer		Yield (kg/ha) *
	Dead Heart (%)	White Ears (%)	
BIPM 1 Organic with *Trichoderma*	11.94 (20.19)	3.55 (10.68)	5980.00[b]
BIPM 2 Organic with *Pseudomonas*	11.78 (20.06)	4.36 (11.90)	5900.00[bc]
Farmers Practice with insecticides	10.61 (18.99)	22.72 (28.42)	6340.00[c]
Organic without seed treatment	11.35 (19.68)	7.73 (16.11)	5425.00[a]
Untreated Control	15.88 (23.48)	16.62 (24.06)	5133.33[a]
CD (P=0.05)	1.29	2.66	398.02
CD (P=0.01)	-	3.66	-
CV	0.17	0.71	0.09

* Projected Yield

Table 53. Insect pest incidence at Odisha BIPM trial, *Kharif* 2019

Location	Leaf folder (% leaves damaged)		Stem borer (% dead hearts/ white ears)		BPH No./5 hills	
	IPM*	FP	IPM*	FP	IPM*	FP
Gayaganda village, Ganjam district	5.06	8.41	5.88	22.35	143.00	193.00
Bakhandari village, Jajpur district	1.98	5.81	10.20	17.37	97.50	160.00
Mean	4.04	6.96	8.27	18.53	120.25	176.50
t - test of significance	2.05*		4.71**		2.27*	

*Seed treatment with *Trichoderma* @ 10 g / litre of water / kg seed; Basal and top dressing of FYM and vermicompost. YSB pheromone traps @ 8/ ha. Six times weekly release of *T. japonicum* 5 cc egg cards/ha

Table 54. Yield and benefit cost of cultivation at Odisha BIPM trial, *Kharif* 2019

Location	Yield (Kg/ha)		Benefit cost Ratio	
	IPM	FP	IPM	FP
Ganjam	4285	4000	1.95	1.77
Jajpur	6000	4400	2.59	2.46

2. MAIZE

2.1 Evaluation of entomopathogenic fungi and *Bt* against maize stem borer,*Chilo partellus* (PAU)

The experiment was undertaken with the treatment details mentioned hereunder

1. Bb-5a isolate (1×10^8 conidia/ml)@ 10 ml/litre water
2. Ma-35 isolate (1×10^8 conidia/ml)@ 10 ml/litre water
3. NBAIR Bt G4 @ 2 %
4. Commercial Bt formulation @ 600 ml /acre
5. Chemical control (chlorantraniliprole 18.5 SC @ 75 ml/ha)
6. Untreated control

The experiment conducted with the variety PMH 1 during July 2019 revealedsignificant differences among the treatments. Chemical control was significantly better than other treatments in reducing the leaf injury incidence (2.24%) and dead hearts (2.78 %) due to maize stem borer (Table 55). Leaf injury and dead heart incidence in different fungal and Bt based biopesticides varied from 10.84 to 18.10 and 6.45 to 11.17 per cent, respectively as compared to 22.27 and 15.19 per cent in untreated control. Among biopesticides, lowest dead heart incidence was recorded in commercial Bt formulation (6.45%) and it did not differ significantly from Bb-5a (8.57%) and NBAIR Bt (8.62%). The dead heart damage in Ma-35 was 11.17 per cent and it was not significantly different from NBAIR Bt and Bb-5a. Grain yield was highest in chemical control (49.26 q/ha) followed by commercial Bt formulation (46.04 q/ha), Bb-5a (44.11 q/ha), NBAIR Bt (43.44 q/ha) and Ma-35 (42.04 q/ha) which did not differ significantly among each other.

Table 55 : Evaluation of entomopathogenic fungi and *Bt* against stem borer, *C. partellus* in maize during 2019

Treatments	**Leaf injury (%)**	**Dead hearts (%)**	**Grain yield (q/ha)**
Bb-5a isolate *B. bassiana* @ 10 ml/litre	16.11^{bc} (4.13)	8.57^{bc} (3.08)	44.11
Ma-35 isolate of *M. anisopliae*@ 10 ml/litre	18.10^{c} (4.36)	11.17^{c} (3.49)	42.04
NBAIR Bt G4 @ 2%	15.51^{bc} (4.00)	8.62^{bc} (3.09)	43.44
Commercial Bt @ 600 ml/acre	10.84^{b} (3.43)	6.45^{b} (2.73)	46.04
Chlorantraniliprole 18.5 SC@ 100 ml/ha	2.24^{a} (1.79)	2.78^{a} (1.94)	49.26a
Untreated Control	22.27^{d} (4.82)	15.19^{d} (4.02)	39.44
CD (p=0.05)	(0.83)	(0.43)	4.74
CV %	12.11	7.76	5.92

Figures in parentheses are square root transformed values

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

2.2.1 ANGRAU, Anakapalle

Demonstration was conducted at farmer's fields in three locations i.e Srikakulam, Visakhapatnam and Vizianagaram districts during *rabi*, 2019-20 over an area of 15 acres. In all the three locations, maize stem borer, *C. partellus*damage was nil in *Trichogramma* released plot and low in chemical sprayed plot (2.67% DH). *Sesamia inferens* damage as shot holes was low in *T.chilonis* released plot (6.7 %) as well as *Trichogramma pretiosum* released plot (6.39 %) and it was higher in chemical sprayed plot (11.84 %) (Table 56). Fall armyworm, *Spodoptera frugiperda* damage recorded low in *T. pretiosum* released plot (15.72 %) followed by *T. chilonis* released plot (21.2 %) and higher in chemical sprayed plot (41.45%).Percent reduction in fall army worm incidence was high in *T.pretiosum* released plot (62.07%) followed by *T. chilonis* released plot (48.85%) compared to farmers practice. The cob yield estimation of the trial is in progress.

Table 56. Biological control of maize stem borer, *C. partellus* using *T. chilonis*

Treatment	***C. partellus* damage (%DH)**	***S. inferens* (% incidence)**	***S. frugiperda* (%Incidence)**
Kondaguddi, Pusapatirega mandal, Vizianagaram district			
T1: *T. chilonis* @ 75,000/ ha, 3 times from 15 DAS + spraying emamectin benzoate @ 0.4 g/lt	0.0	7.1	21.61
T2: *T. pretiosum* @ 75,000/ ha, 3 times from 15 DAS+ spraying emamectin benzoate @ 0.4 g/lt	0.0	6.67	14.67
T3 : FP- Neem formulation @ 5 ml/lt after 15DAS followed by chlorantraniliprole@ 0.4 ml/lt + spraying emamectin benzoate @ 0.4 g/lt	2.67	12.67	38.35
Venkatapuram, Ranasthalam mandal , Srikakulam district			
T1: *T. chilonis* @ 75,000/ ha, 3 times from 15 DAS + spraying emamectin benzoate @ 0.4 g/lt	0.0	5.33	23.35
T2: *T. pretiosum* @ 75,000/ ha, 3 times from 15 DAS+ spraying emamectin benzoate @ 0.4 g/lt	0.0	6.17	16.28
T3 : FP- Neem formulation @ 5 ml/lt after 15DAS followed by chlorantraniliprole@ 0.4 ml/lt + spraying emamectin benzoate @ 0.4 g/lt	3.0	10.35	51.44
Nagulapalli, Munagapaka mandal, Visakhapatnam district			
T1: *T. chilonis* @ 75,000/ ha, 3 times from 15 DAS + spraying emamectin benzoate @ 0.4 g/lt	0.0	7.67	18.65
T2: *T. pretiosum* @ 75,000/ ha, 3 times from 15 DAS+ spraying emamectin benzoate @ 0.4 g/lt	0.0	6.33	16.22
T3 : FP- Neem formulation @ 5 ml/lt after 15DAS followed by chlorantraniliprole@ 0.4 ml/lt + spraying emamectin benzoate @ 0.4 g/lt	2.35	12.5	34.57
T1: *T. chilonis* @ 75,000/ ha, 3 times from 15 DAS + spraying emamectin benzoate @ 0.4 g/lt	0.0	6.7	21.20
T2: *T. pretiosum* @ 75,000/ ha, 3 times from 15 DAS+ spraying emamectin benzoate @ 0.4 g/lt	0.0	6.39	15.72

T3 : FP- Neem formulation @ 5 ml/lt after 15DAS followed by chlorantraniliprole@ 0.4 ml/lt + spraying emamectin benzoate @ 0.4 g/lt	2.67	11.84	41.45
Damage reduction (%) in Field release of *T.chilonis* / *T.pretiosum* over FP	100.0	TC- 43.41 TP- 46.03	TC- 48.85 TP- 62.07

DAS : Days after seedling emergence

2.2.2 PAU, Ludhiana

The demonstrations on the biological control of maize stem borer using *T. chilonis* releases were conducted at farmer's fields on an area of 448 acres in Hoshiarpur, Jalandhar, SBS Nagar, Mohali, 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 Ballowal Saunkri and FASC Jalandhar. Based on the mean of all locations (Table 57), dead heart incidence in fields with the releases of *T. chilonis* was 5.53 per cent and in chemical control, it was 2.03 per cent. However, both the treatments were significantly better than untreated control (11.87%). The reduction in incidence over control was 53.19 and 82.88 per cent in biocontrol and chemical control, respectively. Similarly, yield in biocontrol (41.83 q/ha) and chemical control (44.63 q/ha) fields were significantly more than in untreated control (38.45 q/ha). The yield increase over control was 8.83 per cent in biocontrol as compared to 16.10 per cent in chemical control. The net returns over control in biocontrol package were Rs. 5483/- as compared to Rs.9764/- in chemical control (Table 58).

Table 57. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2019

Treatments	Dead hearts (%)	Per cent reduction in incidence over control	Yield (q/ha)	Per cent yield increase over control
T. chilonis @ 1,00,000 per ha (two releases – 10 and 17 days old crop)	5.53^{b}	53.19	41.83^{b}	8.83
Chlorantraniliprole 18.5 SC @ 75 ml/ha	2.03^{a}	82.88	44.63^{a}	16.10
Untreated control	11.87^{c}	-	38.45^{c}	-

Table 58. Cost Benefit analysis (2019)

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*)	41.83	3.38	5982.60	500.00	5482.60
Chlorantraniliprole 18.5 SC @ 75 ml/ha	44.63	6.18	10938.60	1175.00	9763.60
Untreated control	38.45				

Price of maize Rs. 1770/- per quintal; * includes trichocard/insecticide + labour cost; Price of Coragen (chlorantraniliprole 18.5 SC) @ Rs. 1850/- per 150 ml

2.2.3 MPUAT, Pune

The demonstrations on the releases of *T. chilonis* were conducted atfarmer's fields over an area of 10ha.atUdaipur district of Rajasthan. Results revealed, dead heart incidence in fields with the releases of *T. chilonis* was 9.89 per cent and in chemical control, it was 7.37 per cent(**Table 59**). The reduction in incidence over control was 45.20 and 59.16 per cent in biocontrol and farmers practice plots, respectively. The yield in *T. chilonis*released field was (28.65q/ha) and it was 31.45 q/ha inspinosad treated fields, were significantly more than the untreated control (23.48 q/ha).

Table 59. Effect of *T. chilonis* release on incidence of *C. partellus* and yield in *Kharif* maize during 2019

S. No.	Treatments	DH (%)	Per cent reduction over control	Yield(q/ha)	Yield (Per cent increase over control)
1.	**T. chilonis* @ 100,000/ha	9.89	45.20	28.65	22.01
2.	Spinosad 45 SC @ 1.0ml/ 3 lit (Farmers practice)	7.37	59.16	31.45	33.94
3.	Untreated control	18.05	-	23.48	-

*Three releases at 15, 22 and 29 days after crop germination

2.3 Bio-ecological engineering for the management of major insect pests of maize and benefit of their natural enemies (SKUAST- Jammu)

The experiment was undertaken with the treatment details mentioned hereunder

T1:	Maize + okra (intercrop) + sorghum (border crop)
T2:	Maize + mash (intercrop) + sorghum (border crop)
T3:	Maize + cowpea (intercrop) + sorghum (border crop)
T4:	Maize + sesamum (intercrop) + sorghum (border crop)
T5:	Maize + okra (intercrop) + naiper (border crop)
T6:	Maize + mash (intercrop) + naiper (border crop)
T7:	Maize + cowpea (intercrop) + naiper (border crop)
T8:	Maize + sesamum (intercrop) + naiper (border crop)
T9:	Sole maize
T10:	Sole maize + sorghum (border crop)
T11:	Sole maize + naiper (border crop)
T12:	Sole maize with cartap hydrochloride (Recommended check)

The results revealed, percent plant damage by *C. partellus* on maize was significantly lower in T_3 – Maize + cowpea + Sorghum (Table 60) . Irrespective of the different intercrops, sorghum as border crop attracted significantly more infestation by *C. partellus*.Number of *S. litura* larvae per five intercropped plants and whiteflies per five leaves of various intercrops were significantly lowest in T_3 - Maize + cowpea +sorghum(Table 61).The natural enemies like Coccinellid spp. and spiders were more active in okra and mash intercrops, where the population of whiteflies and *S. litura* larvae were also more(Table 62).Significant higher maize equivalent yield (986.63q/ha) was obtained in T_7 – Maize + cowpea + sorghum(Table 63).

Table 60. Percent stem borer infestation on maize as affected by various inter and border crops

Treatments	Per cent plant damage in maize			Per cent plant damage in border crops	
	30 DAS	**50 DAS**	**70 DAS**	**30 DAS**	**50 DAS**
T_1	4.26^{ab}(11.91)	6.25^{ab}(14.48)	8.83^{ab}(17.29)	2.60^{b}(9.28)	12.67^{a} (20.85)
T_2	3.18^{ab}(10.27)	5.91^{ab} (14.07)	7.52^{ab}(15.92)	3.67^{bc} (11.04)	14.57^{b} (22.44)

T_3	3.13^{a}(10.19)	5.16^{a} (13.13)	7.18^{ab}(15.54)	1.00^{a} (5.74)	10.33^{a} (18.75)
T_4	4.83^{ab}(12.70)	6.25^{ab}(14.48)	8.04^{ab} (16.47)	3.00^{b} (9.97)	17.33^{bc} (24.60)
T_5	3.18^{ab}(10.27)	5.04^{a} (12.97)	6.91^{ab}(15.24)	21.67^{g}(27.74)	32.23^{c}(34.59)
T_6	3.25^{a} (10.38)	4.16^{a}(11.77)	6.26^{ab} (14.49)	14.00^{d} (21.97)	36.67^{d} (37.27)
T_7	2.18^{a} (8.49)	3.18^{a} (10.27)	5.44^{a} (14.82)	15.67^{e}(23.32)	26.47^{c} (30.96)
T_8	3.56^{a} (10.88)	5.47^{a} (13.53)	6.28^{ab}(14.51)	16.33^{e}(23.83)	30.00^{c} (33.21)
T_9	15.91^{c} (23.51)	25.64^{d} (30.42)	30.94^{e}(33.79)	-	-
T_{10}	7.28^{b} (15.65)	10.11^{b} (18.54)	11.56^{c} (19.88)	4.33^{c} (12.01)	15.57^{a} (23.24)
T_{11}	5.13^{ab} (13.09)	6.83^{ab} (15.15)	8.83^{bc} (17.29)	29.33^{f} (32.79)	43.33^{e} (41.17)
T_{12}	3.30$^{a\ b}$(10.47)	16.56^{c} (24.01)	23.44^{d} (28.96)	-	-
CD	(2.96)	(2.53)	(2.05)	(1.92)	(2.74)

The mean difference is significant at 0.05 level
Figures in parenthesis are arc-sine transformed values

Table 61. Population of *Spodoptera* larvae and whiteflies on maize and intercrops

Treatments	No. of *Spodoptera* per five plants				No. of whitefly per five leaves	
	On Maize		On Intercrops		On Intercrops	
	20 DAS	32 DAS	20 DAS	32 DAS	20 DAS	32 DAS
T_1	2.00^{ab} (1.73)	1.30^{a} (1.51)	3.60^{c} (2.14)	11.60^{b}(3.55)	112.00^{d} (10.63)	70.70^{c}(8.47)
T_2	1.70^{ab} (1.64)	1.00^{a} (1.41)	2.00^{b}(1.73)	20.00^{d} (4.58)	145.30^{g}(12.09)	81.00^{d} (9.06)
T_3	2.00^{b} (1.73)	1.30^{a} (1.51)	2.00^{b}(1.73)	19.30^{d} (4.51)	42.00^{b} (6.56)	29.00^{b}(5.48)
T_4	1.30^{ab} (1.51)	0.70^{a} (1.30)	3.30^{c}(2.07)	16.60^{c}(4.19)	110.70^{e} (10.57)	90.30^{e}(9.56)
T_5	1.70^{ab} (1.64)	1.30^{a} (1.51)	2.00^{b}(1.73)	10.00^{bc} (3.32)	95.70^{d} (9.83)	59.30^{c} (7.77)
T_6	1.30^{ab} (1.51)	1.00^{a} (1.41)	1.30^{a} (1.51)	8.30^{b}(3.05)	123.70^{f} (11.17)	65.00^{c} (8.12)
T_7	1.70^{ab} (1.64)	1.30^{a} (1.51)	1.00^{a}(1.41)	6.70^{a}(2.77)	31.30^{a}(5.68)	20.70^{a} (4.66)
T_8	1.00^{a} (1.41)	1.00^{a} (1.41)	1.70^{b} (1.64)	5.30^{a}(2.51)	80.00^{c}(9.00)	62.30^{c} (7.96)
T_9	3.00^{b} (2.00)	2.30^{b} (1.82)	-	-	-	-
T_{10}	1.70^{ab} (1.64)	1.30^{a} (1.51)	-	-	-	-
T_{11}	2.00^{ab} (1.73)	1.70^{a} (1.64)	-	-	-	-
T_{12}	2.70^{ab} (1.92)	0.70^{a} (1.30)	-	-	-	-
CD	(0.32)	(0.40)	(0.21)	(0.34)	(0.38)	(0.40)

The mean difference is significant at 0.05 level
Figures in parenthesis are square root transformed values

Table 62. Natural enemy population on border crop

Treatments	No. of lady bird beetle per five plants on border crops		No. of lady bird beetle/m^{2}area on maize and intercrops		No. of spider/m^{2}area on maize and intercrops	
	30DAS	40DAS	30DAS	40DAS	30DAS	40DAS
T_1	3.60^{b} (2.15)	4.00^{b} (2.24)	6.67^{c}(2.77)	9.33^{cd}(3.21)	1.67^{b} (1.63)	2.67^{d} (1.92)
T_2	3.00^{b}(2.00)	3.30^{ab} (2.07)	6.33^{c}(2.71)	6.67^{bc}(2.77)	1.33^{ab} (1.53)	2.00^{cd}(1.73)
T_3	3.30^{b} (2.07)	3.60^{ab} (2.15)	4.33^{b}(2.31)	4.67^{b}(2.38)	1.00^{ab} (1.41)	1.33^{bcd} (1.53)
T_4	3.60^{b} (2.15)	3.60^{ab} (2.15)	4.67^{bc}(2.38)	5.67^{bc}(2.58)	0.67^{ab} (1.29)	1.67^{bcd} (1.63)
T_5	3.00^{b} (2.00)	3.30^{ab} (2.07)	6.33^{c} (2.71)	8.33^{c} (3.05)	1.33^{b} (1.53)	2.67^{d} (1.92)

T_6	2.60^{a}(1.89)	3.00^{ab} (2.00)	5.00^{bc}(2.45)	6.00^{bc}(2.65)	1.00^{ab} (1.41)	1.67^{bcd} (1.63)
T_7	2.30^{a}(1.81)	2.60^{a} (1.89)	4.00^{b}(2.24)	4.67^{b}(2.38)	0.67^{ab} (1.29)	1.00^{bc}(1.41)
T_8	3.00^{b} (2.00)	3.30^{ab} (2.07)	4.33^{b}(2.31)	5.00^{b}(2.45)	0.67^{ab} (1.29)	1.33^{bcd} (1.53)
T_9	-	-	1.67^{a} (1.63)	2.00^{a}(1.73)	0.00^{a} (1.00)	0.33^{ab} (1.15)
T_{10}	2.60^{a}(1.89)	3.30^{ab} (2.07)	2.00^{a}(1.73)	2.33^{a}(1.82)	0.33^{ab} (1.15)	0.33^{ab} (1.15)
T_{11}	2.00^{a}(1.73)	2.60^{a} (1.89)	1.67^{a} (1.63)	2.00^{a}(1.73)	0.00^{a} (1.00)	0.33^{ab} (1.15)
T_{12}	-	-	0.67^{a} (1.29)	0.67^{a} (1.29)	0.00^{a} (1.00)	0.00^{a} (1.00)
CD	(0.22)	(0.25)	(0.76)	(0.82)	(0.48)	(0.37)

Table 63. Maize, intercrop and Maize equivalent yield in various treatment

Treatments	No. of lady bird beetle per five plants on border crops		No. of lady bird beetle/m^{2}area on maize and intercrops		No. of spider/m^{2}area on maize and intercrops	
	30DAS	40DAS	30DAS	40DAS	30DAS	40DAS
T_1	3.60^{b} (2.15)	4.00^{b} (2.24)	6.67^{c}(2.77)	9.33^{cd}(3.21)	1.67^{b} (1.63)	2.67^{d} (1.92)
T_2	3.00^{b}(2.00)	3.30^{ab} (2.07)	6.33^{c}(2.71)	6.67^{bc}(2.77)	1.33^{ab} (1.53)	2.00^{cd}(1.73)
T_3	3.30^{b} (2.07)	3.60^{ab} (2.15)	4.33^{b}(2.31)	4.67^{b}(2.38)	1.00^{ab} (1.41)	1.33^{bcd} (1.53)
T_4	3.60^{b} (2.15)	3.60^{ab} (2.15)	4.67^{bc}(2.38)	5.67^{bc}(2.58)	0.67^{ab} (1.29)	1.67^{bcd} (1.63)
T_5	3.00^{b} (2.00)	3.30^{ab} (2.07)	6.33^{c} (2.71)	8.33^{c} (3.05)	1.33^{b} (1.53)	2.67^{d} (1.92)
T_6	2.60^{a}(1.89)	3.00^{ab} (2.00)	5.00^{bc}(2.45)	6.00^{bc}(2.65)	1.00^{ab} (1.41)	1.67^{bcd} (1.63)
T_7	2.30^{a}(1.81)	2.60^{a} (1.89)	4.00^{b}(2.24)	4.67^{b}(2.38)	0.67^{ab} (1.29)	1.00^{bc}(1.41)
T_8	3.00^{b} (2.00)	3.30^{ab} (2.07)	4.33^{b}(2.31)	5.00^{b}(2.45)	0.67^{ab} (1.29)	1.33^{bcd} (1.53)
T_9	-	-	1.67^{a} (1.63)	2.00^{a}(1.73)	0.00^{a} (1.00)	0.33^{ab} (1.15)
T_{10}	2.60^{a}(1.89)	3.30^{ab} (2.07)	2.00^{a}(1.73)	2.33^{a}(1.82)	0.33^{ab} (1.15)	0.33^{ab} (1.15)
T_{11}	2.00^{a}(1.73)	2.60^{a} (1.89)	1.67^{a} (1.63)	2.00^{a}(1.73)	0.00^{a} (1.00)	0.33^{ab} (1.15)
T_{12}	-	-	0.67^{a} (1.29)	0.67^{a} (1.29)	0.00^{a} (1.00)	0.00^{a} (1.00)
CD	(0.22)	(0.25)	(0.76)	(0.82)	(0.48)	(0.37)

The mean difference is significant at 0.05 level

Figures in parenthesis are square root transformed values

Table 64. Maize, intercrop and Maize equivalent yield in various treatment

Treatments	Yield (q/ha)		
	Maize yield	Intercrop yield	Maize Equivalent yield
T_1	21.91[a]	291.34[c]	313.75[d]
T_2	23.89[b]	108.70[a]	132.42[b]
T_3	26.85[c]	847.69[d]	874.05[e]
T_4	25.86[bcd]	159.66[b]	185.69[c]
T_5	24.88[bcd]	291.67[b]	316.71[d]
T_6	27.84[cd]	113.60[a]	141.11[b]
T_7	27.84[cd]	958.79[c]	986.63[f]
T_8	27.35[cd]	169.54[bc]	196.39[cd]
T_9	22.24[a]	-	22.24[a]
T_{10}	32.28[e]	-	32.28[a]
T_{11}	30.00[d]	-	30.00[a]
T_{12}	25.86[bcd]	-	25.86[a]
CD	1.42	46.10	37.98

2.4 Field trial against Fall armyworm in maize at AICRP-BC centres

(IIMR, Maize Hyderabad, ANGRAU, PJTSAU, AAU-Anand, OUAT, UAS Raichur, MPKV and TNAU)

The experiment was undertaken with the treatment details mentioned here under:

T1:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & second one after one week of first release) + NBAIR *Bt* 25 2% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T2:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *M. anisopliae* NBAIR -Ma 35, 0.5% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T3:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *B. bassiana* NBAIR -Bb 45, 0.5% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T4:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & the second one after one week of first release) + EPN *H. indica* NBAIR H38 (1-2 whorl sprays @ 4kg/acre, first spray after 15 days of planting & then the next sprays at 10 days interval)
T5:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *P. fluorescens (Pf DWD* 2%) (2-3 sprays @ 20g/liter depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T6:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + SpfrNPV(NBAIR1) (2-3 sprays @ 2ml/liter depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T7:	*T. pretiosum* alone (1 card per acre (2 releases, first release after one week of planting & then second

	one after one week of first release)
T8:	Pheromones @15 traps/acre (install one week after planting and the lures to be replaced once in 25-30 days)
T9:	Insecticidal check (Emamectin benzoate 0.4gm/lt)
T10:	Untreated check (control)

2.4.1. Winter Nursery Centre, ICAR-IIMR, Hyderabad

The experiment was conducted at Winter Nursery Centre, ICAR-IIMR, Hyderabad (var.Shaktiman 5**)** during *kharif* 2019. Among the treatments, minimum per cent plant infestation was observed in *T. pretiosum* 1 Card/ acre+ Spfr NPV (NBAIR 1) (15.70), *T. pretiosum* 1 Card/ acre+ *Pf* DWD2% (16.46) and *T. pretiosum* 1 Card/ acre+ NBAIR *Bt* 25 (18.90)(Table 64).The next best treatments were *T. pretiosum* 1 Card/ acre+ NBAIRH38, *T. pretiosum* 1 Card/ acre+ NBAIR *Bb* 45 and *T. pretiosum* 1 Card/ acre+ NBAIR Ma35 recorded per cent plant infestation of 22.29, 22.88 and 24.80, respectively at ten days after second spray. Treatments *T. pretiosum* alone and Pheromone traps recorded per cent plant infestation of 30.01 and 30.09, respectively. However,standard check emamectin benzoate (13.97) was significantly different as compared to biopesticides treatments and untreated control (50.47).

Egg mass laid were minimum in *T. pretiosum* 1 Card/ acre +NBAIR *Bb 45* (1.66) and *T. pretiosum* 1 Card/ acre +NBAIR*H*38 (2.00) and *T. pretiosum* 1 Card/ acre +*Pf* DWD2% (2.67) and were significantly different compared to control (14.67) (Table 65).Minimum number of larvae were observed in *T. pretiosum* 1 Card/ acre+ Spfr NPV (NBAIR 1) (7.00), *T. pretiosum* 1 Card/ acre+ NBAIR *MA* 35- 0.5% (8.00), *T. pretiosum* 1 Card/ acre +NBAIR *Bb* 45 (8.33), *T. pretiosum* 1 Card/ acre+ *Pf* DWD2% (8.33) and were significantly different compared to untreated control (17.33).

The treatments *T. pretiosum* 1 Card/ acre+ NBAIR *MA* 35- 0.5% and NBAIR *Bb* 45- 0.5% recorded maximum number of dead larvae of 5.67 and 4.33, respectively while standard check Emamectin benzoate and untreated control recorded 8.33 and 1.67 respectively (Table 65). Maximum grain yield was recorded in *T. pretiosum* 1 Card/ acre+ NBAIR *H*38 0.5% (4436.66 kg/ha), *T. pretiosum* 1 Card/ acre+ NBAIR *Bb* 45 0.5% (4275.55 kg/ha) and *T. pretiosum* 1 Card/ acre+ Spfr NPV (NBAIR 1) (4048.89 kg/ha) and were significantly different compared to control (3240.56 kg/ha)(Table 65). However, standard check emamectin benzoate (4555.56) gave highest yield when compared to all the treatments.

Table.65. Evaluation of different bio-agents and pesticides against fall armyworm during *Kharif* 2019

Treatment	(%) Plant infestation			(%) Overall mean of two sprays	No. of Egg mass recorded			Overall mean of two sprays	Grain Yield (Kg/ha)at 12% Moisture
	Pre Count	10 days after 1st Spray	10 days after 2nd Spray		Pre treatment Count	10 days after 1st Spray	10 days after 2nd Spray		
T1-*T. pretiosum* 1 Card/ acre+ NBAIR *Bt* 25 2% (2ml/ liter water)	13.64	32.99	18.90	25.95	3.33	7.33	5.67	5.44	3848.33
T2- *T. pretiosum* 1 Card/ acre+ NBAIR *MA* 35 0.5% (5g/ liter water)	31.69	26.42	24.80	25.61	5.67	7.67	5.00	6.11	3888.89
T3- *T. pretiosum* 1 Card/ acre+ NBAIR *Bb* 45 0.5% (5g/ liter water)	19.55	23.15	22.88	23.02	4.67	6.00	1.66	4.11	4275.55
T4- *T. pretiosum* 1 Card/ acre+ NBAIR EPNH38 (10g/ liter water)	24.41	33.07	22.29	27.68	5.33	4.33	2.00	3.89	4436.66
T5- *T. pretiosum* 1 Card/ acre+ *Pf* DWD2% (20g/ liter water)	21.30	35.46	16.46	25.96	6.33	6.67	2.67	5.22	3996.67
T6- *T. pretiosum* 1 Card/ acre+ Spfr NPV (NBAIR 1) (2 ml/ liter water)	20.69	34.33	15.70	25.01	4.67	6.33	4.33	5.11	4048.89
T7- *T. pretiosum* alone 1 Card/ acre	21.45	37.67	30.01	33.84	6.33	7.00	4.00	5.78	3447.78
T8- Pheromones @ 15 traps/ acre	23.59	42.18	30.09	36.14	6.33	6.67	4.67	5.89	3491.11
T9- Emamectin benzoate (0.4gm/ lit)	26.49	17.72	13.97	15.85	7.33	2.67	1.67	3.89	4555.56
T10- Un treated Control	23.25	48.34	50.47	49.40	5.33	12.67	14.67	10.89	3240.56
CD	NS	NS	9.996		NS	0.414	0.544		314.893
CV (%)	17.576	36.30	23.7		19.4	8.9	13.6		4.7

Table 66. Evaluation of different bio-agents and pesticides against fall armyworm larvae during *Kharif* 2019

Treatment	No. of Larvae recorded			Overall mean of two sprays	No. of Dead Larvae recorded			Overall mean of two sprays
	Pre Count	10 days after 1st Spray	10 days after 2nd Spray		Pre Count	10 days after 1st Spray	10 days after 2nd Spray	
T1-*T. pretiosum* 1 Card/ acre+ NBAIR *Bt* 25 2% (2ml/ liter water)	10.33	10.33	10.00	10.22	0.00	3.33	4.00	2.44
T2- *T. pretiosum* 1 Card/ acre+ NBAIR *MA* 35 0.5% (5g/ liter water)	8.67	9.00	8.00	8.56	0.00	2.33	5.67	3.56
T3- *T. pretiosum* 1 Card/ acre+ NBAIR *Bb* 45 0.5% (5g/ liter water)	11.00	8.67	8.33	9.33	0.00	4.00	4.33	2.78
T4- *T. pretiosum* 1 Card/ acre+ NBAIR EPNH38 (10g/ liter water)	9.67	9.33	9.00	9.33	0.00	3.33	2.33	1.89
T5- *T. pretiosum* 1 Card/ acre+ *Pf* DWD2% (20g/ liter water)	9.33	9.67	8.33	9.11	0.00	4.67	3.00	2.56
T6- *T. pretiosum* 1 Card/ acre+ Spfr NPV (NBAIR 1) (2 ml/ liter water)	11.00	8.00	7.00	8.67	0.00	4.00	3.33	2.44
T7- *T. pretiosum* alone 1 Card/ acre	11.67	10.67	8.33	10.22	0.00	0.67	1.33	0.67
T8- Pheromones @ 15 traps/ acre	10.67	9.33	9.00	9.67	0.00	0.33	1.00	0.44
T9- Emamectin benzoate (0.4gm/ lit)	9.33	4.33	2.33	5.33	0.00	6.67	8.33	4.11
T10- Un treated Control	10.00	13.67	17.33	13.67	0.00	0.33	1.67	0.67
CD	NS	0.355	0.408		-	0.513	0.851	
CV (%)	11.0	6.5	7.7		-	15.7	24.4	

2.4.2 ANGRAU, Anakapalle

The experiment was undertaken during *rabi* 2019-20 with variety PAC751. Results revealed,Fall armyworm damage at 20 DAS was low in *T. pretiosum* released treatments (23.8 - 35.1 %) with egg parasitisation (5.84-9.01 parasitized eggs/20 plants). Fall armyworm damage recorded high in untreated control (27.5%) **(**Table 67). Higher larval mortality was recorded ininsecticidal check (50.38) followed by *T. pretiosum* release+ *M. anisopliae*sprays (42.9) and *T. pretiosum* release + NBAIR Bt sprays (41.9).High parasitized egg mass per plot recorded in *T. pretiosum* release alone followed by *T. pretiosum* release + *M. anisopliae* sprays and *T. pretiosum* release+ NBAIR Bt sprays. Predators per plot were more in untreated control.Cob yield recorded high in insecticidal check (82.09’000/ha and 40.18 q/ha) and was on par with *T. pretiosum* release + NBAIR Bt (63.23’000/ha and 39.97q/ha); *T. pretiosum* release + *M. anisopliae* (64.2 ’000/ha and 39.38 q/ha)and low in untreated check (53.12 ’000/ha and 22.63 q/ha). It is concluded from the experiment that, treatments*T. pretiosum* release+ *M. anisopliae*sprays and *T. pretiosum* release + NBAIR Bt sprays were found effective in reducing fall armyworm damage due to egg parasitisation and larval mortality with high cob yield and was on par insecticide check.

Table 67. Evaluation of biocontrol agents for management of *S. frugiperda* during *rabi* 2019-20

Treatment	Before spray 20 DAS				After 1st spray 30 DAS			After three sprays upto 50 DAS					Yield	
	Damage %	Live larvae / 20 plants	Parasitized egg mass / 20 plants	Predators / 20 plants	Damage %	Dead larvae / 20 plants	Predators / 20 plants	Damaged plants /plot	Damage %	Dead larvae/ plot	Parasitized eggmass /plot	Predators /plot	Cobs '000 / ha	Q/ha
T1 : TP +Bt	25.2	7.0	7.39 (15.75)	6.6	5.63	3.33	0.36	85.0	56.0	41.9 (40.25)	7.39 (15.75)	60.93	63.23	39.97
T2 : TP+ Ma	23.8	8.0	8.19 (16.53)	3.0	5.9	1.67	0.42	89.67	56.1	42.9 (40.61)	8.19 (16.53)	58.03	64.20	39.38
T3: TP+Hi	31.3	7.3	5.97 (14.98)	5.6	6.17	4.32	0.46	86.67	56.4	45.7 (42.49)	5.97 (14.98)	59.82	52.42	36.81
T4: TP+Pf	32.9	4.6	5.84 (13.83)	6.0	9.93	3.67	0.36	117.67	64.1	33.68 (35.41)	5.84 (13.83)	59.92	77.43	34.71
T5 : TP alone	35.1	7.6	9.01 (17.23)	5.0	8.83	2.0	0.25	138.0	71.1	0.0	9.01 (17.23)	56.55	82.32	31.28
T6: Pheromones	27.8	5.6	0.0	4.0	17.05	3.33	0.55	155.33	79.0	0.0	0.0	62.33	80.29	27.88
T7: Insecticidal check	35.9	5.3	0.0	6.6	3.36	1.67	0.20	45.0	18.2	50.38 (45.17)	0.0	72.53	82.09	40.18
T8: Untreated Check	27.5	5.3	0.0	7.6	16.17	4.66	0.32	169.33	85.4	0.0	0.0	92.43	53.12	22.63
CD (0.05)	NS	NS	2.95	NS	5.21	NS	NS	NS	14.9	10.13	2.95	NS	10.01	8.06
CV%	21.3	29.4	17.22	25.52	36.22	28.21	34.31	14.02	12.4	22.47	17.22	38.33	11.42	12.93

2.4.3 PJTSAU, Hyderabad

The trial undertaken during *rabi* 2019-20 is recently harvested.The pest incidence was found to be less in the treatment plots and also control plots. The yield data and analyses are in progress. The final outcome of the experiment will be submitted within week after processing and analyzing of data recorded.

2.4.4 AAU, Anand

The experiment was carried out during 2019-20 at Agronomy farm, AAU, Anand with GAYMH-1 variety. Among different biocontrol agents tested, significantly lowest number of *S. frugiperda* larvae/ 10 plants was recorded in the treatment T1-*T. pretiosum* @ 1 card/acre + *B. thuringiensis* - NBAIR BTG1 - 1% WP(1.78 larvae/ 10 plants) which was at par with the treatment T2-*T. pretiosum* @ 1 card/acre + *M. anisopliae* - NBAIR Ma35 - 1% WP (2.19 larvae/10 plants). The next best treatment was T5-*T. pretiosum* @ 1 card/acre + *P. fluorescens* NBAIR PfDWD - 1% WP(3.19larvae/ 10 plants)(Table 69). With regard to the efficacy of biocontrol agents in reducing the plant damage, lowest plant damage (%) was recorded in the treatment T1 (10.96 %) which was at par with the treatment T2(11.96 %). The next best treatment was T5(19.65 %) as compared to untreated control treatment T10- (48.29 %). Similarly lowest cob damage (%) was recorded in the treatment T1(4.32 %) which was at par with the treatment T2(4.42 %) (Table 70). With regard to yield of the crop, the treatment T1 recorded the highest grain and fodder yield (3736.67 & 7066.67 kg/ha) which was at par with the treatment T2(3716.67 & 7066.67 kg/ha).No significant differences were found with regard to number of egg patches/ 10 plants and number of predators/ 10 plants among biocontrol treatments. Significant numbers of dead larvae due to entomopathogens were found in biocontrol treatments.

Table 68. Influence of different biocontrol treatments on yield of maize

Treatments	Yield (kg/ha)	
	Grain yield	Fodder yield
T1	3736.67b	7066.67b
T2	3716.67b	7066.67b
T3	2766.67d	6266.67d
T4	2950.00d	6900.00c
T5	3333.33c	6916.67bc
T6	2800.00d	6366.67cd
T7	2700.00d	6166.67d
T8	2683.33d	6000.00d
T9	4116.67a	7850.00a
T10	1616.67e	5166.67e
S. Em ± Treatment (T)	123.84	233.47
C.D. at 5% T	367.96	693.68
C. V. (%)	7.05	6.15

Table 69. Bio-efficacy of different biocontrol treatments against fall army worm, *S. frugiperda* on maize

Treatments		No. of larvae/ 10 plants										
		BS	1st Spray			2nd Spray			3rd Spray			Pooled over periods over sprays
			5 DAS	10 DAS	Pooled	5 DAS	10 DAS	Pooled	5 DAS	10 DAS	Pooled	
T1		2.78a (7.23)*	1.68b (2.32)	1.68b (2.32)	1.68b (2.32)	1.56b (1.93)	1.44b (1.57)	1.50b (1.75)	1.44b (1.57)	1.29b (1.16)	1.37b (1.38)	1.51b (1.78)
T2		2.67a (6.63)	1.95bc (3.30)	1.77b (2.63)	1.86bc (2.96)	1.86bc (2.96)	1.46b (1.63)	1.66b (2.26)	1.46b (1.63)	1.34b (1.30)	1.40b (1.46)	1.64b (2.19)
T3		2.80a (7.34)	2.47d (5.60)	2.34ef (4.98)	2.40fg (5.26)	2.48d (5.65)	2.34d (4.98)	2.41d (5.31)	2.27d (4.65)	2.27d (4.65)	2.27d (4.65)	2.36de (5.07)
T4		2.39a (5.21)	2.27cd (4.65)	2.04cd (3.66)	2.15de (4.12)	2.34d (4.98)	2.26d (4.61)	2.30d (4.79)	2.26d (4.61)	2.20d (4.34)	2.23d (4.47)	2.23d (4.47)
T5		2.71a (6.84)	2.11c (3.95)	1.95c (3.30)	2.03cd (3.62)	1.95c (3.30)	1.86c (2.96)	1.91c (3.15)	1.87c (3.00)	1.77c (2.63)	1.82c (2.81)	1.92c (3.19)
T6		2.54a (5.95)	2.34d (4.98)	2.20de (4.34)	2.27ef (4.65)	2.41d (5.31)	2.27d (4.65)	2.34d (4.98)	2.27d (4.65)	2.20d (4.34)	2.23d (4.47)	2.28d (4.70)
T7		2.56a (6.05)	2.48d (5.65)	2.48f (5.65)	2.48g (5.65)	2.54d (5.95)	2.35d (5.02)	2.45d (5.50)	2.34d (4.98)	2.35d (5.02)	2.34d (4.98)	2.42e (5.36)
T8		2.61a (6.31)	2.54d (5.95)	2.48f (5.65)	2.51g (5.80)	2.55d (6.00)	2.41d (5.31)	2.48d (5.65)	2.35d (5.02)	2.41d (5.31)	2.38d (5.16)	2.46e (5.55)
T9		2.76a (7.12)	1.34a (1.30)	1.34a (1.30)	1.34a (1.30)	1.17a (0.87)	1.05a (0.60)	1.11a (0.73)	1.05a (0.60)	0.88a (0.27)	0.97a (0.44)	1.14a (0.80)
T10		2.78a (7.23)	2.68e (6.68)	2.79g (7.28)	2.74h (7.01)	2.92e (8.03)	2.79e (7.28)	2.85e (7.62)	2.86e (7.68)	2.85e (7.62)	2.86e (7.68)	2.81f (7.40)
	S. Em± Treatment (T)	0.23	0.11	0.09	0.07	0.11	0.12	0.08	0.12	0.13	0.08	0.05
	Period (P)	-	-	-	0.03	-	-	0.04	-	-	0.04	0.02
	Spray (S)	-	-	-	-	-	-	-	-	-	-	0.03
	T x P	-	-	-	0.10	-	-	0.12	-	-	0.12	0.09
	T x S	-	-	-	-	-	-	-	-	-	-	0.04

	S x P	-	-	-	-	-	-	-	-	-	-	0.07
	T x S x P	-	-	-	-	-	-	-	-	-	-	0.12
	C.D. at 5 % T	NS	0.33	0.26	0.19	0.33	0.37	0.22	0.36	0.37	0.23	0.14
	P	-	-	-	-	-	-	-	-	-	-	0.06
	S	-	-	-	-	-	-	-	-	-	-	0.08
	T x P	-	-	-	NS	-	-	NS	-	-	NS	NS
	T x S	-	-	-	-	-	-	-	-	-	-	NS
	S x P	-	-	-	-	-	-	-	-	-	-	NS
	T x S x P	-	-	-	-	-	-	-	-	-	-	NS
	C. V. (%)	14.87	8.70	7.25	8.04	8.84	10.65	9.73	10.33	11.13	10.73	10.15

Note: * Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values
NS = Non –significant BS= Before Spray DAS = Days After Spray

Table 70. Influence of different biocontrol treatments on plant damage and cob damage of maize

Treatments	Plant damage (%)										Cob damage (%)
	1st Spray			2nd Spray			3rd Spray			Pooled over periods over sprays	
	5 DAS	10 DAS	Pooled	5 DAS	10 DAS	Pooled	5 DAS	10 DAS	Pooled		
T1	21.14b (13.01)	18.43b (9.99)	19.78b (11.45)	18.43b (9.99)	21.14b (13.01)	19.78b (11.45)	18.43b (9.99)	18.43b (9.99)	18.43b (9.99)	19.33b (10.96)	12.00b (4.32)
T2	21.14b (13.01)	21.14bc (13.01)	21.14b (13.01)	21.14bc (13.01)	21.14b (13.01)	21.14bc (13.01)	18.43b (9.99)	18.43b (9.99)	18.43b (9.99)	20.23b (11.96)	12.13b (4.42)
T3	33.20c (29.98)	28.77d (23.16)	30.98cd (26.50)	33.20de (29.98)	28.77c (23.16)	30.98e (26.50)	26.77cd (20.29)	26.55c (19.98)	27.66cd (21.55)	29.88ef (24.82)	17.44c (8.98)
T4	28.77c (23.16)	26.55cd (19.98)	27.66c (21.55)	26.55cd (19.98)	26.06b (19.30)	26.31d (19.65)	26.55c (19.98)	26.55c (19.98)	26.55c (19.98)	26.84cd (20.39)	17.10c (8.65)
T5	28.77c (23.16)	26.55c (19.98)	27.66c (21.55)	26.06c (19.30)	23.85b (16.35)	24.95cd (17.79)	26.55c (19.98)	26.06c (19.30)	26.31c (19.65)	26.31c (19.65)	15.66c (7.29)
T6	33.20c (29.98)	28.77d (23.16)	30.98c (26.50)	30.78d (26.19)	26.55bc (19.98)	28.67de (23.02)	28.77c (23.16)	26.55c (19.98)	27.66c (21.55)	29.10de (23.65)	17.12c (8.67)
T7	33.20cd (29.98)	30.98de (26.50)	32.09de (28.22)	33.20de (29.98)	30.98c (26.50)	32.09ef (28.22)	33.20d (29.98)	28.77c (23.16)	30.98d (26.50)	31.72fg (27.64)	18.09cd (9.64)

T8	39.22d (39.98)	32.99e (29.65)	36.10e (34.72)	35.20e (33.23)	32.99c (29.65)	34.10f (31.43)	33.20d (29.98)	28.77c (23.16)	30.98d (26.50)	33.73g (30.83)	18.73de (10.31)
T9	12.29a (4.53)	6.14a (1.14)	9.21a (2.56)	6.14a (1.14)	12.29a (4.53)	9.21a (2.56)	6.14a (1.14)	0.00a (0.00)	3.07a (0.29)	7.17a (1.56)	8.74a (2.31)
T10	46.90e (53.31)	44.98f (49.97)	45.94f (51.64)	44.98f (49.97)	43.06d (46.62)	44.02g (48.29)	44.98e (49.97)	39.22d (39.98)	42.10e (44.95)	44.02h (48.29)	21.12e (12.98)
S. Em ± (T)	2.14	2.14	1.42	2.35	2.29	1.64	2.16	1.53	1.31	0.88	0.93
Period (P)	-	-	0.68	-	-	0.73	-	-	0.59	0.47	-
Spray (S)	-	-	-	-	-	-	-	-	-	0.58	-
T x P	-	-	2.14	-	-	2.32	-	-	1.87	1.84	-
T x S	-	-	-	-	-	-	-	-	-	0.82	-
S x P	-	-	-	-	-	-	-	-	-	1.50	-
T x S x P	-	-	-	-	-	-	-	-	-	2.60	-
C.D. at 5 % T	6.35	6.35	4.06	6.99	6.80	4.66	6.41	4.55	3.72	2.61	2.76
P	-	-	-	-	-	-	-	-	-	1.33	-
S	-	-	-	-	-	-	-	-	-	1.63	-
T x P	-	-	NS	-	-	NS	-	-	NS	NS	-
T x S	-	-	-	-	-	-	-	-	-	NS	-
S x P	-	-	-	-	-	-	-	-	-	NS	-
T x S x P	-	-	-	-	-	-	-	-	-	NS	-
C. V. (%)	12.42	13.94	13.14	14.78	14.86	14.82	14.10	11.08	12.85	16.78	10.16

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

NS = Non –significant   DAS= Days after spray

2.4.5 OUAT, Bhubaneswar

The experiment was carried out during November 2019 - March 2020 with DKC-9141variety. Results revealed that, the number of egg patches, larvae per 10 plants, plant damage due to fall armyworm and numbers of predators/10 plants were highest in untreated check and lowest in chemical control as compared to different biocontrol agents. The green cob yield was higher (15.93t/ha) in chemical check and lowest (8.40t/ha) in untreated control. Among the tested biocontrol agents,*T. pretiosum* @ 1 card/acre + *B. thuringiensis* - NBAIR BTG1 - 1% WP expressed highest yield (14.12t/ha) and lowest pest damage (36.3%) which is comparable to emamectin benzoate and closely followed by*T. pretiosum* @ 1 card/acre + *M. anisopliae* - NBAIR Ma35 - 1% WP(Table 71).

Table 71. Bio-efficacy of biocontrol agents 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	2.30 (1.52)	3.60(1.90)	36.3	0.3 (0.55)*	14.12
T_2: Trichocards 2 releases + *Metarhizium* 2 sprays	2.45 (1.57)	4.10(2.02)	48.0	0.36 (0.60)	12.81
T_3: Trichocards 2 releases +2 sprays of EPN	2.68 (1.64)	4.70(2.17)	60.0	0.84 (0.92)	9.60
T_4: Trichocards 2 releases +2 sprays of *Pseudomonas*	2.39 (1.54)	3.90(1.97)	51.3	0.48 (0.69)	12.59
T_5: Trichocards 2 releases +2 sprays of *SpfrNPV*	2.57 (1.60)	4.50(2.12)	54.6	0.65 (0.81)	11.28
T_6: Trichocards 2 releases	2.51(1.58)	4.30(2.07)	52.7	0.6 (0.77)	11.66
T_7: Pheromone traps @15 traps/ac	2.61(1.61)	4.60(2.14)	57.0	0.72 (0.85)	10.40
T_8: Emamectin benzoate @0.4g/l 2 sprays	2.09(1.44)	3.30(1.82)	33.0	0.24 (0.49)	15.93
T_9: Untreated check	3.05(1.75)	5.20(2.28)	63.0	0.92(0.96)	8.40
S.E. (m)±	0.04	0.06	3.28	0.03	0.65
C.D. 0.05	0.11	0.18	9.17	0.09	1.82

Trichocards-*T. pretiosum;*Figures in parentheses are square root transformed values

2.4.6 UAS, Raichur

The experiment was carried out during 2019-20 at Main Agricultural Research Station, Raichur with Syngenta NK 6240 variety.Among different biocontrol agents tested, T3.*T. pretiosum* + EPN *H. indica* NBAIR H38 whorl application recorded lowestof 0.62 larva per plant with higher grain yield (58.50q/ha) which was at par with chemical treatment, emamectin benzoate which recorded 0.54 larva per plant and registered yield to the tune of 62.75 q/ha (Table 72).

Table 72. Demonstration of IPM modules for the management of Fall Armyworm in *Rabi* maize during 2019-20

Sl. No.	Particulars	Number of larvae per plant*				Plant damage# (%)	Grain yield (q/ha)
		1DBS	3DAS	7DAS	10DAS		
T_1	*T. pretiosum* (1 card per acre to be installed after one week of planting) + NBAIR Bt (2 sprays) 2%	1.54 (1.43)	1.16 (1.29)	0.96 (1.21)	0.72 (1.10)	18.25 (25.29)	50.25
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	1.48 (1.41)	1.04 (1.24)	0.68 (1.09)	0.54 (1.02)	16.75 (24.16)	51.75
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	1.36 (1.36)	0.48 (0.99)	0.22 (0.85)	0.18 (0.82)	14.25 (22.18)	61.25
T_4	*T. pretiosum* (1 card per acre to be installed after one week of planting) + *S. furigeperga* NPV @ 2ml/liter	1.52 (1.42)	1.26 (1.33)	1.14 (1.28)	1.08 (1.26)	31.5 (34.14)	46.75
T_5	*T. pretiosum* (1 card per acre to be installed after one week of planting) + *Pseudomonas fluorescens (Pf DWD 1%)* (2 sprays)	1.56 (1.44)	1.22 (1.31)	1.1 (1.26)	0.98 (1.22)	26.25 (30.82)	48.25
T_6	*T. pretiosum* (1 card per acre to be installed after one week of planting) alone	1.62 (1.46)	1.42 (1.39)	1.08 (1.26)	1.02 (1.23)	34.85 (36.18)	41.5
T_7	Insecticidal check (Emamectin benzoate 0.4gm/lt)	1.58 (1.44)	0.36 (0.93)	0.14 (0.80)	0.06 (0.75)	12.75 (20.92)	64.5
T_8	Untreated check (control)	1.46 (1.40)	1.52 (1.42)	1.58 (1.44	1.62 (1.46)	41.25 (39.96)	42.25
S Em ±		**0.09**	**0.05**	**0.07**	**0.05**	**0.65**	**1.98**
CD (P=0.05)		**NS**	**0.16**	**0.21**	**0.16**	**1.95**	**5.95**

#Figures in parentheses are arcsine transformed values

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

2.4.7 MPKV, Pune

The experiment was carried out during 2020 at Research Farm, College of Agriculture, Punewith Panchgangavariety.Results revealed,significant reduction in the number of egg patches was recorded after first release of *T. pretiosum*.The lowest (0.60) egg patches was observed in T9(Emamectin benzoate 0.4g/l) treatment which was at par with T1 (*T. pretiosum* 1 card (2 Rel.) + *Bt* 25 2 % @ 2.0 ml/l.), T_2 (*T. pretiosum* 1 card (2 Rel.)+*M. anisopliae* Ma 35, 0.5%@ 2.0 g/l) and T_8 (Pheromones traps @15 /acre)treatments **(**Table 73). The highest egg masses were observed in the untreated control (1.43). With regards to eggparasitization**,** highest (18.47 %) was recorded in T2 treatment (*T. pretiosum* 1 card (2 Rel.)+*M. anisopliae* Ma 35, 0.5%@ 2.0 g/l) and it was significantly superior over rest of the treatments. Significant reduction in the larval population was observed in T9 i.eemamectin benzoate sprayed plot. All the *T. pretiosum* released treatments were at par with each other and recorded the larval population in the range of 0.30 to 0.40 larvae/10 plants/plotexcept T5(0.43larvae/10 plants/plot) and T^7 (0.57larvae/10 plants/plot).

In terms of per cent plant damage**,**T9 i.eemamectin benzoate sprayed plotwas significant in reduction of plant damage (4.44%)over rest of the treatments. All other treatments were at par with each other except untreated control. Amongst biocontrol agents, the treatment T4(*T. pretiosum* 1 card (2 Rel.)+EPN *H. indica* NBAIR H38 @ 4kg/acre and T2(*T. pretiosum* 1 card (2 Rel.)+ *M. anisopliae* Ma 35, 0.5%@ 2.0 g/l) were the next best treatments and recorded plant damage of 28.89 %.

The highest dead larvae 0.33/10 plants/plot was recorded in T2treatment (*T. pretiosum* 1 card (2 Rel)+*M. anisopliae* Ma 35, 0.5%@ 2.0 g/l.) which was at par with treatment T6(*T. pretiosum* 1 card (2 Rel)+*Spfr*NPV(NBAIR1) 2-3 sprays @ 2ml/litre and recorded (0.27). The treatments T1(*T. pretiosum* 1 card (2 Rel) + *Bt* 25 2 % @ 2.0 ml/l.)andT3(*T. pretiosum* 1 card (2 Rel)+*B. bassiana*-Bb 45, 0.5% @ 2.0 g/l) recorded0.20 larvae/10 plants/plotand were the next best treatments. Yield data from the experiment is awaited.

2.4.8 TNAU, Coimbatore

The experiment was carried out during 2019-20 in farmer fields atSinthulippu(GPS:10.7354° N, 77.2035° E), Tiruppur District with Hishellvariety.Among the biocontrol agents, 89.24 per cent damaged plants was observed in *T. pretiosum*+ *B. bassiana* NBAIR-Bb 45 followed by *T. pretiosum*+ *M. anisopliae* Ma 35 (89.75%), *T. pretiosum*+NBAIR Bt 2% (90.58%)and *T. pretiosum*+Spfr NPV(NBAIR1) (90.67%) on 45 DAS while in insecticide treated plots, 59.57 per cent damage was observed. Yield was maximum (6300Kg/ha)in *T. pretiosum*+ *B. bassiana* NBAIR-Bb 45 plots followed by *T. pretiosum*+ *M. anisopliae* Ma-35(6067Kg/ha) and these two treatments were on par with the yield (6513 Kg/ha) in the insecticide treated plots.

Table 73. Effect of biocontrol agents against Fall armyworm in Maize during 2019-20

Treatment	Egg patches /10 plants/plot (Nos)			% egg parasitization		Mean	Larvae /10 plants/plot (Nos)				% larval Parasitization			Average Larval. popln
	Pre count	Post count	Post count	Post count	Post count		Pre count	Post count 1st appln.	Post count 2nd appln.	Post count 3rd appln.	Post Count	Post Count	Post Count	
T1: *T. pretiosum* 1 card (2 Rel) + *Bt* 25 2 % @ 2.0 ml/l.	0.93^{a} *(1.20)	0.63^{a} (1.06)	0.63^{a} (1.06)	15.87^{a} **(23.46)	15.87^{a} (23.46)	15.87^{b} (23.47)	0.13^{a} * (0.79)	0.40^{b} (0.95)	0.40^{b} (0.95)	0.33^{b} (0.91)	8.33^{a} ** (11.91)	8.33^{a} (11.91)	8.33^{a} (11.91)	8.33^{a} (16.78)
T2: *T. pretiosum* 1 card (2 Rel)+*M. anisopliae* Ma 35, 0.5%@ 2.0 g/l.	0.87^{a} (1.17)	0.63^{a} (1.06)	0.63^{a} (1.06)	20.55^{a} (26.88)	16.39^{a} (23.79)	18.47^{a} (25.42)	0.20^{a} (0.83)	0.40^{b} (0.95)	0.43^{b} (0.96)	0.33^{b} (0.91)	5.55^{a} (9.94)	5.55^{a} (9.94)	8.33^{a} (11.91)	6.48^{a} (14.68)
T3: *T. pretiosum* 1 card (2 Rel)+*B. bassiana* - Bb 45, 0.5% @ 2.0 g/l	0.83^{a} (1.15)	1.00^{b} (1.22)	1.00^{b} (1.22)	13.40^{b} (21.19)	15.82^{a} (23.32)	14.61^{b} (22.46)	0.20^{a} (0.84)	0.43^{b} (0.97)	0.43^{b} (0.97)	0.40^{b} (0.95)	6.67^{a} (10.77)	6.67^{a} (10.77)	8.33^{a} (11.91)	7.22^{a} (15.57)
T4: *T. pretiosum* 1 card (2 Rel)+EPN *H. indica* NBAIR H38 @ 4kg/acre.	0.87^{a} (1.16)	0.97^{b} (1.21)	0.97^{b} (1.21)	13.42^{b} (21.42)	13.42^{a} (21.42)	13.42^{c} (21.49)	0.27^{a} (0.87)	0.60^{b} (1.05)	0.47^{b} (0.98)	0.40^{b} (0.95)	4.17^{a} (8.81)	5.55^{a} (9.94)	6.67^{a} (10.77)	5.46^{a} (13.46)
T5: *T. pretiosum* 1 card (2 Rel)+ *P. fluorescens (Pf DWD 2%)* @ 2ml/l.	1.03^{a} (1.24)	0.90^{b} (1.18)	0.90^{b} (1.18)	10.53^{b} (18.90)	14.54^{a} (22.25)	12.53^{c} (20.67)	0.27^{a} (0.87)	0.43^{b} (0.97)	0.43^{b} (0.97)	0.43^{c} (0.97)	8.33^{a} (11.91)	6.67^{a} (10.77)	6.67^{a} (10.77)	7.22^{a} (15.57)
T6: *T. pretiosum* 1 card (2 Rel)+*Spfr*NPV(NBAIR1) 2-3 sprays @ 2ml/litre	0.83^{a} (1.15)	1.03^{b} (1.24)	1.03^{b} (1.24)	9.81^{b} (18.23)	15.50^{a} (23.04)	12.66^{c} (20.72)	0.33^{a} (0.91)	0.43^{b} (0.96)	0.43^{b} (0.96)	0.30^{b} (0.89)	6.67^{a} (10.77)	6.67^{a} (10.77)	6.67^{a} (10.77)	6.67^{a} (14.96)
T7: *T. pretiosum* 1 card per acre alone (2 release).	0.80^{a} (1.14)	0.93^{b} (1.20)	0.93^{b} (1.20)	10.74^{b} (19.13)	14.07^{a} (21.84)	12.41^{c} (20.58)	0.23^{a} (0.85)	0.47^{b} (0.98)	0.50^{b} (1.00)	0.57^{c} (1.03)	5.55^{a} (9.94)	5.55^{a} (9.94)	5.55^{a} (9.94)	5.55^{a} (13.63)

T8:Pheromones traps @15 /acre.	1.00 ^{a} (1.22)	0.73 ^{a} (1.11)	0.73 ^{a} (1.11)	14.54 ^{a} (22.25)	14.54 ^{a} (22.25)	14.54 ^{b} (22.41)	0.30 ^{a} (0.89)	0.47 ^{b} (0.98)	0.47 ^{b} (0.98)	0.57 ^{c} (1.03)	5.55 ^{a} (9.94)	5.55 ^{a} (9.94)	5.55 ^{a} (9.94)	5.55 ^{a} (13.63)
T9: Chemical control (Emamectin benzoate 0.4g/l).	0.90 ^{a} (1.18)	0.53 ^{a} (1.01)	0.60 ^{a} (1.04)	0.00 ^{c} (2.87)	0.00 ^{b} (2.87)	0.00 ^{d} (2.87)	0.37 ^{a} (0.93)	0.03 ^{a} (0.73)	0.00 ^{a} (0.71)	0.00 ^{a} (0.71)	0.00 ^{a} (2.87)	0.00 ^{a} (2.87)	0.00 ^{a} (2.87)	0.00 ^{a} (2.87)
T10 : Untreated control	0.90 ^{a} (1.18)	1.23 ^{c} (1.32)	1.43 ^{c} (1.39)	13.35 (21.28)	16.19 ^{a} (23.66)	14.77 ^{b} (22.58)	0.40 ^{a} (0.94)	1.00 ^{c} (1.22)	1.00 ^{c} (1.22)	1.23 ^{d} (1.32)	6.67 ^{a} (13.25)	6.67 ^{a} (13.25)	8.19 ^{a} (16.61)	7.17 ^{a} (15.52)
SE ±	0.043	0.036	0.036	1.59	1.79	1.70	0.04	0.035	0.027	0.02	7.24	6.88	6.90	7.01
CD at 5%	NS	0.11	0.11	4.73	5.33	1.70	NS	0.10	0.08	0.06	NS	NS	NS	NS
CV (%)	6.33	5.52	5.36	14.08	14.95	14.49	8.34	6.23	4.87	3.56	25.33	19.05	11.24	18.82

*Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values (**Figures in parenthesis are arcsine transformed values)

Table 73. (Contd….) **Effect of biocontrol agents against Fall armyworm in Maize during 2019-20**

Treatment	**Damaged plants (%) plot**				**Mean**	**Dead larvae/10 plants/plot**			
	Pre count	**Post count 1st appln.**	**Post count 2nd appln**	**Post count 3rd appln**		**Pre count**	**Post count1st appln.**	**Post count 2nd appln**	**Post count 3rd appln**
T1: *T. pretiosum* 1 card (2 Rel) + *Bt* 25 2 % @ 2.0 ml/l.	20.00 ^{a} **(26.57)	26.67 ^{b} (31.00)	30.00 ^{b} (33.21)	33.33 ^{b} (35.22)	30.00 ^{b} (33.19)	0.03 ^{a} *(0.73)	0.13 ^{b} (0.80)	0.20 ^{a} (0.84)	0.20 ^{a} (0.84)
T2: *T. pretiosum* 1 card (2 Rel)+*M. anisopliae* Ma 35, 0.5%@ 2.0 g/l.	20.00 ^{a} (25.37)	26.67 ^{b} (30.79)	23.33 ^{b} (28.78)	23.33 ^{b} (28.78)	28.89 ^{b} (32.50)	0.00 ^{a} (0.71)	0.30 ^{a} (0.89)	0.33 ^{a} (0.91)	0.33 ^{a} (0.91)
T3: *T. pretiosum* 1 card (2 Rel)+ *B. bassiana* -Bb 45, 0.5% @ 2.0 g/l	20.00 ^{a} (26.57)	30.00 ^{b} (33.21)	30.00 ^{b} (33.21)	36.67 ^{b} (37.22)	32.22 ^{b} (34.56)	0.00 ^{a} (0.71)	0.17 ^{a} (0.82)	0.20 ^{a} (0.84)	0.20 ^{a} (0.84)
T4: *T. pretiosum* 1 card (2 Rel)+EPN *H. indica* NBAIR H38 @ 4kg/acre.	26.67 ^{a} (30.29)	26.67 ^{b} (30.29)	23.33 ^{b} (28.29)	26.67 ^{b} (30.29)	28.89 ^{b} (32.25)	0.00 ^{a} (0.71)	0.10 ^{c} (0.77)	0.17 ^{a} (0.82)	0.17 ^{b} (0.82)
T5: *T. pretiosum* 1 card (2 Rel)+ *P. fluorescens (Pf DWD 2%)* @ 2ml/l.	26.67 ^{a} (30.79)	36.67 ^{b} (37.22)	43.33 ^{b} (41.15)	43.33 ^{c} (41.15)	41.11 ^{b} (39.87)	0.03 ^{a} (0.73)	0.10 ^{c} (0.77)	0.10 ^{c} (0.77)	0.13 ^{b} (0.80)

T6: *T. pretiosum* 1 card (2 Rel)+*Spfr*NPV(NBAIR1) 2-3 sprays @ 2ml/litre	33.33 [a] (35.01)	26.67 [b] (31.00)	30.00 [b] (33.21)	30.00 [b] (33.21)	30.00 [b] (33.19)	0.00 [a] (0.71)	0.17 [a] (0.81)	0.23 [a] (0.86)	0.27 [a] (0.88)
T7: *T. pretiosum* 1 card per acre alone (2 release).	23.33 [a] (28.08)	33.33 [b] (35.22)	36.67 [c] (37.22)	40.00 [c] (39.15)	40.00 [b] (39.19)	0.00 [a] (0.71)	0.10 [c] (0.77)	0.13 [b] (0.80)	0.13 [b] (0.80)
T8:Pheromones traps @15 /acre.	30.00 [a] (33.00)	36.67 [b] (37.22)	36.67 [c] (37.22)	43.33 [c] (41.07)	41.11 [b] (39.86)	0.03 [a] (0.73)	0.10 [c] (0.77)	0.10 [b] (0.77)	0.10 [c] (0.77)
T9: Chemical control (Emamectin benzoate 0.4g/l).	26.67 [a] (31.00)	6.67 [a] (13.25)	3.33 [a] (8.06)	3.33 [a] (8.06)	4.44 [a] (12.00)	0.00 [a] (0.71)	0.07 [d] (0.75)	0.07 [b] (0.75)	0.00 [c] (0.71)
T10 : Untreated control	30.00 [a] (33.00)	46.67 [c] (43.08)	53.33 [d] (46.92)	56.67 [d] (48.85)	53.33 [c] (46.52)	0.03 [a] 0.73	0.07 [d] (0.75)	0.07 [b] (0.75)	0.17 [b] (0.82)
SE ±	4.40	3.22	2.71	3.11	2.71	0.014	0.025	0.023	0.018
CD at 5%	NS	9.56	8.08	9.32	7.69	NS	0.075	0.069	0.055
CV (%)	25.44	17.30	14.39	15.84	13.59	3.24	5.53	5.02	3.94

*Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values (**Figures in parenthesis are arcsine transformed values)

Table 74. Effect of biocontrol agents on fall armyworm in maize

Treatments	Damaged plants/plot % 15DAS	Damaged plants/plot % 30 DAS	Damaged plants/plot % 45DAS	% decrease from control	Yield Kg/ha	% increase over control
T1 *T. pretiosum*+ NBAIR Bt 2%	47.60 (41.6)^{a}	82.75 (65.43)^{bc}	90.58 (72.19)^{ab}	3.09	6007 (3.778)^{bcd}	8.19
T2 *T. pretiosum*+ *M. anisopliae* Ma 35	39.88 (41.1)^{a}	84.50 (66.80)^{b}	89.75 (71.4)^{b}	3.98	6067 (3.783)^{abc}	9.37
T3 *T. pretiosum*+ *B. bassiana* NBAIR -Bb 45	43.36 (41.3)^{a}	81.50 (64.50)^{bc}	89.24 (70.8)^{b}	4.53	6300 (3.799)^{ab}	12.57
T4 *T. pretiosum*+ EPN *H. indica* NBAIR H38	45.25 (41.4)^{a}	79.80 (63.30)^{c}	90.93 (72.4)^{ab}	2.72	5629 (3.750)^{cde}	2.26
T5 *T. pretiosum*+*P. fluorescens (Pf DWD 1%)*	39.83 (41.4)^{a}	83.25 (65.90)^{bc}	90.69 (72.2)^{ab}	2.97	5640 (3.751)^{cde}	2.44
T6 *T. pretiosum*+Spfr NPV(NBAIR1)	48.75 (41.9)^{a}	84.25 (66.60)^{b}	90.67 (72.2)^{ab}	3.00	5910 (3.772)^{bcde}	7.07
T7 *T. pretiosum* alone	55.99 (41.57)^{a}	83.50 (66.10)^{bc}	90.83 (72.3)^{ab}	2.82	5581 (3.747)^{de}	1.50
T8 Pheromone traps	54.14 (41.27)^{a}	81.50 (64.50)^{bc}	91.05 (72.63)^{ab}	2.59	5586 (3.747)^{de}	1.69
T9 Insecticide Emamectin benzoate	54.06 (41.52)^{a}	44.75 (42.00)^{d}	59.57 (50.51)^{c}	36.27	6513 (3.814)^{a}	15.52
T10 Control	50.24 (41.14)^{a}	90.75 (72.30)^{a}	93.47 (75.17)^{a}	-	5497 (3.740)^{e}	-
SEd	3.369	1.337	1.515	-	0.015	-
CD(P=0.05)	7.132	2.830	3.259	-	0.033	-

DAS – Days After Sowing
Figures in parentheses are arcsine transformed values (Damage) and logarithmic transformed values (Yield)
Means followed by a common letter in a column are not significantly different by DMRT; Values are mean of three replications

3. SORGHUM, FINGER, BARNYARD, FOXTAIL MILLET

3.1 Studies on abundance of natural enemies of borers in Millets (ICAR-IIMR, Hyderabad)

Chilo partellus was predominant (8 – 10 %) as compared to Sesamia inferens (5%) in Sorghum. About 15 – 20 % parasitization by *Cotesia flavipes* was observed in *C. partellus* during *kharif*, 2019.

Surveys for incidence of *S. frugiperda* was carried out along with AICRP- Sorghum trials monitoring during *kharif* season in Mahboobnagar (Telangana), Dharwad (Karnataka), Parbhani, Rahuri, Akola, Solapur (Maharastra), Ludhiana (Punjab), Indore (Madhya Pradesh), Surat (Gujarat) where incidence of pest was observed at low levels (3- 10 %) foliar damage on Sorghum. During *rabi* season 15-40 % foliar damage was observed at Hyderabad, Warangal, Parbhani.

In Barnyard, Proso, Little, Kodo millets the incidence of shoot flies were recorded at seedling, panicle stages causing deadhearts and white ears, respectively. Egg parasitoid *Trichogrammatoidea* *simmondsi* (20 %); Larval parasitoid, *Neotrichoporoides nyemitawus* (18.0 %) and pupal parasitoid, *Spalangia endius* (10%) were found parasitizing shoot flies across species and millets.

3.2 Evaluation of entomopathogenic fungi formulations against millet borersin Finger millet (IIMR, Hyderabad)

Three isolates of *B. bassiana* (Bb 5a, Bb 23 and Bb 45), one isolate of *M. anisopliae* were evaluated for their efficacy for managing pink borer of Finger millet (*S. inferens*) during *kharif* 2019 at ICAR-IIMR, Hyderabad. The treatments were applied twice at 20 and 40 DAE. The data on deadhearts, White earheads due to pink borer infestation was recorded.The DH caused in Finger millet due to pink borer were significantly least in T3-Bb 45 (3.08%) and it was on par with T4 Ma-35 (3.31%) and statistically better than carbofuran soil application (4.13%). There was 57.0 and 53.8 % reduction in DH over the control **(**Table 75) while T5(application of carbofuran) resulted in 42.3% reduction in deadhearts over the untreated control. WEH were least in T5 (2.50 %) and it was statistically on par with T4 Ma-35 (2.68%) and T3Bb45 (2.78%). There were 70. 6 and 69.5 % reduction in WEH over the control in T4 and T3, while carbofuran 3G soil application resulted in 72.6% reduction in WEH over the untreated control and it was most effective treatment (Table 75). Highest grain yield was obtained in T5 (3.78 kg/plot) which was on par with T4 Ma-35 (3.62 kg/plot) and T3Bb45 (3.48 kg/plot). There was 76.7 % and 69.7% increase in grain yield over the control. Soil application of carbofuran (T5) resulted in 83.5% increase in yield over untreated control.

Overall based upon the reduction in damage reduction and increase in yield realized, the bio-control agents T4 (application of Ma-35 oil based formulation @ 10 ml/lit at 20 & 40 DAE) and T3 (application of Bb-45 oil based formulation @ 10 ml/lit at 20 & 40 DAE) were the best and on par with soil application of carbofuran 3G.

Table 75. Evaluation of entomofungal formulations against Pink borer *Sesamia inferens* in Finger millet (*kharif* 2019)

Sl.No	**Treatment**	**Deadhearts (%)**			**White earhead (%)**			**Yield (Kg/plot)**	**Yield increase over control (%)**
		Pre (20DAE)	40 DAE	Red. over Control	Pre (50DAE)	At harvest	Red. over Control		
T1	Bb-5a @ 10 ml /lt	7.45	5.42 [c]	24.3	8.70	4.52 [c]	50.3	2.85[d]	38.7
T2	Bb-23 @ 10 ml /lt	7.42	4.20 [b]	41.4	8.20	3.51 [b]	61.5	3.23[c]	57.5
T3	Bb-45 @ 10 ml /lt	7.15	3.08 [a]	57.0	8.17	2.78 [ab]	70.6	3.48[bc]	69.7
T4	Ma-35 @10 ml /lt	7.46	3.31 [a]	53.8	8.23	2.68 [a]	69.5	3.62[ab]	76.7
T5	Carbofuran 3G granules @ 20 kg/ha) soil application	7.21	4.13 [b]	42.3	8.08	2.50 [a]	72.6	3.78[a]	83.5
T6	Untreated/Control	7.18	7.16 [d]	-	8.53	9.10		2.05[e]	
	Mean	7.31	4.55		8.32	4.18		3.17	
	CD (0.05)	NS	0.50		NS	0.75		0.36	
	CV (%)	4.60	14.16		5.14	13.86		8.40	

3.3 Field trial against Fall Armyworm in sorghum at AICRP-BC centres (IIMR Millets, Hyderabad, UAS-Raichur)

The experiment was undertaken with the treatment details mentioned hereunder

T1:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & second one after one week of first release) + NBAIR *Bt* 25 2% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T2:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *M. anisopliae* NBAIR -Ma 35, 0.5% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T3:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *B. bassiana* NBAIR -Bb 45, 0.5% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T4:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & the second one after one week of first release) + EPN *H. indica* NBAIR H38 (1-2 whorl sprays @ 4kg/acre, first spray after 15 days of planting & then the next sprays at 10 days interval)
T5:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *P. fluorescens (Pf DWD* 2%) (2-3 sprays @ 20g/liter depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T6:	*T. pretiosum* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + SpfrNPV(NBAIR1) (2-3 sprays @ 2ml/liter depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)
T7:	*T. pretiosum* alone (1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release)
T8:	Pheromones @15 traps/acre (install one week after planting and the lures to be replaced once in 25-30 days)
T9:	Insecticidal check (Emamectin benzoate 0.4gm/lt)
T10:	Untreated check (control)

3.3.1 ICAR-IIMR (Millets), Hyderabad

The experiment was undertaken during *rabi* 2019-20 with variety C 43. Results revealed, 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 to 3.0 eggs patches/10 plants/ plot. Emamectin benzoate sprayed plot recorded lowest egg patches (0.0/10 plants which was on par with treatment T2- i.e*T. pretiosum* 1 Card/ acre+ NBAIR Ma 35 0.5% (0.30 / 10 plants) and T6- i.e *T. pretiosum* 1 Card/ acre+ Spfr NPV (NBAIR 1) (0.70 egg patches/ 10 plants(Table 76). Significant reduction in the larval population was observed in T9- i.emamectin benzoate sprayed plot (0.10 nos/10 plants) and it was on par with T2 - i.e*T. pretiosum* 1 Card/ acre+ NBAIR Ma 35 0.5% (1.30 /10 plants) and T6- i.e *T. pretiosum* 1 Card/ acre+ Spfr NPV (NBAIR 1) (1.30 /10 plants) by 40 DAE ie after application of second round of treatment. Among the bio-control agents, treatment T2 and T6 resulted in 77.0 % reduction in larval population over the untreated control on 40 DAE.

In terms of per cent plant damage**,** T9- i.e emamectin benzoate sprayed plotwas significant in reduction of plant damage (0.0 nos/10 plants) after application of second round of treatment and it was on par with T2 - i.e*T. pretiosum* 1 Card/ acre+ NBAIR Ma 35 0.5% (2.6 %) and T4-*T. pretiosum* 1 Card/ acre+ NBAIR EPN H38 (3.60 %). There was 93.8 and 91.4% reduction in leaf damage over the untreated control.

Highest yield was recorded in treatment T9- i.e emamectin benzoate sprayed plot(7.573 kg/ plot) which was on par withT2- *T. pretiosum* 1 Card/ acre+ NBAIR Ma 35 0.5% (7.320 kg), T4- *T. pretiosum* 1

Card/ acre+ NBAIR EPN H38 (6.945 kg) and T3-*T. pretiosum* 1 Card/ acre+ NBAIR *Bb* 45 0.5% (6.670kg/plot). 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) oil based formulation 0.5 % at 20, 30 DAE) was the best for reduction in egg patches, larval population, plant whorl damage and increased yield over the control. However, the treatment (emamectin benzoate 0.4 gm/lt at 20, 30 DAE) was significantly the best and it was on par with T2.

Table 76. Evaluation of biocontrol agents for management of *S. frugiperda* during *rabi* 2019-20

Treatment	Egg patches/10 plants/plot (nos)		Larvae/10 plants/plot (nos) +			Per cent damaged plants/plot (%) @			Grain yield (kg/plot)
	Pre (20 DAE)	PostT1 (30 DAE)	Pre T	Post T1	Post T2	Pre T	Post T1	Post T2	
T1	2.0 (1.7)	1.00 (1.4)	4.00 (2.2)	3.30 (2.1)	3.00 (2.0)	24.9 (29.9)	13.3 (21.4)	8.1 (16.5)	5.420
T2	2.0 (1.7)	0.30 (1.1)	3.70 (2.2)	1.30 (1.5)	1.30 (1.5)	23.1 (28.7)	10.8 (19.1)	2.6 (9.2)	7.320
T3	2.0 (1.7)	1.30 (1.5)	4.00 (2.2)	3.00 (2.0)	3.00 (2.0)	22.3 (28.1)	12.2 (20.3)	8.5 (16.8)	6.670
T4	2.0 (1.7)	1.00 (1.4)	4.00 (2.2)	3.00 (2.0)	2.30 (1.8)	24.5 (29.6)	12.9 (20.7)	3.6 (10.9)	6.945
T5	2.0 (1.7)	1.30 (1.5)	4.00 (2.2)	3.70 (2.2)	4.00 (2.2)	21.7 (27.7)	15.7 (23.3)	20.0 (26.5)	6.067
T6	2.0 (1.7)	0.70 (1.3)	4.00 (2.2)	2.70 (1.9)	1.30 (1.5)	21.3 (27.4)	9.3 (17.7)	6.8 (15.1)	6.117
T7	2.0 (1.7)	1.00 (1.4)	4.00 (2.2)	3.30 (2.1)	3.70 (2.2)	20.6 (27.0)	10.6 (18.9)	33.7 (35.5)	5.330
T8	1.7 (1.6)	1.36 (1.5)	3.70 (2.2)	3.00 (2.0)	3.30 (2.1)	21.2 (27.4)	9.0 (17.4)	22.2 (27.9)	5.060
T9	2.0 (1.7)	0.0 (1.0)	4.00 (2.2)	0.70 (1.3)	0.10 (1.0)	23.8 (29.2)	2.1 (8.2)	0.0 (0.6)	7.573
T10	2.0 (1.7)	3.0 (2.0)	5.00 (2.4)	4.70 (2.4)	5.70 (2.6)	25.8 (30.4)	34.0 (35.6)	42.0 (40.4)	4.260
CD (0.05)	NS	0.3	NS	0.2	0.5	N/A	4.0	4.3	1.242
CV (%)	10.4	12.4	9.2	7.4	8.0	8.1	11.4	12.6	11.823

+ Figures in parentheses are square root transformed values
@ Figures in parentheses are arc sine transformed values

3.3.2 UAS, Raichur

The experiment was carried out during *rabi* 2019-20 at Main Agricultural Research Station, Raichur with M 35-1 variety. Number of egg patches of FAW ranged from 1.58 to 1.84 per plant which was statistically non significant. Minimum of 0.64 larva per plant was noticed in T3 -*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 28.75 per cent. The highest grain yield of 13.10 q/ha was noticed in T3-*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 77).

Table 77.Efficacy of biocontrol agents against Fall Armyworm in *rabi* sorghum during 2019-20

Sl. No.	Particulars	Egg patches per plant (No.)	Larvae per plant (No.)	Damaged plant (%)#	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%	1.72 (1.49)	1.08 (1.26)	13.25 (21.35)	3.25 (1.94)	21.50 (27.62)	12.25
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	1.68 (1.48)	1.12 (1.27)	11.50 (19.82)	8.15 (2.94)	20.75 (27.10)	12.85
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	1.58 (1.44)	0.68 (1.09)	6.25 (14.48)	23.05 (4.85)	22.25 (28.14)	13.10
T_4	*T. pretiosum* (1 card per acre to be installed after one week of planting) + *S. litura* NPV @ 2ml/liter	1.64 (1.46)	1.24 (1.32)	10.50 (18.91)	2.25 (1.66)	22.5 (28.32)	12.50
T_5	*T. pretiosum* (1 card per acre to be installed after one week of planting) + *P. fluorescens (Pf DWD 1%)* (2 sprays)	1.78 (1.51)	1.36 (1.36)	11.50 (19.82)	0.00 (0.71)	23.75 (29.17)	12.10
T_6	Insecticidal check (Emamectin benzoate 0.4gm/lt)	1.84 (1.53)	0.52 (1.01)	5.50 (13.56)	28.45 (5.38)	0.00 (0.00)	13.25
T_7	*T. pretiosum* (1 card per acre to be installed after one week of planting) alone	1.62 (1.46)	1.12 (1.27)	12.25 (20.49)	0.00 (0.71)	28.75 (32.42)	12.5
T_8	Pheromones @15 traps/acre (install one week after planting and lures to be replaced once in 25-30 days)	1.58 (1.44)	1.32 (1.35)	13.85 (21.85)	0.00 (0.71)	0.00 (0.00)	12.25
T_9	Untreated check (control)	1.64 (1.46)	1.72 (1.49)	15.00 (22.79)	2.05 (1.60)	2.5 (9.10)	11.85
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

*Figures in parentheses are arcsine transformed values

#Figures in parentheses are square root transformed values

PULSES

4. PIGEONPEA

4.1 Evaluation of NBAIR *Bt* formulation on pigeon pea against pod borer complex

4.1.1 PAU, Ludhiana

NBAIR *Bt* formulation was evaluated against pod borer complex in pigeonpea at farmer's field in collaboration with the KVK Nurmahal at Bhardwazia village, Tehsil Nurmahal, District Jalandhar on area of one ha area during 2019. The experiment was conducted on pigeonpea variety AL 201 sown in June 2019. There were three treatments, *viz.*, NBAII BT G4 (2%), chemical control (chlorantraniliprole18.5 SC @ 150 ml/ ha) and untreated control. The experiment was conducted in exploded block design where six equal sized units were considered as replications. There were three sprays at pre flowering, post flowering and pod formation. Per cent pod damage and grain yield was recorded.

Table 78. Large scale evaluation of NBAIR *Bt* formulation against pod borer complex on pigeonpea during 2019.

Treatments	**Per cent pod damage***	**Pod yield (q/ha)**
NBAIR *Bt* G4 @ 2%	9.84 [b] (18.03)	11.15 [b]
Chlorantraniliprole 18.5 SC @ 150ml/ha	5.97 [a] (13.83)	12.05 [a]
Untreated control	20.59 [c] (26.83)	9.75 [c]
CD (p = 0.05)	(3.06)	0.72
CV (%)	19.56	16.69

Figures in parentheses are arc sine transformed values

Results:

The per cent pod damage was minimum (5.97%) in chemical control and was significantly better than NBAIR *Bt* (9.84%). However, the damage was highest in untreated control (20.59%). The NBAIR *Bt* recorded 11.15 q/ha grain yield which was significantly better than untreated control (9.75 q/ha) However, maximum yield (12.05 q/ha) was observed in chemical control (Table 1). It was concluded that per cent pod damage and grain yield in NBAIR *Bt* G4 and chemical control were significantly better than untreated control.

4.1.3 UAS, Raichur

Experiment details:

Crop	: Pigeon Pea
Variety	: TS3 R
Date of Sowing	: 17-07-2019
Location	: Rampur village of Raichur taluk
Area	: 10 ha
Treatment imposition	: Four sprays of NBAIR *Bt* G4 on 18-10-2019, 27-10-2019, 18-11-2019 and 02-12-2019 Two sprays of insecticides in farmers field 1. Chlorantriniliprole 18.5 SC @ 0.25 ml/l 2. Emamectin benzoate 5 SG @ 0.2g/l
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 3.18 to 3.34 per plant. At seven days after spray, NBAIR *Bt*G4 recorded 1.76 larvae per plant, while in farmer practice it was 1.02 larvae per plant and similar trend noticed at ten days after spray. The per cent pod damage in NBAIR *Bt*G4 was 10.16 per cent while in farmers practice it was 7.38 per cent. In NBAIR *Bt*G4 the grain yield was 10.68q/ha in farmers practice 13.04 q/ha (Table 79).

Table 79. Evaluation of NBAIR *Bt*G4 in comparison with farmers practice during 2019-20

Treatment	Larval count (No./plant) *			Pod damage (%)#	Grain Yield (q/ha)
	1 DBS	7 DAS	10 DAS		
NBAIR *Bt*G4	3.18 (1.92)	1.76 (1.50)	1.32 (1.35)	10.16 (18.59)	10.68
Farmers Practice	3.34 (1.96)	1.02 (1.23)	0.64 (1.07)	7.38 (15.76)	13.04
S Em ±	0.07	0.04	0.06	0.53	0.48
CD (p = 0.05)	NS	0.13	0.18	1.54	1.44

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

4.1.4 PDKV, Akola

There was a significant differences among the treatments. The data on number of*Helicoverpaarmigera* larvae per plant is the mean of three observations. After three spray, it was found that significantly less larvae (0.22 per plant) was recorded in insecticide sprayed followed by *Bt* sprayed treatment (0.30 larvae per plant) and was found at par with each other. Both the treatments were significantly superior over untreated control (1.49 larvae per plant). During this year, larvae of *Euproctis* sp. were noticed in appreciable numbers.

Results:

The mean observation of three sprays on pod damage revealed that significantly lower damage was recorded in insecticidal treatment (T_2) with the 10.33% pod damage due to lepidopteran pod borers followed by *Bt* treatment (T_1) with 11.21% pod damage and both the treatments were at par with each other and significantly superior over untreated control (27.28%). The data on pod borer damage at harvest also revealed significant differences among the treatments, recording significantly lower damage of 13.13% in *Bt* treatment. It was followed by insecticidal sprays recording 14.13% pod damage and both the treatments were significantly superior to untreated control (24.25%) (Table 80).

Table 80. Effect of different treatments on pod borers, pod damage and yield of pigeonpea

Treatments	Mean no. of *H. armigera* larvae/plant	Mean pod damage after 3 sprays (%)	Pod borer damage at harvest (%)	Grain damage due to pod fly (%)	Yield (q/ha)
T_1 – NBAIR *Bt* G4 @ 2%	0.30 (3.14) *	11.21 (19.56) **	13.13 (21.24) **	12.87 (21.02) **	15.74
T_2 – Insecticidal sprays	0.22 (2.67)	10.33 (18.75)	14.13 (22.08)	4.55 (12.32)	16.59
T_3 – Control	1.49 (7.02)	21.01 (27.28)	24.25 (29.50)	15.2 (22.95)	10.01
SE(m)	0.29	0.71	1.87	1.21	0.58
CD (p = 0.05)	0.90	2.18	5.74	3.71	1.78

* Figures in parentheses are square root transformation values
**Figures in parentheses are Arc sin transformation values

The grain damage due to pod fly was recorded by split opening the pods at harvest and it was found that insecticidal treatment was significantly superior with 4.55 % grain damage than the*Bt* treatment and was significantly less effective and was at par with untreated control. The data on yield revealed the significant differences among the treatments, the insecticidal application recorded significantly higher yield (16.59 q/ha) followed by *Bt* treated field (15.74 q/ha) and both treatments were at par with each other and significantly superior over untreated control.

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

Objective: To demonstrate the use of *Trichoderma* sp. for the management of *Fusarium* wilt in pigeonpea

Experiment details:

Year of commencement	:	*Kharif*2018-19
Location	:	Farmer's field, Sankheda taluka, Vadodara district
Area	:	1 ha

Variety	:	Local variety (Daftari)
Treatments	:	T1: Seed treatment – *T. harzianum* @ 10g/ kg seeds Soil application of *T. harzianum* @ 10 kg/ha multiplied in 250 kg FYM 10 days prior to its application and apply at the time of sowing T2: Farmer's practice
Replications	:	Each block was divided into 8 equal sized units and each unit was considered as replication (each unit = one replication)
Observations	:	Disease incidence (%) Plant stand (%) at 30, 45, 60, 75, 90 DAS Yield (q/ha)

Results:

The demonstration experiment is under progress at farmer's field, Manjrol (Sankheda) Vadodara district.

5. COWPEA

5.1 Evaluation of entomopathogenic fungi against pod bug, *Riptortus pedestris* on cowpea *Vigna unguiculata*

5.1.1 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 (*Vigna unguiculata*) at farmer's field in Kuruvai, Vadakkenchery from March 2018 to May, 2018as per the technical programme.There was no significant difference between the treatments in terms of pod damage or yieldand hence the experiment was repeated during the period from March 2019 to May 2019. The results are presented in Table 81.

Results:

Six days after first spray, there was significant differences in the treatments.*B. bassiana* recorded the lowest pod damage (3.99 per cent) and which was on par with the malathion (22.89%) and both being significantly superior to *M. anisopliae*and untreated control (Table 4). After ten days, *B.bassiana* emerged as significantly superior to the remaining treatments with an average of 15.72% pod damage. Six days after the second spray, *B. bassiana*, malathion and *M. anisopliae* were found on par with each other with the mean pod damage of 15.9, 16.05 and 24.46 per cent respectively. A similar trend was observed eight days after second spray. There was no significant difference among the treatments in terms of yield, though plots treated with *B.bassiana* recorded the highest yield of 822.91 g/plot. Throughout the trial, the entomopathogenic fungus *B. bassiana* registered pod damage at par with malathion. Considering that the trial was conducted at Palghat, one of the hottest districts in Kerala during peak summer, the finding underlines the potential of the fungus in the biocontrol of pod bug in cowpea.

Table 81. Effect of entomopathogenic fungi on pod bug infestation in cowpea

Treatment	Mean pod damage per plot (%)										
	Pre count	4 DAS1	6 DAS1	10 DAS1	12 DAS1	2 DAS2	6 DAS2	8 DAS2	10 DAS2	12 DAS2	Yield (g/plot)
B. bassiana	0	3.51 (1.61)	3.99 (1.69)	15.72 (3.81)	36.89 (5.97)	27.69 (5.14)	15.90 (3.92)	14.07 (3.71)	21.54 (4.52)	19.79 (4.31)	822.91
M.anisopliae	0	20.33 (3.71)	34.76 (5.74)	42.67 (6.50)	36.38 (5.46)	27.70 (5.19)	24.46 (4.79)	26.66 (5.05)	19.10 (4.19)	17.96 (4.18)	682.78
Malathion	0	15.11 (3.29)	22.89 (4.19)	34.00 (5.73)	34.78 (5.77)	23.72 (4.76)	16.05 (3.95)	17.18 (4.03)	20.56 (4.46)	20.96 (4.56)	801.84
Control	0	11.98 (3.23)	28.22 (5.17)	40.07 (6.33)	43.66 (6.34)	28.54 5.33)	37.84 (6.06)	34.65 (5.73)	26.19 (4.99)	24.08 (4.80)	741.40
CD@ 5%		NS	2.68	1.75	NS	NS	40	1.50	NS	NS	NS

Values in parenthesis are Arc sine transformed values

5.2 Field evaluation of ICAR-NBAIR entomopathogenic strains against cowpea aphid (*Aphis craccivora*)

5.2.1 KAU, Thrissur

Field evaluation of ICAR-NBAIR strains of entomopathogenic fungi against cowpea aphid (*Aphis craccivora*) was carried out at the instructional farm of College of Horticulture, Vellanikkara from September, 2019 to January, 2020. The experiment could be completed as per the technical programme due to the delayed incidence of aphids towards the end of the crop, possibly due to the delay in cessation of the monsoon. The experiment will be repeated during 2020-21.

5.2.2 IIVR, Varanasi

The experiment was conducted during September to December, 2019 at the experimental farm of ICAR-IIVR, Varanasi. Since, the black bean aphid (*Aphis craccivora*) populationwas fairly low throughout the experimental period; the result could not be derived.

5.3 Screening of promising fungal and bacterial isolates for management of anthracnose disease in cowpea (*Vigna unguiculata* sub sp. *sesquipedalis*)

5.3.1 KAU, Kumarakom

The experimental results revealed that the fungal isolate *Trichoderma harzianum* (Th-3), *T. viride* (KAU strain) and *Pseudomonas fluorescens* (KAU strain) were effective in controlling yard long bean anthracnose to about 67%. The next effective treatment was *Hanseniaspora uvarum*(Y-73). Higher yields were obtained in biocontrol agent treated plots but were not significant when compared to control (Table 82).

Table 82. Efficacy of fungal and bacterial isolates on anthracnose disease of yard long bean

Treatment	Percent Disease Index*	Percent reduction over control	Yield (kg/plot)
T1: *Pichia guilliermondi* (Y-12) @ $2x10^8$ spores/ml – 10ml/lt	65.49 (54.09)	10.61	14.90
T2: *Hanseniaspora uvarum*.(Y-73)$2x10^8$ spores/ml – 10ml/lt	32.12 (34.47)	56.16	16.01
T3: *Trichoderma harzianum* (Th-3) @ $2x10^8$ spores/g – 10g/lt	23.91 (29.25)	67.36	17.48
T4: *Trichoderma viride* (KAU strain) @ $2x10^8$ spores/g – 10g/lt	24.17 (29.07)	67.01	16.36
T5: *Pseudomonas fluorescens* (KAU strain) @ $1x10^8$ spores/g -20g/L	24.53 (28.98)	66.52	16.90
T6: Carbendazim @ 2g/kg (seed treatment) and 2g/L spray	11.67 (19.47)	84.07	22.45
T7: Untreated control	73.26 (59.02)	-	11.44
CD (0.05)	8.66		NS
CV	16.04		25.42

6. CHICKPEA

6.1 Integration of botanicals, microbials and insecticide spray schedule for the management of *Helicoverpa armigera* on chickpea

6.1.1 PAU, Ludhiana

The experiment (chickpea variety PBG 7) was sown at Entomological Research Farm, Punjab Agricultural University, Ludhiana on 14.11.2019 in a randomized block design with a plot size of 18 m^2. There are ten treatments with three replications.

Tr. No.	1^{st} Spray	2^{nd} Spray
T1	*Bacillus thuringiensis* @ 2.0 kg/ha	Azadirachtin 300 ppm @ 2.5 litre/ha
T2	*Bacillus thuringiensis* @ 2.0 kg/ha	*Bacillus thuringiensis* @ 2.5 kg/ha
T3	*Bacillus thuringiensis* @ 2.0 kg/ha	Chlorantraniliprole 18.5 SC @ 125 ml/ha
T4	Azadirachtin 300 ppm @ 2.5 litre/ha	Azadirachtin 300 ppm @ 2.5 litre/ha
T5	Azadirachtin 300 ppm @ 2.5 litre/ha	*Bacillus thuringiensis* @ 2.0 kg/ha
T6	Azadirachtin 300 ppm @ 2.5 litre/ha	Chlorantraniliprole 18.5 SC @ 125 ml/ha
T7	Chlorantraniliprole 18.5 SC @ 125 ml/ha	Azadirachtin 300 ppm @ 2.5 litre/ha

Result: The experiment is in progress

6.2 Biological suppression of pod borer, *Helicoverpa armigera* infesting chickpea

6.2.1 MPUAT, Udaipur

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. Before treatment, the larval population ranged from 3.3 to 4.1 larvae per plant which was statistically non-significant.

Results:

The maximum reduction was recorded in quinalphos 25 EC @ 250g a.i/ha treatment (1.7 larvae per plant) and the minimum reduction was observed in*Bt*@ 1 Kg/ha(2.2 larvae per plant) at ten days after spray;whereas, the untreated control recorded least reduction in larval population (5.0 larvae per plant). Minimum per cent pod damage was recorded in treatment of quinalphos 25 EC @ 250g a.i/ha(8.68%) and maximum was in *Bt*@ 1 Kg/ha (13.56%) (Table 82.1).

Table 82.1 Efficacy of bioagents on pod Borer, *Helicoverpa armigera* (Hubner) infesting Chickpea in field

Treatments	Larval count (Mean number/plant)					Pod damage (%)	Grain Yield (q/ha)
	PTP	3 DAS	7 DAS	10 DAS	15 DAS		
B. bassiana @ 1x108 conidia /gm @ 5 gm/l	3.9	3.6	3.0	2.5	3.1	12.18	Yet to be harvest
Bt. @ 1 Kg/ha	3.5	3.1	2.7	2.2	3.0	13.56	
Quinalphos 25 EC @ 250g a.i/ha	3.3	2.8	2.3	1.7	2.4	8.68	
Untreated control	4.1	4.5	4.9	5.2	6.0	18.59	

6.3 Evaluation of bio-agent consortium in glasshouse (pot experiments) and in field for crop health management in chickpea

6.3.1 GBPUAT, Pantnagar

A glasshouse experiment was conducted at Plant Pathology Department, Pantnagar during Rabi 2019-20 to test the efficacy of bio-agents consortium plant growth parameters. Soil was pre inoculated with *Fusarium* (5g inoculum/pot) one week before sowing. The bio-agents were applied as seed bio-priming (10g /kg seed), soil application (10 g formulation with 100 g vermicompost) and as three foliar sprays (10g /lit). The experiment was laid out in a completely randomized design in three replications (pot size 2kg).

Table 83. Efficacy of bioagent consortia under glass house condition

Treatments	Germination % (15 DAS)	Plant Length(cm)		Fresh Weight (gm)		Dry Weight (gm)	
		Root	Shoot	Root	Shoot	Root	Shoot
Th17+Psf173	82.58	19.96	40.00	0.28	2.62	0.18	0.85
Th17+Psf2	81.92	17.43	42.90	0.21	2.60	0.18	0.78
Th17+Th14	80.93	19.37	38.46	0.21	2.57	0.17	0.73
Th14+Psf2	83.00	17.13	37.43	0.23	2.22	0.16	0.76
Th-17	70.50	15.80	37.53	0.18	2.04	0.17	0.75
Th-14	73.21	16.51	35.70	0.18	2.17	0.16	0.74
Psf-2	79.31	15.61	36.33	0.19	1.97	0.16	0.67
Psf-173	71.26	15.68	35.73	0.18	1.93	0.16	0.72
PBAT-3	84.29	21.70	41.80	0.27	2.84	0.17	0.84
Carbendazim	81.00	17.53	38.60	0.19	1.96	0.16	0.66
Control	66.00	14.26	34.86	0.15	1.74	0.13	0.43
C.D. (p=0.05)		0.96	1.59	0.02	0.18	0.01	0.02
C.V.		3.27	2.45	4.44	4.80	3.16	1.32

*05 counted seeds were sown in each pot

Results: The mixed formulations showed better performance than individual isolates with respect to their effect on seed germination. In mixed formulation treatments maximum germination percentage was observed by PBAT-3 (84.29%) followed by Th14+Psf2 (83.00%), Th17+Psf173 (82.58%), Th17+Psf2 (81.92%), carbendazim (81.00%) and Th17+Th14 (80.93%). However minimum germination percentage was recorded in control (66.00%). Maximum root length was observed with PBAT-3 (21.70 cm) followed by Th17+Psf173 (19.96 cm),Th17+Th14 (19.37 cm) and carbendazim (17.53 cm) which were significantly different from each other including control (14.26 cm). Maximum shoot length was observed with Th17+Psf2 (42.90 cm) which was statistically at par with PBAT-3 (41.80 cm) followed by Th17+Psf173 (40.00 cm), carbendazim (38.60 cm). Minimum shoot length was observed in control (34.86 cm). Maximum fresh weight was observed with Th17+Psf173 (0.28 gm) which was statistically at par with PBAT-3 (0.27 gm) but significantly better than control (0.15 gm). Maximum shoot weight was observed with PBAT-3 (2.84 gm) which was significantly different from Th17+Psf173 (2.62 gm), Th17+Psf2 (2.60 gm) and Th17+Th14 (2.57 gm) including Control (1.74 gm). Maximum dry root weight was observed with Th17+Psf173 & Th17+Psf2 (0.18 gm) which did not differ significantly from Th17+Th14, Th-17 & PBAT-3 (0.17 gm) but proved better than control (0.13 gm). Significantly maximum shoot dry weight was observed with Th17+Psf173 (0.85 gm), which was statistically at par with PBAT-3 (0.84 gm) but was better than Control (0.43 gm) (Table 83).

Field experiment:Plant mortality and mature plant wilt under field

Maximum percentage of seed germination was observed with PBAT-3 (86.08%), while minimum percentage of seed germination was recorded in control (69.24%). Maximum plant stand, 60 DAS and 120 DAS respectively was recorded with consortium Th17+Psf173 (208.74 and 205.38) followed by PBAT-3 (205.50 and 203.83), carbendazim (204.20 and 201.53), Th-14 (204.17 and 201.50), which did not differ significantly from each other but were better than control (167.48 and 163.48). Minimum number of mature plant wilt at 120 DAS was observed with consortium Th17+Psf173 (3.24), while maximum in control (6.10) after 120 days of sowing (Table 84).

Table 84. 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.)	(%)
Th17+Psf173	211.61	84.64	208.74	205.38	3.24	208.62	1.50
Th17+Psf2	206.85	82.74	200.92	199.25	4.22	203.47	2.04
Th17+Th14	210.23	84.09	202.20	199.53	4.38	203.91	2.08
Th14+Psf2	210.49	84.19	203.33	199.00	4.05	203.05	1.92
Th-17	205.81	82.32	199.37	196.71	5.12	201.83	2.48
Th-14	207.76	83.10	204.17	201.50	5.14	206.64	2.47
Psf-2	206.20	82.48	199.56	198.56	5.45	204.01	2.64
Psf-173	204.24	81.69	198.83	197.83	5.16	202.99	2.52
PBAT-3	215.07	86.08	205.50	203.83	3.27	207.10	1.52
Carbendazim	209.37	83.74	204.20	201.53	4.16	205.69	1.98
Control	173.10	69.24	167.48	163.48	6.10	169.58	3.52
CD (0.05)	4.64	-	5.02	5.84	0.33	-	-
CV (%)	1.31	-	1.46	1.73	4.31	-	-

*250 counted seeds were sown in each plot

6.4 Habitat manipulation / Bio-ecological engineering for the management of *Helicoverpa armigera* in chickpea

6.4.1 SKUAST, Jammu

Objectives

- To assess the impact of various intercrops and border crops on major insect pests of maize
- Impact of intercrops and border crops on the natural enemies abundance

Treatment details:

T1	Chickpea + Linseed (intercrop) + napier (border crop)
T2	Chickpea + Coriander (intercrop) + napier (border crop)
T3	Chickpea + Fenugreek (intercrop) + napier (border crop)
T4	Chickpea + Fennel (intercrop) + napier (border crop)
T5	Chickpea + Linseed (intercrop) + mustard (border crop)
T6	Chickpea + Corainder(intercrop) + mustard (border crop)
T7	Chickpea + Fenugreek (intercrop) + mustard (border crop)
T8	Chickpea + Fennel (intercrop) + mustard (border crop)
T9	Sole chickpea
T10	Sole chickpea + napier (border crop)
T11	Sole chickpea + mustard (border crop)
T12	Novaluron @ 25kg/ha (recommended check)

Observations to be recorded

- No. of larvae / 5 plants
- Percent pod damage by *Helicoverpa* on chickpea, intercrops and border crops
- Natural Enemy abundance on chickpea, intercrops and border crops
- Grain yield
- Equivalent chickpea grain yield

Helicoverpa armigera is one of the major insect pest in Jammu region, with its regular occurrence from vegetative to pod formation and maturity stage. Field experiment is being conducted during Rabi 2019-20 by manipulating the habitat of chickpea for the benefit of NEs and to the disadvantage of chickpea pod borer.A buffer distance of 14 m is maintained in between the treatments with napier and mustard as border crop, so as to nullify their effect on each other.Twelve treatments were imposed, taking four intercrops (Linseed, Coriander, Fenugreek and Fennel) in additive series (1:1). Sole chickpea with and without insecticidal spray Novaluron @ 25 kg/ha is taken as recommended check.

Results: The trial is in progress, yet to be harvested.

6.5 BIPM module for management of *Helicoverpa armigera* on chickpea

6.5.1 PAU, Ludhiana

The experiment (chickpea variety PBG 7) was sown at Entomological Research Farm, Punjab Agricultural University, Ludhiana on 15.11.2019 in a randomized block design with a plot size of 20 m^2. There are four treatments with six replications.

Results: The experiment is in progress

6.5.1 TNAU, Coimbatore

A field trial was conducted in a farmer's field at Vellamadai, Coimbatore District to evaluate two BIPM modules for the management of *Helicoverpa armigera* on chickpea. Observations on larval population and pod damage were recorded. The number of larval population ranged between 4.00 and 4.5 per 10 plants before spraying of entomopathogens and insecticide.

Results:

The larval population in BIPM module 1 and 2 were statistically similar with 3.17 and 3.00 larvae/ 10 plants, respectively on seventh day after spraying (DAS). The same trend was observed on 14DAS also. Pod damage was significantly less (7.29%) in chemical treatment as compared to BIPM modules. However, there was 35.93 to 37.53 per cent reduction in the pod damage in BIPM modules. The yield was maximum in chemical treatment (644 kg/acre) followed by BIPM module 2 (578 kg/acre) and BIPM module 1 (567 kg/acre)(Table 85).

Table 85 . BIPM module for management of *Helicoverpa armigera* on chickpea

Treatments	Nos. of larvae/10plants			Pod damage (%)	% decrease from control	Yield kg/acre	% increase over control	CB ratio
	Pre treatment	7 DAS	14 DAS					
T1 - BIPM module - 1 (HaNPV) @ 500ml/ha + Bird perches @ 8/acre + Pheromone traps @ 1/ plot	4.00 (2.23)	3.17 (2.03)[b]	4.00 (2.22)[b]	11.32 (19.52)[b]	37.53	567 (2.754)[b]	14.61	2.47
T2 - BIPM module - 2 (Bt) @ 2kg/ha + Bird perches@8/acre + Pheromone traps @1/ plot	4.17 (2.26)	3.00 (1.98)[b]	3.83 (2.19)[b]	11.61 (19.81)[b]	35.93	578 (2.762)[b]	16.85	1.81
T3 – Chemical (farmer practice)	4.50 (2.33)[a]	1.67 (1.61)[c]	3.17 (2.07)[c]	7.29 (15.32)[a]	59.77	644 (2.810)[a]	30.34	6.14
T4 – Control	4.33 (2.28)	6.17 (2.67)[a]	8.17 (3.02)[a]	18.12 (25.10)[c]		494 (2.695)[c]	-	-
SEd.	NS	0.135	0.117	1.751		0.0007	-	-
CD (*P* = 0.05)	NS	0.290	0.251	3.766		0.0016	-	-

DAS – Days after spraying
Means followed by a common letter in a column are not significantly different by DMRT
Figures in parentheses are square root values (No. of larvae), arcsine transformed values (Damage) and logarithmic transformed values (Yield)
Values are mean of six replication

COMMERCIAL CROPS

7. COTTON

7.1. Management of Pink bollworm by using *Trichogrammatoidea bactrae* in Bt cotton (UAS-R, PDKV, PJTSAU, TNAU)

7.1. 1: 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
T_3: Control

Observation:

In each block eight quadrants of size 500 sq mt were made in T_1 and T_2 while in T_3 a quadrant of size 100 sq mt 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 5.18 and 2.36 larvae per 10 bolls, respectively while in T_3 maximum of 8.94 larvae per 10 bolls were noticed. Rosette flower in T_1 (6.28 %) and T_2 (4.36 %) which differed statistically and T_3 recorded highest rosette flower of 10.26 per cent. Highest locule damage of 45.86 per cent was noticed in T_3 which was statistically inferior to T_1 and T_2 which recorded 11.38 and 7.92 per cent locule damage, respectively. Similarly, highest seed cotton yield of 31.80 q/ha was noticed in T_2 while T_1 recorded 27.35 q/ha and lowest seed cotton yield of 17.75 q/ha was recorded in T_3 (Table 86).

Table 86. Biointensive management of Pink bollworm in *Bt* cotton ecosystem during 2019-20

Sl. No	Particulars	PBW larvae per 10 bolls*	Rosette flower (%) at 50% flowering #	Locule damage (%) #	Seed cotton yield (q/ha)
1.	**T_1**: 1. Erection of Pheromone Traps (Funnel type) @ 10/acre 2. Release of *T. bactrae* @ 100000/	5.18 (2.38)	6.28 (14.51)	11.38 (19.72)	27.35

	ha 11 releases from 55 DAS 3. Application of azadiractin 1500 ppm @ ETL				
2.	**T_2**: 1. Profenophos 50 EC @ 2.0 ml/lt at 70 DAS 2. Thiodicarb 75 wp @ 1.0 gm/lt at 90 DAS 3. Lamda cyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS	2.36 (1.69)	4.36 (12.05)	7.92 (16.35)	31.80
3.	**T_3**: Control	8.94 (3.07)	10.26 (18.68)	45.86 (42.63)	17.75
S Em ±		**0.43**	**0.17**	**0.78**	**1.08**
CD (P=0.05)		**1.29**	**0.54**	**2.35**	**3.25**

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

7.1.2: PDKV, Akola

Treatments

T1: Standard practice of plant protection till 55th day or appearance of PBW.
i) Erection of pheromone traps (Funnel type).
ii) Releases of *Trichogrammatoidea bactrae* 100,000/ha/release, 6 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 40 EC @ 20 ml/10 Lt
2nd spray – Spinosad 45 SC @ 2.2 ml/10 Lt
3rd spray – B-cyfluthrin 2.5 %@10 ml/10 Lt
4th spray – Fenpropathrin 10 EC @ 10 ml/10 Lt

T3: Control

Observations: No. of rosette flowers, No. of green bolls (10 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

Results

The data on per cent rosette flowers, presented in Table 87 revealed that there were non-significant differences among the treatments as the infestation was overall low on flowers. Due to low incidence of pink bollworm, the data on green boll damage was also recorded to be non-significant. The data during cotton picking was recorded on per cent good and bad open bolls and it was revealed that significant minimum bad open bolls were recorded in treatment T2 with 23.50 % bad open bolls, followed by treatment T1 with 26.09%, both the treatments being at par with each other and significantly superior over untreated control which has recorded 36.58 % bad open bolls. The data on yield of seed cotton revealed that the treatment T2 recorded significantly maximum yield of 1316.87 Kg/ha seed cotton, followed by treatment T1 recording 1221.71 Kg/ha seed cotton. Both these treatments were significantly superior over untreated control that has recorded significantly minimum yield of 812.76 Kg/ha seed cotton.

Table 87. Effect of different treatments on damage due to Pink bollworm and seed cotton yield

Treatment	% Rosette flowers/5 plants	% Green boll damage	% bad open bolls	Seed Cotton Yield (Kg/ha)
T1 – Trichogrammatoidea *bactrae* releases (6 releases)	1.39 (6.77)	3.13 (10.18)	26.09 (30.72)	1221.71
T2 – Insecticidal sprays (sprays of 4 insecticides)	0.84 (5.26)	1.88 (7.87)	23.50 (29.00)	1316.87
T3 – Untreated Control	1.32 (6.59)	6.88 (15.20)	36.58 (37.21)	812.76
SE(m)	1.67	3.03	0.66	5.31
CD at 5 %	NS	NS	2.03	16.27

Figures in parentheses are Arc sin transformation values

Table 88. Effect of different treatments on per cent green bolls

Treatment	Per cent Green boll damage	
	110 DAS	130 DAS
T1 – Trichogrammatoidea releases (6 releases)	2.50 (9.10)	3.75 (11.17)
T2 – Insecticidal sprays (sprays of 4 insecticides)	1.25 (6.42)	2.50 (9.10)
T3 – Untreated Control	5.00 (12.92)	8.75 (17.21)
SE(m)	0.41	0.49
CD at 5 %	NS	NS

Figures in parentheses are Arc sin transformation values

Table 89. Effect of different treatments on per cent bad open bolls

Treatment	Per cent bad open bolls		
	130 DAS	140 DAS	150 DAS
T1 – Trichogrammatoidea releases (6 releases)	22.11 (28.05)	25.48 (30.32)	30.18 (33.32)
T2 – Insecticidal sprays (sprays of 4 insecticides)	21.87 (27.88)	22.61 (28.39)	25.99 (30.65)
T3 – Untreated Control	35.81 (36.76)	38.15 (38.15)	35.97 (36.85)
SE(m)	1.36	1.46	0.85
CD at 5 %	4.17	4.47	2.59

Figures in parentheses are Arc sin transformation values

7.1.3.PJTSAU

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.

iii) Erection of Pheromone traps (Funnel type) @ 10/ plot.

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

v) 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.
- Yield at harvest was recorded.

Results:

Despite low incidence of PBW during *Kharif*, 2019-20, the module with Pheromone traps (Funnel type) @ 10/ plot + releases of *Trichogrammatoidea bactrae* 100,000/ha/release, 6-8 releases starting from 55 days after germination + application of 5% Neem Seed Kernel Extract (NSKE) fared better than untreated control in terms of infestation by PBW.

Table 90. 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 *Trichogrammatoidea bactrae* 100,000/ha/release, 6-8 releases starting from 55 days after germination+ Application of Azadirachtin 1500 ppm @ 5ml/l at ETL	4.23	19.30	6.12
2.	Module 2: Spraying of insecticide during PBW infestation	5.67	24.67	7.13
3.	Control Plot	14.25	50.13	15.23

7.1.4 TNAU, Coimbatore

Treatments : T1:

i. Imidacloprid 200 SL 100 ml/ha for leaf hopper control

ii.Erection of pheromone traps (Funnel type) @ 10/ plot/PB Robe

iii.6 releases of *Trichogrammatoidea bactrae* 100,000/ha/release, starting from 55 days after germination.

T2: Spraying of insecticides (3 sprayings)

T3: Control

Results: In the field trial, pink boll worm damage was 22.50 per cent in BIPM plots which was 28.57 per cent lesser than the damage in the control plot (Table 91). There was 36.13 per cent reduction in pink boll worm damage in the insecticide sprayed plots. The yield was maximum in insecticide sprayed plots (1654Kg/ha) followed by 1562Kg/ha and 1344Kg/ha in BIPM and control plots respectively. The CB ratios were 1:2.41 and 1:2.57 for BIPM and insecticide treatments respectively.

Table 91. Bio-intensive management in Pink bollworm on Bt cotton:

Treatments	Bolls with locule damage %	% reduction over control	Yield Kg/ha	% increase over control	CB ratio
T1: Imidacloprid 200 SL 100 ml/ha for leaf hopper control 6 releases of *Trichogrammatoidea bactrae*@2cc/ac+ pheromone traps	22.5 (28.81)[b]	**28.57**	1562 (3.19)[a]	**13.96**	2.41
T2: Insecticide spray (3 sprays)	20.12 (29.00)[b]	**36.13**	1654 (3.21)[a]	**18.74**	2.57
T3: Control	31.5 (31.17)[a]	-	1344 (3.12)[b]	-	1.91
SEd	**2.220**	**-**	**0.016**	-	-
CD(P=0.05)	**4.884**	**-**	**0.033**	-	-

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

Figures in parentheses are arcsine transformed values (Damage) and logarithmic transformed values (Yield)

Values are mean of eight replications

7.2. Evaluation of entomofungal agents and botanical for the management of sucking pests in cotton (MPKV, PJTSAU)

7.2.1.MPKV

Pooled means for two years (2017-18 and 2018-19)indicated that amongst the biopesticides,*Lecanicillum lecanii* (1 x 10^8conidia/g) @ 5 g/litre recorded lowest population of sucking pests *viz.*, aphids (5.74), jassids (2.69), thrips (2.61), and white flies (1.77) on 3 leaves per plant compared to the untreated control which recorded aphids (39.24), jassids (12.73), thrips (31.67), and white flies (10.62) on 3 leaves per plant. The *Lecanicillum lecanii* (1 x 10^8conidia/g) @ 5 g/litre recorded seed cotton yield of 18.32 q/hawhich is at par with dimethoate 0.05 per cent (19.02 q/ha) with B:C ratio (1.25), and 1.32, respectively. Whereas, untreated control recorded lowest seed cotton yield of 7.88 q/ha with B:C ratio (0.57).

The trial on cotton was vitiated in *Kharif* season for the year 2019-20 due to continuous heavy rains from July, 2019 onwards in Pune region.

7.2.2: PJTSAU

Details of Treatments:

T1: *Metarhizium anisopliae* (1x10^8 conidia/g) @ 5 g/ litre
T2: *Lecanicillium lecanii* (1x10^8 conidia/g) @ 5 g/ litre
T3: *Beauveria bassiana* (1x10^8 conidia/g) @ 5 g/ litre
T4: NSKE @ 5% suspension
T5: Imidacloprid @ 0.05% spray
T6: Control

Observations taken:

The first spray was given on occurrence of the pest and rest continued till abundance of the pest.

1. 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.
2. 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.
3. The population of other sucking pests was also recorded.
4. Yield per plot was recorded at harvest.

Results:

Among the biologicals 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 92. Efficacy of entomofungal agents and botanicals for the management of sucking pests in cotton

	Treatment	Mean No./Plant			
		Aphids	Jassids	Thrips	White flies
1.	*Metarhizium anisopliae*(1x10^8 conidia/g) @5 g/ litre	0.67	9.47	0.93	0.45
2.	*Lecanicillium lecanii*(1x10^8 conidia/g) @5 g/ litre	0.53	6.32	1.23	0.12
3.	*Beauveria bassiana*(1x10^8 conidia/g) @5 g/ litre	0.97	9.21	0.87	0.47
4.	Azadirachtin 1500 ppm@ 5ml/l	0.91	7.39	0.65	0.32

5.	Imidacloprid (Chemical Check) 0.05%	0.97	8.09	0.43	0.17
6.	Untreated Control (Water spray)	1.52	12.32	1.72	0.42
	CD at 5% (p=0.05)	NS	0.259	NS	NS

7.3. Biointensive Pest Management in *Bt* cotton ecosystem during 2019-20 (AAU-A, UAS, Raichur)

7.3.1 AAU-A

Treatments : **T1: BIPM package**

- Seed bio-priming with *Trichoderma harzianum* @ 10g/kg of seeds.
- Maize as border crop
- Pheromone traps @ 40/ha for bollworms
- Release of *Trichogrammatoidea bactrae* @ 100,000/ha (6-8 releases starting from 55[th] DAS or with appearance of PBW)
- Application of Azadirachtin 1500 ppm @ 5 ml/ lit for sucking pests
- Spray of *Beauveria bassiana* ($1x10^8$) @ 5g/lit
- Spray of *Lecanicillium lecanii* ($1x10^8$) @ 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., Aphid, Jassid, Whitefly and Thrips were counted and recorded before spray, 3 and 7 days after each spray
- Yield (q/ha)

Results:

In the year 2019-20, the incidence of PBW was very low (1-2%). In case of sucking pests, incidence of thrips and aphid was observed. Over all, lower population of thrips and aphid was recorded in farmers' practice as compared to BIPM practice. The data on yield depicted no significant impact of BIPM package on yield of the crop.

Disease incidence: Very low incidence of leaf reddening disease (1-2%) was observed in both the modules.

Table 93. Effect of different modules on sucking pest complex in *Bt* cotton (2019-20)

Treatments	**aphid/leaf**							**thrips/ leaf**							**Cotton seed yield (q/ha)**
	BS	**First spray**			**Second spray**			**BS**	**First spray**			**Second spray**			
		3 DAS	**7 DAS**	**Pooled**	**3 DAS**	**7 DAS**	**Pooled**		**3 DAS**	**7 DAS**	**Pooled**	**3 DAS**	**7 DAS**	**Pooled**	
BIPM package	10.27 ±1.84	8.81 ±1.57	2.25 ±0.45	5.52 ±0.92	6.77 ±1.28	3.9 ± 1.24	5.33 ± 1.18	9.87 ±2.90	8.18 ± 1.86	2.05 ± 0.70	5.11 ± 1.10	7.77 ±1.26	3.55 ± 1.16	5.66 ± 1.04	22.10 ± 2.27
Farmers' practice	11.00 ± 2.70	6.87 ±1.68	3.47 ±0.79	5.17 ± 1.20	4.87 ±1.89	2.72 ±0.69	3.79 ± 1.38	10.76 ±4.09	5.92 ±1.70	2.67 ±1.43	4.2 ± 1.52	5.75 ±1.44	2.37 ± 0.61	4.25 ± 0.98	23.13 ± 2.25
t-test	-	*	*	-	*	-	*	-	*	-	*	*	*	*	-
P value	NS	0.03	0.003	NS	0.03	NS	0.10	NS	0.001	NS	0.01	0.009	0.02	0.01	NS

DAS: Days after spray

7.3.2 UAS-Raichur

Treatments:

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 leccani @ 1x 10^8 spores/gm @ 5 g/lit
7. Pseudomonas fluorescenes @ 2 per cent

T_2: Famers Practice

Observation:

Sucking pest population *Viz*; thrps, leafhoppers, aphids and whiteflies population was more in biointensive practice (7.84, 11.36, 5.36 and 0.76 thrips, leafhoppers, aphids and whiteflies/leaf) compared to farmer practice (2.92, 4.84, 2.18 and 0.26 thrips, leafhoppers, aphids and whiteflies/ leaf). Biointensive practice recorded 11.32, 33.68 and 21.86 PBW larvae, GOB and BOB per plant, respectively and in farmers practice it was 7.98, 39.84 and 13.85 PBW larvae, GOB and BOB per plant, respectively. Maximum locule damage of 29.25 per cent was noticed in biointensive practice, while in farmer practice it was 18.86 per cent. Biointensive practice recorded 27.25 q/ha seed cotton yield while in farmer practice it was 31.75 q/ha (Table 94).

Results:

Sucking pest population *Viz*; thrips, leafhoppers, aphids and whiteflies population was more in biointensive practice (7.84, 11.36, 5.36 and 0.76 thrips, leafhoppers, aphids and whiteflies/leaf) compared to farmer practice (2.92, 4.84, 2.18 and 0.26 thrips, leafhoppers, aphids and whiteflies/ leaf). Biointensive practice recorded 11.32, 33.68 and 21.86 PBW larvae, GOB and BOB per plant, respectively and in farmers practice it was 7.98, 39.84 and 13.85 PBW larvae, GOB and BOB per plant, respectively. Maximum locule damage of 29.25 per cent was noticed in biointensive practice, while in farmer practice it was 18.86 per cent. Biointensive practice recorded 27.25 q/ha seed cotton yield while in farmer practice it was 31.75 q/ha (Table 94).

Table 94. Biointensive Pest Management in *Bt* cotton during 2019-20

Sl. No.	Particulars	Thrips/ leaf	Leaf hoppers/ leaf	Aphids/ leaf	Whiteflies/ leaf	PBW larvae per 10 bolls	GOB /plant	BOB /plant	Locule damage (%)#	Seed cotton yield (q/ha)
1.	**T_1**: 1. Seed treatment with *T. harazinium* @ 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 leccani @ 1x 10^8 spores/gm @ 5 g/lit 7. Pseudomonas fluorescenes @ 2 per cent	7.84 (2.89)	11.36 (3.44)	5.36 (2.42	0.76 (1.12)	11.32 (3.44)	33.68 (5.85)	21.86 (4.73)	29.25 (32.74)	27.25
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. Lamda cyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS	2.92 (1.85)	4.84 (2.31)	2.18 (1.64)	0.26 (0.87)	7.98 (2.91)	39.84 (6.35)	13.84 (3.79)	18.86 (25.74)	31.75
S Em ±		**0.07**	**0.11**	**0.06**	**0.08**	**0.05**	**0.28**	**0.15**	**0.21**	**1.18**
CD (P=0.05)		**0.21**	**0.34**	**0.19**	**0.25**	**0.16**	**0.84**	**0.46**	**0.63**	**3.55**

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

7.4. Monitoring of whitefly and its natural enemies in cotton belt of Punjab (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* 2019. No major outbreak was recorded. The population of whitefly remained low to moderate throughout the cropping season. The PAU recommended strategy was successfully implemented in cotton growing areas through the joint efforts of PAU and Department of Agriculture (Punjab). The execution of IPM strategy involving regular monitoring and surveillance and timely advisement to farmers regarding non-chemical and chemical approaches did not allow whitefly population to build up and it remained under control during kharif 2019 season. Farmers were also acquainted with identification of natural enemies in cotton ecosystem. The farm literature regarding whitefly management was also distributed.

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. Sixteen species of natural enemies were recorded including 7 species of insect predators; 2 species of parasitoids and 7 species of spiders. Among predators, *Coccinella septempunctata*, *Cheilomenes sexmaculata*, *Brumoides suturalis*, *Serangiumparcesetosum*, *Chrysoperlazastrowi sillemiZanchiusbreviceps*, *Geocoris* sp. and spiders (*Neosconatheisi* Walckenaer, *Argiope* sp., *Oxyopes* sp., *Thomisus* sp., *Runcinia* sp., *Hyllus* sp. and *Chrysilla* sp.) were recorded. Out of these, *Chrysoperla* was the predominant species followed by spiders. The population of *Chrysoperla* increased till mid-July, but declined thereafter. However, spider population was at peak during mid to end-August. The population of coccinellids was negligible throughout the cropping season. *Encarsialutea* (Masi) and *Encarsia sophia* (Girault & Dodd) were the two parasitoids that emerged from whitefly nymphs. Out of 11378 nymphs observed, 855 were found to be parasitized. The mean parasitization of whitefly by *Encarsia* spp. in different cotton growing areas of Punjab was 7.51 per cent (range = 0.90 to 24.1%).

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

Objectives:

1- To study the seasonal dynamics of whitefly, its predators and parasitoids in cotton crop in different locations in farmers' fields in North Zone.
2- 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 all locations throughout the season except few location in July. In the month of October population of whitefly and other pests was negligible. Mean population (average of all locations) of whitefly (adults per three leaves) was maximum (Table-1) in July (9.44±5.12)followed by Aug (5.23±1.39), Sep (4.55±3.29), June (3.63±1.19) and October (1.85±0.66). Among the all locations maximum population (mean of the season) was observed in Fazilka (8.19±6.37), followed by Sirsa (5.2±2.28), Muktsar(3.81±1.91), Hanumangarh (3.79±2.17) and Sriganganagar (3.71±2.82). 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.

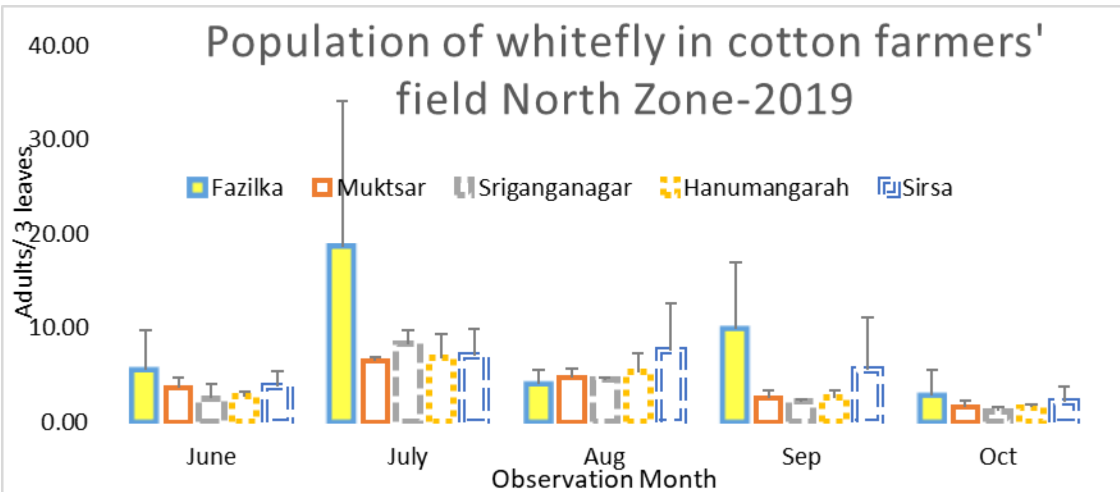


Fig 42. Dynamics of whitefly in cotton in North Zone

Among natural enemies predators Chrysopid and spiders were the dominant. Population of Coccinelid beetles was not found in most of the fields. Maximum population (mean of all locations) of Chrysopids (egg/larvae per plant) was observed in the month of July (2.22±0.52) followed by June (1.97±0.61), Aug (1.94±0.43), Oct (1.48±0.14) and 0.97±0.18. Among all locations Chrysopid population (mean of the season) was maximum in Muktsar (2.07±0.91) followed by Sirsa (1.71±0.75), Sriganganagar (1.64±0.43), Hanumangarh (1.63±0.36) and Fazilka (1.53±0.44).

Spider (adults/spiderlings per plant) population (mean of all locations) was maximum in the month of Oct (0.87±0.19) followed by Sep (0.75±0.21) and Aug (0.44±0.15) July (0.34±0.21). In the month of June Spider population was not found in cotton fields. Among all locations spider population (mean of the season)was maximum in Sriganganagar (0.55±0.47) followed by Fazilka (0.53±0.37), Sirsa (0.50±0.29) Hanumangarh (0.45±0.45) and Muktsar (0.36±0.26).In the beginning of the season spider population was absent but it starts build up from July onwards and reached maximum at the end of the season. Population of Chrysopids were present in large numbers from the beginning of the season and continue throughout the season.

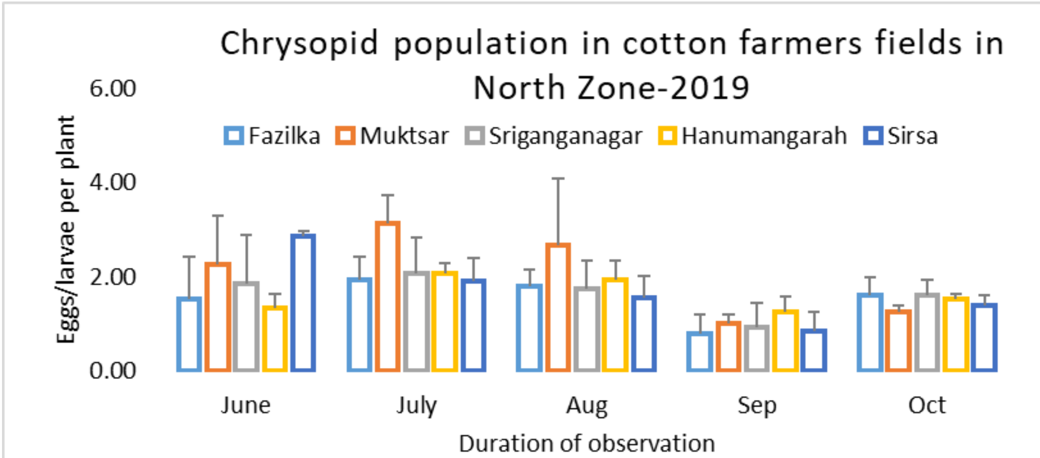


Fig 43. Dynamics of Chrysopid in cotton in North Zone

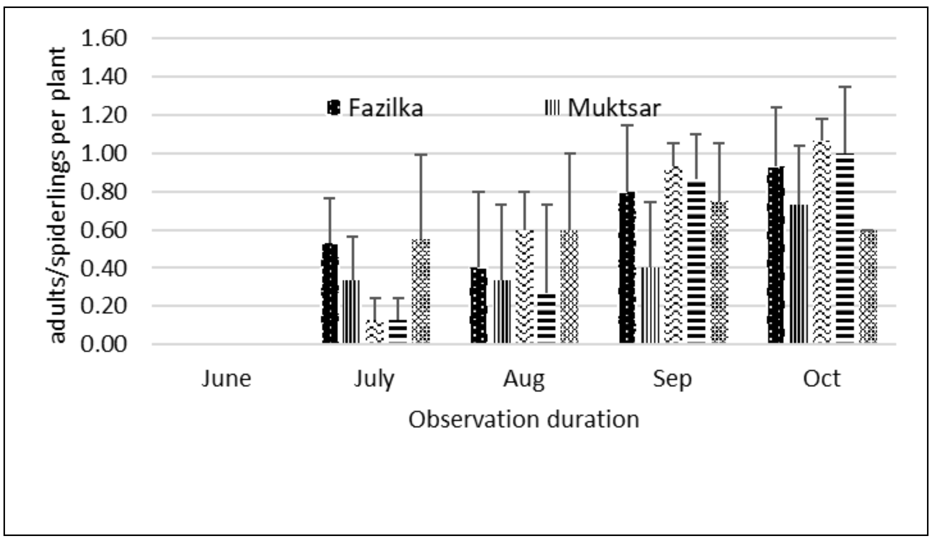


Fig 44. Dynamics of Spiders in cotton in North Zone

Parasitization of whitefly in cotton by *Encarsia sp*:

During observation on parasitization of whitefly nymphs in the laboratory total (sum of all locations throughout the season) 3428 whitefly nymph/pupae were counted, out of which 1009 were found parasitized. Mean (average of the season) parasitization (per cent) of whitefly nymphs by *Encarsia* spp or other parasitoids was recorded maximum in Muktsar (33.85, Range 25.00 – 57.14) followed by Sirsa (29.650 Range 12.50-40.90), Fazilka (29.28 range 18.11-39.42), Sriganganagar (26.57; range 12.33-38.46) and Hanumangarh (25.40 range 14.71-37.93).Overall average of all locations indicates that parasitisation fluctuated between 2.34 to 27.83 per cent which was maximum in August and minimum in October.The study clearly indicated that the heavy parasitization of whitefly by *Encarsia* and other species of parasitoids and natural control by predators 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 previous years.

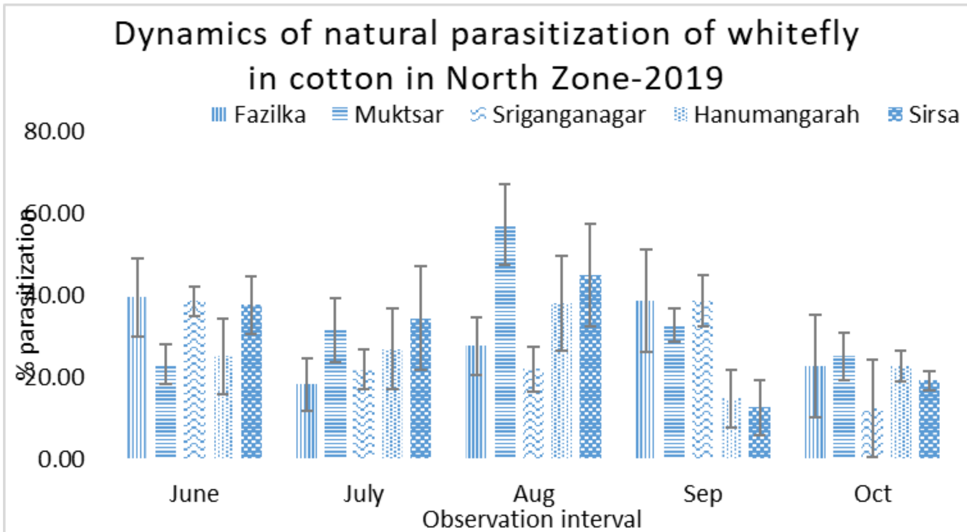


Fig 45 Parasitization of whitefly nymphs by *Encarsia spp* in cotton in different districts in north zone

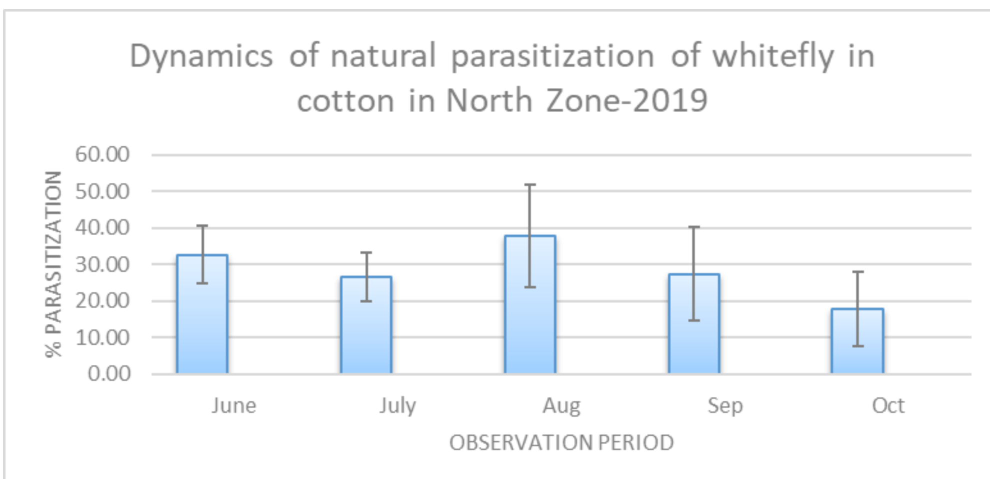


Fig 46. Parasitization of whitefly nymphs by *Encarsia spp* in cotton in north zone

8. SUGARCANE

8.1. Efficacy of entomopathogenic nematodes and entomofungus for the management of whitegrubs in sugarcane ecosystem (ANGRAU, MPKV, UAS-Raichur)

8.1.1: ANGRAU

Treatments : 4

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

Results:

During 2019-20, White grub incidence was not noticed in white grub endemic areas of Navabharath sugars, samalkota operational area during the year 2019 due to large scale application and promotion of Entomopathogenic nematodes, *Heterorhabditis indica* and entomopathogenic fungi, *Metarhizium anisopliae* in white grub endemic areas from the year 2014-15 with the support of Navabharath sugars, Samalkota, East Godavari district.

During 2017-18, demonstrations conducted in 30 acres showed that entomopathogenic nematode, *Heterorhabditis indica* was found significantly effective in reducing white grub damage compared to entomofungus , *Metarhizium anisopliae*. Percent reduction in plant damage due to white grub recorded high in *Heterorhabditis indica* (79.86 %), *Metarhizium anisopliae* (67.74%) and Chlorantraniliprole 18.5SC (72.91%) over untreated control . Higher yield increase was recorded in *H. indica* (52.75 t/ha) compared to *M. anisopliae* (48.89 t/ha) and Chlorantraniliprole 18.5SC (49.67 t/ha) compared to untreated control (13.65 t/ha).

During 2018-19, demonstrations conducted in 10 acres showed that entomopathogenic nematode, *Heterorhabditis indica* was found significantly effective in reducing white grub damage followed by entomofungus , *Metarhizium anisopliae.* Per cent reduction in plant damage due to white grub recorded high in *Heterorhabditis indica* (81.17%), *Metarhizium anisopliae* (78.83%) and Chlorantraniliprole 18.5SC (54.17%) over untreated control. Higher cane yield recorded in *H. indica* (65.5 t /ha), *M. anisopliae* (64.29 t/ha), Chlorantraniliprole 18.5SC (61.11 t/ha) compared to untreated control (22.98 t/ha).Promotion of Biocontrol agents helps the farmers to reduce expenditure on pesticides for the management of white grub in sugarcane ecosystem.

8.1.2: MPKV, Pune

The details of treatments are as follows:

T_1: *H. indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)
T_2: *H. bacteriophora* WP @ $1.0x10^5$/ m^2 (NBAIR WP formulation)
T_3: *S. carpocapsae* WP @ $1.0x10^5$/ m^2 (NBAIR WP formulation)
T_4: *S. abbasi* WP@ $1.0x10^5$/ m^2 (NBAIR WP formulation)

T_5: Chemical control(Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)
T_6: Control

Method of recording observations: The observations in field were recorded at 5 spots with 1 m^2 area per plot and the number of damaged clumps was counted before application of treatment and also after 30 and 60 days after treatment application. The sugarcane clump mortality data were recorded and it was angularly transformed and subjected to analysis of variance. The white grub population count was taken at 5 spots at 1 m row length at the time of harvesting.

Results:

Clump Mortality/15 clumps in plot due to white Grub: The data on efficacy of EPN strains against white grubs in sugarcaneare presented in Table 95 and the data on cost of spraying and economics of treatment are given in Table 6 and 97. It is seen from Table 95 that the pre count clump mortality due to white grub was ranged from 3.33 to 4.98/15 clumps in a plot. However, post count observations 30 and 60 days after first and second applications recorded significant difference amongst all the treatments.

Mean clump mortality/15 clumps in plot due to white grub after two applications: For comparison study data for two applications are pooled and mean of clump mortality was work out. Mean clump mortality was ranged from 10.16 to 24.71 %. Lowest clump mortality was recorded 10.16 % in T_5 - Chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L) which is at par with all EPN strains except untreated control (24.71 %). Amongst the EPN treatments, T_1 - *H. indica* @ $1.0x10^5$/ m^2 is promising treatment and recorded clump mortality of 11.94 %.

White grubper cent reduction over control after two application: Highest white grub reduction over control was recorded in T_5 -chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)(58.88 %) followed by the treatments T_1 -*H. indica* @ $1.0x10^5$/ m^2 (51.67 %), T_3 -*H. bacteriophora* @ $1.0x10^5$/ m^2 (48.92%), T_4 and T_2 (*S. abbasi* @ $1.0x10^5$/ m^2 (47.71%) and *S. carpocapsae* @ $1.0x10^5$/ m^2 (44.07 %), respectively.

Cane Yield (Mt/ha): The cane yield was ranged from114.00 to 147.93 Mt/ha. The highest cane yield 147.93 Mt/ha was recorded in chemical treatment T_5 (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)) which was at par with all the treatments except untreated control (114.00 Mt/ha). The next best treatment was T_1 - *H. indica* @ $1.0x10^5$/ m^2 which recorded 139.50 Mt/ha after that T_4 - *S. abbasi* @ $1.0x10^5$/ m^2 with 135.60 Mt/ha.

Table 95. Efficacy of EPN strains against white grubs in sugarcane (Year 2018-19)

Tr.No.	Treatment	Per cent Clump Mortality/15 clumps plot due to white grubs					Mean clump mortality % after two appln.	% white grub reduction over control on mean clump mortality after two appln.	Av. no of white Grub / 5 m	Cane yield (Mt./ha)	B: C ratio
		Precount	Post count 30 DAA 1st	Post count 60 DAA 1st	Post count 30 DAA 2nd	Post count 60 DAA 2nd					
T_1	*H. indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	3.33 [a] (8.89)	6.66 [a] (14.96)	11.70[a] (19.93)	11.68[a] (19.90)	17.74[a] (24.83)	11.94 [a] (19.96)	51.67	3.00 [a] (1.87)	139.50 [a]	1.93
T_2	*H. bacteriophora* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	3.33[a] (8.91)	7.20 [a] (15.55)	12.18[b] (20.84)	12.74 [a] (20.87)	18.38 [a] (25.36)	12.62 [a] (20.57)	48.92	3.65 [b] (2.04)	132.78 [a]	1.83
T_3	*S. carpocapsae* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	3.45[a] (9.05)	7.39 [a] (15.77)	13.36 [b] (21.37)	13.87[a] (21.85)	20.67 [a] (27.02)	13.82 [a] (21.53)	44.07	3.80 [b] (2.07)	131.03 [a]	1.81
T_4	*S. abbasi* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	3.33[a] (8.91)	6.78[a] (15.09)	12.19 [b] (20.35)	13.36[a] (21.36)	19.33 [a] (26.01)	12.92 [a] (20.76)	47.71	3.43 [b] (1.98)	135.60 [a]	1.88
T_5	Chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)	3.75 [a] (9.37)	5.41[a] (12.39)	9.13 [a] (17.58)	10.62[a] (18.93)	15.47 [a] (23.09)	10.16 [a] (18.30)	58.88	2.80 [a] (1.82)	147.93 [a]	2.46
T6	Untreated control	4.98[a] (11.92)	12.00[b] (20.23)	19.51 [c] (26.20)	25.34[b] (30.11)	41.99 [b] (40.38)	24.71 [b] (29.27)	-	3.85 [c] (2.09)	114.00[b]	1.95
SE ±		3.55	1.41	0.84	1.30	1.06	1.19	-	0.032	6.21	
CD at 5%		NS	4.24	2.54	3.94	3.19	3.35	-	0.096	18.73	
CV (%)		74.68	17.96	8.01	11.80	7.63	10.90	-	3.24	9.31	

(DAA- Days after application * Figures in parenthesis are arc sin transformed values)

Table 96. Cost of spraying

Tr. No.	Treatment	Cost of biopesticides (Rs. lit/kg)	Quantity/ (L/kg/ha.)	Qty. used/ha for 2 appln.	Cost (Rs./ha)	Labour charges (Rs./ha)	Total cost (Rs./ha)
T_1	*Heterorhabditis indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	800/-	20	40	32000/-	2790	34790/-
T_2	*H. bacteriophora* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	800/-	20	40	32000/-	2790	34790/-
T_3	*Steinernema carpocapsae* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	800/-	20	40	32000/-	2790	34790/-
T_4	*S.abbasi* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	800/-	20	40	32000/-	2790	34790/-
T_5	Chemical (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)	1400/-	0.500	1000	1400/-	2790	4190/-
T_6	Untreated control	-	-	-	-	-	-

Table 97. Economics of EPN treatments

Tr. No.	Treatment	Cost of Cultivat-ion/ha	Cost of Spraying Rs	Total cost Rs.	Yield (Mt/ha)	Rate/ Mt (Rs)	Gross returns (Rs./ha)	Net return (Rs. /ha)	B: C ratio
T_1	*H. indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	1,45,846/	34790/-	180636/-	139.50	2500	348750/-	168114/-	1.93
T_2	*H. bacteriophora* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	1,45,846/	34790/-	180636/-	132.78	2500	331950/-	151314/-	1.83
T_3	*S. carpocapsae* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	1,45,846/	34790/-	180636/-	131.03	2500	327575/-	146939/-	1.81
T_4	*S. abbasi* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	1,45,846/	34790/-	180636/-	135.60	2500	339000/-	158364/-	1.88
T_5	Chemical treatment (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)	1,45,846/	4190/-	150036/-	147.93	2500	369825/-	217789/-	2.46
T_6	Untreated control	1,45,846/	-	1,45,846/	114.00	2500	285000	139154/-	1.95

Results (2019-20):

Clump Mortality/15 clumps in plot due to white Grub: The data on efficacy of EPN strains against white grubs in sugarcane are presented in Table 38. It is seen from Table 38 that, pre count clump mortality due to white grub was ranged from 3.32 to 5.12/ 15 clumps in plot. However, post count observations at 30 and 60 days after first and second applications recorded significant differences amongst all the treatments except first application at 30 days after application.

Mean of clump mortality/15 clumps in plot due to white grub: For comparison study two applications are pooled and mean clump mortality was work out. Mean clump mortality was ranged from 9.18 to 25.20 %. Lowest clump mortality was recorded (9.18 %) in T_5 - chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)) treatment which was at par with all EPN strains except untreated control (25.20 %). Amongst the EPN treatments, T_1 - *H. indica* @ $1.0x10^5/ m^2$ is promising treatment and recorded clump mortality of 11.41 %.

White grubper cent reduction over control after two application: Highest (63.57%) white grub reduction was recorded in T_5 - chemical control(Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L). The next best treatments are T_1 - *H. indica* @ $1.0x10^5/ m^2$ (54.72 %), T_4- *S. abbasi* @ $1.0x10^5/ m^2$ (50.19 %), T_2 andT_3 *H. bacteriophora* @ $1.0x10^5/ m^2$ and *S. carpocapsae* @ $1.0x10^5/ m^2$ (49.12 and 43.25 %), respectively.

Cane Yield (Mt/ha): The crop is yet to be harvested and hence this trial is in progress

Table 98. Efficacy of EPN strains against white grubs in sugarcane (Year 2019-20)

Tr.. No	Treatment		Percent Clump Mortality /15 clumps plot due to white Grub				Mean clump mortality % after two appln.	% white grub reduction over control on mean clump mortality after two appln.
		Pre-count	Post count 30 DAA 1st	Post count 60 DAA 1st	Post count 30 DAA 2nd	Post count 60 DAA 2nd		
T_1	*H. indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	3.32 [a] (8.89)	5.00 [a] (11.93)	11.67 [b] (19.92)	12.74 [a] (20.87)	16.23 [a] (23.71)	11.41 [a] (19.39)	54.72
T_2	*H. bacteriophora* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	5.00[a] (11.93)	6.90 [a] (15.23)	12.18 [b] (20.38)	13.81 [b] (21.81)	18.38 [b] (25.36)	12.82 [a] (20.71)	49.12
T_3	*S. carpocapsae* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	3.33[a] (8.91)	7.20 [a] (15.55)	14.43 [c] (22.30)	14.91[b] (22.70)	20.67 [b] (27.02)	14.30 [b] (21.91)	43.25
T_4	*S. abbasi* @ $1.0x10^5$/ m^2 (NBAIR WP formulation)	3.33[a] (8.91)	6.66 [a] (14.96)	12.22 [b] (20.44)	14.19 [b] (22.10)	17.13 [b] (24.38)	12.55 [a] (20.50)	50.19
T_5	Chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)	5.12 [a] (12.07)	5.12 [a] (12.07)	9.13 [a] (17.58)	9.55 [a] (17.99)	12.92 [a] (21.06)	9.18 [a] (17.43)	63.57
T6	Untreated control	4.98[a] (11.92)	12.11 [a] (20.27)	19.51 [d] (26.19)	27.19 [c] (31.33)	41.99 [c] (40.38)	25.20 [c] (29.60)	-
SE ±		2.90	1.94	0.68	0.99	0.93	1.23	-
CD at 5%		NS	NS	2.04	2.99	2.81	3.49	-
CV (%)		55.62	25.88	6.40	8.69	6.92	11.42	-

(DAA- Days after application * Figures in parenthesis are arc sin transformed values).

8.2 Field efficacy of dose application of EPN against white grubs in sugarcane (MPKV, Pune)

The treatment details are as follows:

T1: *H. indica* @ 1.0x10^5/ m^2 (NBAIR WP formulation)
T2: *H. indica* @ 2.0 x 10^5/ m^2 (NBAIR WP formulation)
T3: *H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation)
T4: *H. indica* @ 1.0 x10^5/ m^2 (Commercial WP formulation)
T5: *H. indica* @ 2.0. x10^5/ m^2 (Commercial WP formulation)
T6: *H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation)
T7: Chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)
T8: Control

Results (2018-19):

Clump Mortality/15 clumps plot due to white grub: The data on efficacy of dose application of EPN against white grubs in sugarcane are presented in Table 99 and the data on cost of spraying and economics of treatment are given in Tables 100 and 101. It is seen from Table 99 that pre count clump mortality due to white grub was ranged from 2.22 to 6.94/15 clumps in plot. In case of post count observation at 30 and 60 days after first and second application, significant differences amongst the treatments were recorded.

Mean clump mortality/15 clumps in plot due to white grub after two application: For comparison study, two applications clump mortality are pooled and mean clump mortality was work out. Mean clump mortality was ranged from 8.69 to 29.72 %. Lowest clump mortality was recorded (8.69 %) in T_5 - chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L) which is at par with T_3 - *H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation) and T_6 - *H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation) and recorded 9.46 % and 11.57 % mortality, respectively.

White grubper cent reduction over control after two application: Highest white grub reduction over control (70.76 %) was recorded in T_7 -Chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L). The next best treatment is T_3 - *H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation) with 63.21 % mortality followed by T_6 - *H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation) with 61.07 %) mortality.

Cane Yield (Mt/ha): The cane yield was ranged from116.83 to 152.46 Mt/ha.The highest cane yield 152.46 Mt/ha was recorded in T_7 treatment - Chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L) which was at par with T_3 - *H. indica* @ 3.0 x10^5/ m^2(NBAIR WP formulation), T_6 - *H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation) and T_2 -*H. indica* @ 2.0 x 10^5/ m^2(NBAIR WP formulation) and recorded 145.50 , 143.92 and 135.83 Mt/ha, respectively.

Table 99. Efficacy of EPN strains against white grubs in sugarcane (Year 2018-19)

Tr. No	Treatment	Percent Clump Mortality 15 clumps /plot due to white Grub					Mean clump mortality % after two appln.	% white grub redn. over control on mean clump mortality after two appln.	Average no of white Grub / 5 m	Cane yield (Mt.ha)	B: C ratio
		Precount	Post count 30 DAA 1st	Post count 60 DAA 1st	Post count 30 DAA 2nd	Post count 60 DAA 2nd					
T_1	*H. indica* @ $1.0x10^5/m^2$ (NBAIR WP formulation)	4.44[a] (10.93)	6.82[b] (15.14)	13.65[b] (21.58)	17.17[b] (24.47)	18.51[b] (25.46)	14.04[b] (21.69)	45.41	3.40[b] (1.97)	134.00[b]	1.85
T_2	*H. indica* @ $2.0 x 10^5/m^2$ (NBAIR WP formulation)	4.44[a] (10.93)	7.47[b] (15.82)	11.80[a] (20.04)	14.76[a] (22.57)	16.23[b] (23.76)	12.40[b] (20.45)	58.72	3.27[b] (1.94)	135.83[a]	1.60
T_3	*H. indica* @ $3.0 x10^5/m^2$ (NBAIR WP formulation)	4.44[a] (10.93)	4.44[a] (10.93)	8.03[a] (16.43)	11.36[a] (19.65)	14.02[a] (21.92)	9.46[a] (17.58)	63.21	2.87[a] (1.83)	145.50[a]	1.48
T_4	*H. indica* @ $1.0 x10^5/m^2$ (Commercial WP formulation)	6.66[a] (14.96)	6.82[b] (15.14)	14.65[b] (22.50)	18.85[b] (25.71)	18.85[b] (25.71)	14.79[b] (22.27)	50.23	3.73[c] (2.06)	133.00[b]	1.84
T_5	*H. indica* @ $2.0. x10^5/m^2$ (Commercial WP formulation)	6.82[a] (15.14)	8.24[b] (16.67)	13.25[b] (21.34)	15.13[a] (22.86)	16.74[b] (24.14)	13.34[b] (21.27)	55.11	3.53[b] (2.01)	135.67[b]	1.60
T_6	*H. indica* @ $3.0 x10^5/m^2$ (Commercial WP Formulation)	6.84[a] (15.16)	7.47[a] (6.90)	9.14[a] (17.59)	13.42[a] (21.42)	15.59[a] (23.15)	11.57[a] (19.68)	61.07	3.47[b] (1.99)	143.92[a]	1.47
T_7	Chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)	2.22[a] (6.90)	2.22[a] (6.39)	7.22[a] (15.56)	12.54[a] (20.68)	12.78[a] (20.94)	8.69[a] (16.46)	70.76	2.60[a] (1.76)	152.46[a]	2.54

T_8	Untreated Control	6.94 ^{a} (15.27)	12.28 ^{b} (20.48)	24.91 ^{c} (29.93)	39.26 ^{c} (38.77)	42.43 ^{c} (40.64)	29.72 ^{c} (32.48)	-	4.07 ^{c} (2.14)	116.83^{c}	2.00
SE ±		2.45	1.83	0.68	0.81	0.80	1.20	–	0.034	5.53	
CD at 5%		NS	5.39	2.72	2.40	2.35	3.40	–	0.100	16.77	
CV (%)		33.98	21.74	5.71	5.76	5.39	11.04	-	3.02	6.98	

(DAA- Days after application * Figures in parenthesis are arc sin transformed values)

Table 100. Costs of spraying

Tr. No.	**Treatment**	**Cost of EPN (Rs. L/kg)**	**Quantity/ per (L/kg/ha.)**	**Qty. used/ha for two application**	**Cost (Rs./ha)**	**Labour charges (Rs./ha)**	**Total cost (Rs./ha)**
T_1	*H. indica* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	800/-	20	40	32000/-	2790/-	34790/-
T_2	*H. indica* @ 2.0 x 10^5/ m^2 (NBAIR WP formulation)	800/-	40	80	64000/-	2790/-	66790/-
T_3	*H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation)	800/-	60	120	96000/-	2790/-	98790/-
T_4	*H. indica* @ 1.0 x10^5/ m^2 (Commercial WP formulation)	800/-	20	40	32000/-	2790/-	34790/-
T_5	*H. indica* @ 2.0. x10^5/ m^2 (Commercial WP formulation)	800/-	40	80	64000/-	2790/-	66790/-
T_6	*H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation)	800/-	60	120	96000/-	2790/-	98790/-
T_7	Chemical control(Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)	700/-	0.500	1000	1400/-	2790/-	4190/-
T_8	Untreated Control	-	-	-	-	-	-

Table 101. Economics of EPN treatments

Tr. No .	Treatment	Cost of Cultivat-ion/ha	Cost of Spraying Rs	Total cost Rs.	Yield (q/ha)	Rate/ Mt(Rs)	Gross returns (Rs. /ha)	Net return (Rs. /ha)	B: C ratio
T_1	*H. indica* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	1,45,846/-	34790/-	180636/-	134.00	2500/-	335000/-	154364/-	1.85
T_2	*H. indica* @ 2.0 x 10^5/ m^2 (NBAIR WP formulation)	1,45,846/	66790/-	212636/-	135.83	2500/-	339575/-	126939/-	1.60
T_3	*H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation)	1,45,846/	98790/-	244636/-	145.50	2500/-	363750/-	119114/-	1.48
T_4	*H. indica* @ 1.0 x10^5/ m^2 (Commercial WP formulation)	1,45,846/	34790/-	180636/-	133.00	2500/-	332500/-	151864/-	1.84
T_5	*H. indica* @ 2.0. x10^5/ m^2 (Commercial WP formulation)	1,45,846/	66790/-	212636/-	135.67	2500/-	339175/-	126539/-	1.60
T_6	*H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation)	1,45,846/	98790/-	244636/-	143.92	2500/-	359800/-	115164/-	1.47
T_7	Chemical control(Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)	1,45,846/	4190/-	150036/-	152.46	2500/-	381150/-	231114/-	2.54
T_8	Untreated Control	1,45,846/	-	145846/-	116.83	2500/-	292075/-	146229/-	2.00

Results (2019-20):

Clump Mortality/15 clumps in plot due to white Grub: The data on efficacy of EPN strains against white grubs in sugarcane are presented in Table 102. It is seen from Table 102 that pre count clump mortality due to white grub is ranged from 2.22 to 4.44/ 15 clumps in plot. In case of post count observation at 30 and 60 days after first and second application, significant differences among treatments were recorded except first application at 30 days after application.

Mean of clump mortality/15 clumps plot due to white grub: For comparison study two applications are pooled and mean was work out. Mean clump mortality was ranged from 6.29 to 26.05 %. Lowest clump mortality was recorded (6.29 %) in T_7- chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L) which is at par with T_3 - *H. indica* @ 3.0 $x10^5$/ m^2 (NBAIR WP formulation) with 7.09 % mortality, T_6 - *H. indica* @ 3.0 $x10^5$/ m^2 (Commercial WP formulation) with 8.79 % and T_2 -*H. indica* @ 2.0 x 10^5/ m^2(NBAIR WP formulation) with 9.91 % mortality.

White grubper cent reduction over control after two applications: Highest white grub reduction over control was recorded (75.85 %) in T_7 - Chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L) and the next best treatment is T_3 - *H. indica* @ 3.0 $x10^5$/ m^2 (NBAIR WP formulation) with72.78 % reduction followed by T_6 - *H. indica* @ 3.0 $x10^5$/ m^2 (Commercial WP formulation) with 66.25 per cent reduction in grubs.

Table 102. Efficacy of EPN strains against white grubs in sugarcane (Year 2019-20)

Tr.. No	Treatment	Per cent Clump Mortality 15 clumps /plot due to white Grub					Mean clump mortality % after two appln.	% white grub reduction over control (mean clump mortality after two appln.)
		Pre-count	Post count 30 DAA 1st application	Post count 60 DAA 1st application	Post count 30 DAA 2nd application	Post count 60 DAA 2nd Application		
T_1	*H. indica* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	2.22[a] (6.90)	4.44 [a] (10.93)	12.35 [b] (20.43)	16.74 [c] (24.14)	18.27 [b] (25.29)	11.18 [b] (20.55)	57.08
T_2	*H. indica* @ 2.0 x 10^5/ m^2 (NBAIR WP formulation)	4.44 [a] (10.93)	4.60 [a] (11.11)	11.48[b] (19.77)	13.65 [b] (21.68)	16.23 [b] (23.76)	9.91 [a] (19.11)	61.95
T_3	*H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation)	4.44[a] (10.93)	4.44 [a] (10.93)	6.82 [a] (15.14)	10.00 [a] (18.43)	13.74 [a] (21.74)	7.09 [a] (16.87)	72.78
T_4	*H. indica* @ 1.0 x10^5/ m^2 (Commercial WP formulation)	4.44[a] (10.93)	7.16[a] (15.52)	13.96[b] (21.94)	13.96 [b] (21.94)	19.99 [c] (26.56)	11.70 [b] (21.49)	55.08
T_5	*H. indica* @ 2.0. x10^5/ m^2 (Commercial WP formulation)	4.44[a] (10.93)	6.82 [a] (15.14)	13.25 [b] (21.34)	14.44[b] (22.31)	15.87[b] (23.46)	11.50 [b] (20.57)	55.85
T_6	*H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation)	4.44[a] (10.93)	6.66[a] (14.96)	7.77[a] (16.17)	11.94 [a] (20.18)	14.76 [a] (22.57)	8.79 [a] (18.78)	66.25
T_7	Chemical control(Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L)	2.22[a] (6.90)	2.22[a] (6. 90)	7.22 [a] (15.56)	9.44 [a] (17.88)	12.78 [a] (20.94)	6.29 [a] (15.75)	75.85
T_8	Untreated Control	4.44[a] (10.93)	12.29 [a] (20.48)	22.69 [c] (28.42)	36.92 [d] (37.38)	43.00 [d] (40.97)	26.05 [c] (31.84)	-
SE ±		3.61	3.04	0.94	0.77	0.65	1.44	-
CD at 5%		NS	NS	2.85	2.34	1.96	4.09	-
CV (%)		63.08	39.75	8.19	5.80	4.37	14.01	-

DAA- Days after application * Figures in parenthesis are arc sin transformed values

8.3 Efficacy of entomopathogenic nematode and entomofungus for the management of white grub in sugarcane ecosystem during 2019-20.

8.3.1 UAS-Raichur

Treatments:

T1: *Heterorhabditis indica* WP (NBAIR) @12 kg/ha in 250 kg FYM per ha. (applied at the time of larval incidence)
T2: *Metarhizium anisopliae* (NBAIR) @2.5 kg/ ha in 250 kg FYM per ha.(applied at the time of larval incidence)
T3: Chemical control (Chlorantraniliprole 18.5SC @ 0.3 ml / lit); (applied at the time of larval incidence)
T4: Untreated control

The pre-treatment observations on plant damage due to white grub ranged from 38.75 to 40.50 per cent and the number of white grubs ranged from 10.25 to 11.75 grubs per 10 mrl. In the post treatment observations the plant damage due to white grub was lowest (8.50 %) in *Heterorhabditis indica* WP (ICAR- NBAIR) and it was at par with *Metarhizium anisopliae* (ICAR-NBAIR Ma 4) and Chlorantraniliprole 18.5 SC which recorded 9.25 and 6.50 per cent plant damage. Highest plant damage of 61.25 per cent was noticed in untreated control. Similarly, the number of white grubs six months after treatment imposition showed that *Heterorhabditis indica* WP (ICAR- NBAIR) recorded lowest of 2.05 grubs per 10 mrl and it was at par with *Metarhizium anisopliae* (ICAR-NBAIR Ma 4) and Chlorantraniliprole 18.5 SC which recorded 2.20 and 1.75 grubs per 10 mrl. *Heterorhabditis indica* WP (ICAR- NBAIR) recorded 121.85t/ha cane yield which was at par with *Metarhizium anisopliae* (ICAR-NBAIR Ma 4) and Chlorantraniliprole 18.5 SC which recorded 118.50 and 123.50t/ha. Untreated control recorded 95.25 t/ha cane yield (Table 103).

Table 103. Efficacy of entomopathogenic nematodes and entomofungus for the management of white grub in sugarcane during 2019-20

Sl. No.	Particulars	Per cent plant damage due to white grubs*			No. of white grub/10 m row length#			Cane yield (t/ha)
		Before treatment imposition	Six month after treatment imposition	Reduction over Untreated control (%)	Before treatment imposition	Six month after treatment imposition	Reduction over Untreated control (%)	
T_1	*Heterorhabditis indica* WP (NBAIR) @12 kg/ha in 250 kg FYM per ha	40.50 (39.52)	8.50 (16.95)	86.12	10.50 (3.32)	2.05 (1.60)	85.18	121.85
T_2	*Metarhizium anisopliae* (NBAIR) @2.5 kg/ ha in 250 kg FYM per ha.	38.75 (38.50)	9.25 (17.71)	84.95	11.25 (3.43)	2.20 (1.64)	83.05	118.50
T_3	Chlorantraniliprole 18.5SC @ 0.3 ml / lit	40.25 (39.38)	6.50 (14.77)	89.38	11.75 (3.50)	1.75 (1.50)	87.75	123.50
T_4	Untreated control	39.75 (39.09)	61.25 (51.50)	-	10.25 (3.28)	13.75 (3.77)		95.25
SEm ±		**0.28**	**1.66**	**-**	**0.13**	**0.07**	**-**	**2.78**
CD (P=0.05)		**NS**	**4.98**	**-**	**NS**	**0.23**	**-**	**12.37**

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

8.4 Large scale demonstrations of *Trichogramma chilonis* against sugarcane borers (ANGRAU, MPKV, OUAT, PJTSAU, PAU, UAS-Raichur), Sunagro, Chennai

8.4.1: ANGRAU

Large Scale Demonstration of Temparature tolerant *Trichogramma chilonis* against Sugarcane borers

Treatments: Two

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 chlorpyriphos @ 2.5 ml/lt from 30 days after planting at 7-10 day interval)

- Large scale demonstration using temperature tolerant strain *T. chilonis* was conducted in one acre at RARS farm and in 12 acres area of 3 farmers plots in Visakhapatnam, Vizianagram and srikakulam districts. 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.
- In farmers fields, cumulative incidence of early shoot borer incidence was low (10.86% DH), internode borer incidence (19.08 %) , internode borer intensity (2.77%) was low in temperature tolerant strain *T. chilonis* release – 8 +4 times compared to farmer's practice of Four sprays with Chlorpyriphos (18.93% DH and 38.98% INB incidence, 5.56 % INB intensity) . Cane yield and incremental benefit cost ratio recorded high in temperature tolerant strain of *T. chilonis* released plot (63.93 t/ha and IBCR : 50.19) compared to farmers practice (53.54 t/ ha and IBCR : 6.74) (Table 104).
- Early shoot borer incidence upto 120 days recorded low in temperature tolerant strain *T. chilonis* release (8+4 times) field at RARS, Anakapalle (28.1% DH) with significantly low internode borer incidence (23.6%) and internode borer intensity (6.87 %) resulted in higher cane yield (83.82 t/ha) with high incremental benefit cost ratio (81.6) compared to farmer's practice of Chlorpyriphos sprays four times (21.24%DH) ; % INB incidence (58.7%); internode borer intensity (7.46%); cane yield 82.06t/ha with low incremental benefit cost ratio (15.0) (Table 105) .

Table 104. Efficacy of Temparature tolerant *Trichogramma chilonis* against Sugarcane borers in farmers fields

Treatment	Cumulative ESB %DH	INB incidence %	INB intensity %	Cane yield t/ha	Sucrose %	Incremental Benefit Cost Ratio
Chuchukonda, Visakhapatnam district						
T1 : TTC releases (8+4 times)	12.2	14.24	2.14	70.42	18.24	64.54
T2:Farmers practice (Four sprays with chlorpyriphos)	19.85	38.1	4.66	63.17	18.5	10.07
Annamrajupeta, Vizianagaram district						
T1 : TTC releases	11.44	22.16	2.94	67.55	19.13	61.0
T2:Farmers practice	17.66	41.03	5.87	55.18	18.07	8.34
Sankili, Srikakulam district						
T1 : TTC releases	8.95	20.83	3.22	53.82	18.67	28.06
T2:Farmers practice	19.27	37.82	6.15	42.26	19.10	3.13
Average						
T1:TTC releases (8+4 times)	10.86	19.08	2.77	63.93	18.68	50.19
T2:FP (Four sprays with chlorpyriphos)	18.93	38.98	5.56	53.54	18.56	6.74

Table 105. Efficacy of Temparature tolerant *Trichogramma chilonis* against Sugarcane borers at RARS farm

Treatment	ESB %DH 30 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
T1 : Temparature tolerant *Trichogramma chilonis* (8+4 releases) in May plant crop 2009A107	7.84	11.4	7.8	1.06	28.1	23.67	6.87	1.62	83.82	18.38	81.6
T2: :Farmers' practice- Four sprays with chlorpyriphos @ 2.5 ml/lt	7.56	9.59	3.53	0.56	21.24	58.75	7.46	4.36	82.06	18.67	15.0
t-test	NS	NS	NS	NS	NS	*	*	*	NS	NS	
t cal	0.12	0.12	0.1	0.12	0.12	-1.78	-1.10	-1.12	0.12	0.1	

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

Promotion of temparature tolerant strain of *Trichogramma chilonis* through large scale frontline demonstrations against early shoot borer and internode borer in sugarcaneimprove the efficiency of biocontol technology in high temperature conditions and reduce the cost on plant protection. This trial helps in effective management of early shoot borer (*Chilo infuscatellus*) and internode borer (*Chilo infuscatellus*; *Chilo sacchariphagus indicus*) utilizing for the benefit of farming community temparature tolerant strain of *Trichogramma chilonis*.

8.4.2 MPKV, Pune

The large scale demonstration on biological suppression of borer complex in sugarcanewas carried out and theeffectiveness of *T. chilonis* TTS against ESB in sugarcane was conducted on the farmers' field at Malegaon Co – operative Sugar Factory Ltd., Malegaon B.K., Tal. Baramati, Dist. Pune in villages Malad (Malegaon), Pandare and Nirawagaj (Baramati Tahashil), in Pune District.Planting of sugarcane cv. Co 86032 @ 25,000 sets/ha was done on 4.2.2019 to 25.2.2019 over 5.0 ha with at 90 x 30 cm plant spacing. Nucleus culture of the parasitoid was obtained from the NBAII, Bangalore and mass cultured in the Biocontrol laboratory at AC, Pune.

The treatments comprised eight releases of *T. chilonis* TTS @ 50,000 adults/ha at weekly interval, farmers' practice of three sprays of chlorpyriphos 0.05% and untreated control. A control plot maintained at 200 m distance from parasitoid released plot. Each treatment plot was divided into 10 subplots as replicates. Releasing of parasitoids was started from 20.4.2019. The pre-release observations on infestation of ESB (% dead hearts) and number of tillers per clump were recorded at 10 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.

Results: The results of shoot borer infestation given in Table 106 for the year 2019-20 indicated that 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 22.30 to 6.95 % dead hearts) and increased number of tillers (9.85 tillers/clump) as well as cane yield (140.96 MT/ha) with B:C ratio 3.11.

Table 106. Efficacy of *T. chilonis* TTS against ESB on sugarcane (Year 2019-20)

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	18.67 [a] *(25.54)	6.95 [a] (15.25)	8.08 [a] **(2.92)	9.85 [a] (3.22)	140.96[a]
T2: Farmers practice- chlorpyriphos 0.05%	17.16 [a] (24.42)	8.54 [b] (16.99)	8.06 [a] (2.92)	9.03 [a] (3.09)	137.64[a]
T3: Untreated control	17.38 [a] (24.55)	22.30 [c] (28.16)	7.85 [a] (2.89)	7.31 [b] (2.78)	122.99[b]
SE ±	0.81	0.44	0.03	0.06	4.54
CD at 5%	**NS**	**1.35**	**NS**	**0.19**	**13.02**
CV (%)	**8.63**	**5.74**	**2.77**	**5.31**	**5.90**

(*Figures in parenthesis are arcsine transformed value of dead heart
**Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values of tillers/clump)

The data on demonstration on efficacy of *T. chilonis* TTS against ESB infestation,number of tillers/clump and cane yield Mt/ha on sugarcane for three years are presented in Table 107 (2017-18), Table 108 (2018-19) and Table 109 (2019-20) and pooled data for the years 2017-18 to2019-20are presented in Table 32 and data on costs of spraying and economic of treatment are given in Table 110 and 110.1.

Table 107. Efficacy of *T. chilonis* TTS against ESB on sugarcane (Year 2017-18)

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	13.96 [a] * (21.92)	5.89 [a] (14.04)	8.48 [a] ** (2.99)	10.91 [a] (3.38)	139.25 [a]
T2: Farmers practice- chlorpyriphos 0.05%	14.13 [a] (22.07)	6.26 [a] (14.47)	7.96 [a] (2.90)	9.38 [b] (3.14)	137.84 [a]
T3: Untreated control	13.78 [a] (21.78)	21.83 [b] (27.82)	7.61 [a] (2.84)	5.76 [c] (2.50)	123.42 [b]
SE ±	0.32	0.35	0.04	0.03	3.53
CD at 5%	**NS**	**1.07**	**NS**	**0.11**	**10.89**
CV (%)	**3.90**	**4.91**	**3.70**	**3.04**	**7.03**

(*Figures in parenthesis are arcsine transformed value of dead heart
**Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values of tillers/clump)

In Maharashtra, only early shoot borer is a pre-dominant pest in sugarcane ecosystem.

Table 108. Efficacy of *T. chilonis* TTS against ESB on sugarcane (Year 2018-19)

Treatment	**Dead hearts (%)**		**No. of tillers/clump**		**Yield**
	Pre-count	**Post count**	**Pre-count**	**Post count**	**(MT/ha)**
T1: *T. chilonis* @ 50,000 parasitoids/ha	16.85 [a] *(24.18)	6.38 [a] (14.58)	8.08 [a] **(2.92)	9.55 [a] (3.17)	138.70 [a]
T2: Farmers practice-chlorpyriphos 0.05%	16.78 [a] (24.12)	7.75 [b] (16.10)	8.05 [a] (2.92)	8.99 [a] (3.08)	136.95 [a]
T3: Untreated control	16.32 [b] (23.74)	22.35 [c] (28.17)	7.85 [b](2.89)	6.90 [b] (2.71)	122.17 [b]
SE ±	0.32	0.29	0.03	0.04	2.88
CD at 5%	**NS**	**0.89**	**NS**	**0.14**	**8.87**
CV (%)	**3.50**	**3.88**	**2.77**	**3.91**	**5.74**

(*Figures in parenthesis are arcsine transformed value of dead heart
**Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values of tillers/clump)

Table 109. Efficacy of *T. chilonis* TTS against ESB on sugarcane (Pooled data for the years 2017-18 to 2019-20)

Treatment	**Dead hearts (%)**		**No. of tillers/clump**		**Yield**	**B: C ratio**
	Pre-count	**Post count**	**Pre-count**	**Post count**	**(MT/ha)**	
T1: *T. chilonis* @ 50,000 parasitoids/ha	16.49 [a] *(23.92)	6.41 [a] (14.66)	8.21 [a] **(2.95)	10.10 [a] (3.26)	139.64 [a]	2.31
T2: Farmers practice-chlorpyriphos 0.05%	16.02 [a] (23.58)	7.52 [a] (15.88)	8.02 [a] (2.92)	9.13 [a] (3.10)	137.48 [a]	2.30
T3: Untreated control	15.83 [b] (23.42)	22.16 [b] (28.08)	7.77 [b](2.88)	6.66 [b] (2.67)	122.38 [b]	2.09
SE ±	0.82	0.55	0.05	0.07	4.54	
CD at 5%	NS	1.59	NS	0.21	13.02	
CV (%)	6.00	4.91	3.11	4.19	5.90	

(*Figures in parenthesis are arcsine transformed value of dead heart
**Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values of tillers/clump)

Results: The ESB infestation was recorded at fortnightly interval and pooled data of ESB infestation, number of tillers/clump and cane yield Mt/ha are presented in Table 32. The result indicated that 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 22.16 to 6.41 % dead hearts) and increased number of tillers (10.10 tillers/clump)as well as cane yield (139.64 Mt/ha) with BC ratio 2.31.

Table 110 Cost of spraying

Tr. No.	**Treatment**	**Cost of trichocard / (Rs. lit/kg)**	**Qty./ per (card / L /ha.)**	**Qty. used/ha for 8 releses**	**Qty. used/ha for 3 sprays**	**Cost (Rs./ha)**	**Labour charges (Rs./ha)**	**Total cost (Rs./ha)**
T_1	*T. chilonis* 50,000 @ parasitoids/ha	100/card	4	32	3200	3200/	1860/-	5060/-
T_2	Farmers practice-chlorpyriphos 0.05%	200/L	1.250 L	-	7.500 L	1500/-	2790/-	4290/-
T_3	Untreated Control	-	-	-		-	-	-

Table 110.1 Economics of treatments

Tr. No.	**Treatment**	**Cost of Cultivat-ion/ha**	**cost of Spraying /card Rs**	**Total cost Rs.**	**Yield (Mt/ha)**	**Rate/ Mt (Rs)**	**Gross returns (Rs. /ha)**	**Net return (Rs. /ha)**	**B: C ratio**
T_1	*T. chilonis* 50,000 @ parasitoids/ha	1,45,846/	5060	1,50,906/	139.64	2500	3,49,100/	1,98,194/-	2.31
T_2	Farmers practice-chlorpyriphos 0.05%	1,45,846/	3290	1,49,136	137.48	2500	3,43,700/	1,94,564/-	2.30
T_3	Untreated Control	1,45,846/	-	145846	122.38	2500	3,05,950/	1,60,104/	2.09

8.4.3 PJTSAU

Details of Treatments:

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)

Results:

The module with releases of *T. chilonis*@ 50,000/ha at weekly intervals 6 releases fared better than farmers' practice (10.57 % of ESB; Cane yield 71.45 t/ha) in terms of infestation levels (9.23 %) as well as net gains (79.89 t/ha).

8.5 Large scale demonstrations of proven biocontrol technologies against sugarcane 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 510 acres in Jalandhar, Hoshiarpur, Patiala, Ludhiana, Kapurthala and Fazilka 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 2.98 and 1.30 per cent, respectively. However, both the treatments were significantly better than untreated control (6.39%). The reduction in incidence over control was 53.36 and 79.66 per cent in released fields and chemical control, respectively. The yield in control (660.0 q/ha) was significantly lower than release fields (720.0 q/ha) and chemical control (848.0 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 112) was high in biocontrol (1: 17.60) as against chemical control (1: 11.08).

Table 112 Cost Benefit analysis (2019)

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	720.0	60.0	18600.0	1000.00	17600.0	17.60
Chlorantraniliprole 0.4 GR @ 25 kg/ha	848.0	188.0	58280.0	4825.00	53455.0	11.08
Control	660.0	-	-	-	-	-

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

8.6 Large Scale demonstration of Temperature Tolerant *Trichogramma chilonis* against sugarcane early shoot borer during 2019-20

Treatments

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
T2: Farmers' practice: Application of chlorpyrifos 20 EC @ 2 ml/lit
T3: Untreated control

Before treatment imposition the per cent of dead hearts ranged from 16.00 to 17.50 per cent per 10 mrl. Two months after treatment imposition the per cent dead hearts was low in *T. chilonis* (temperature tolerant strain) release plot which recorded 1.25 per cent dead hearts per 10 mrl which was significantly superior over farmers practice and untreated control which recorded 2.85 and 5.25 per cent dead hearts per 10 mrl, respectively. The highest cane yield of 123.50 t/ha was recorded in *T. chilonis* (temperature tolerant strain) release plot which was superior over the farmers practice and untreated control which recorded 118.50 t/ha and 108.25 t/ha respectively (Table 113).

Table 113 Large Scale demonstration of *Trichogramma chilonis* (Temperature Tolerant strain) against sugarcane early shoot borer during 2019-20.

Sl. No.	Particulars	Before treatment imposition (% dead hearts)*	Two months after treatment imposition (% dead hearts)*	Cane yield (t/ha)
1	T_1 : Releases of *T. chilonis* (temperature tolerant strain)	17.50 (24.73)	1.25 (6.42)	123.50
2	T_2 : Farmers' practice	16.00 (23.58)	2.85 (9.72)	118.50
3	T_3 : Untreated control	17.00 (24.35)	5.25 (13.25)	108.25
S Em ±		**0.18**	**0.34**	**1.57**
CD (P=0.05)		**NS**	**1.03**	**4.71**

*Figures in parentheses are arcsine transformed values

8.6.1 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

Observation

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 analyzed statistically.

Results

Before treatment imposition the per cent of dead hearts ranged from 16.00 to 17.50 per cent per 10 mrl. Two months after treatment imposition the per cent dead hearts was low in *T. chilonis* (temperature tolerant strain) release plot which recorded 1.25 per cent dead hearts per 10 mrl which was significantly superior over farmers practice and untreated control which recorded 2.85 and 5.25 per cent dead hearts per 10 mrl, respectively. The highest cane yield of 123.50 t/ha was recorded in *T. chilonis* (temperature tolerant strain) release plot which was superior over the farmers practice and untreated control which recorded 118.50 t/ha and 108.25 t/ha respectively (Table 114).

Table 114 Large Scale demonstration of *Trichogramma chilonis* (Temperature Tolerant strain) against sugarcane early shoot borer during 2019-20.

Sl. No.	**Particulars**	**Before treatment imposition (% dead hearts)***	**Two months after treatment imposition (% dead hearts)***	**Cane yield (t/ha)**
1	T_1 : Releases of *T. chilonis* (temperature tolerant strain)	17.50 (24.73)	1.25 (6.42)	123.50
2	T_2 : Farmers' practice	16.00 (23.58)	2.85 (9.72)	118.50
3	T_3 : Untreated control	17.00 (24.35)	5.25 (13.25)	108.25
S Em $\pm$		**0.18**	**0.34**	**1.57**
CD (P=0.05)		**NS**	**1.03**	**4.71**

*Figures in parentheses are arcsine transformed values

PAU, Ludhiana

8.7 Large scale demonstrations of proven biocontrol technologies against sugarcane stalk borer *Chilo auricilius*

A) IN COLLABORATION WITH SUGAR MILLS

Large scale demonstrations on the effectiveness of *T. chilonis* against stalk borer, *Chilo auricilius* were carried out over an area of 7400 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 2.73 per cent. The corresponding figure in control (non-adopted) fields was 6.20 per cent. It can be concluded that in large-scale demonstrations, 10-12 releases of *T. chilonis* @ 50,000 per ha at 10 days internal during July to October reduced the incidence of stalk borer by 56.1 per cent.

B) PAU, LUDHIANA

Large-scale demonstrations on the effectiveness of *T. chilonis* against stalk borer, *C. auricilius* were carried out over an area of 808 acres in Fazilka, Fatehgarh Sahib, Hoshiarpur, Ludhiana, Jalandhar, Kapurthala, Moga, Patiala 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 (2.46%) was significantly lower than untreated control (6.55%). The reduction in incidence over control was 62.44 per cent. 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.

8.8 Large scale demonstrations of proven biocontrol technologies against sugarcane early shoot borer, *Chilo infuscatellus*

IN COLLABORATION WITH SUGAR MILLS

Large scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *Chilo infuscatellus* were carried out over an area of 2150 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 2.35 per cent as compared to 5.00 per cent 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 53.0 per cent.

B) PAU, LUDHIANA

Large scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *C. infuscatellus* were carried out over an area of 538 acres in Fazilka, Fatehgarh Sahib, Hoshiarpur, Ludhiana, Jalandhar, Kapurthala, Moga, Patiala 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 (2.09%) and chemical control (0.96%) was significantly better than untreated control (4.90%). The reduction in incidence over control was 57.35 and 80.41 per cent in released fields and chemical control, respectively. The yield in control (640.0 q/ha) was significantly lower than released fields (701.8 q/ha) and chemical control (840.2 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: 18.16) was high in biocontrol as compared to chemical control (1: 10.03) (Table 115).

Table 115 Cost Benefit analysis (2019)

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/ ha	701.8	61.8	19158.0	1000.00	18158.0	1:18.16
Chlorantraniliprole 18.5 SC @ 375 ml/ ha	840.2	200.2	62062.0	5625.0	56437.0	1: 10.03
Control	640.0	-	-	-	-	-

Price of sugarcane: Rs. 310/- per quintal during 2019; * includes trichocard/insecticide + labour cost; Price of Coragen (chlorantraniliprole 18.5 SC) @ Rs. 1850/- per 150 ml

OIL SEEDS

9. MUSTARD

9.1 Bioefficacy of entomopathogenic fungus against mustard aphid (AAU- Jorhat)

Experimental details:

The experiment was conducted at ICR Farm, AAU, Jorhat during 2019 to study the bioefficacy of entomopathogenic fungus against mustard aphid, *Lipaphis erysimi*. The Mustard crop was sown on 08. 11. 2019, with a plot size of 6m x 5 m. The experiment was designed with RCBD (4 replications, 7 treatments), and the variety used was TS-38. The recommended dose of fertilizer (120:60:60 kg N: P: K/ ha) was applied to the field. The mustard yield was harvested on 14. 02.2020.

Treatment details:

T1: *Beauveria bassiana* (AAU-J Culture) @1X10^8 conidia/g – 5 g/lit
T2: *Metarhizium anisopliae* (AAU-J Culture) @1X10^8 conidia/g – 5 g/lit
T3: Lecanicillium lecanii (AAU – J Culture) @1X10^8 conidia/g – 5 g/lit
T4: *Lecanicillium lecanii* (NBAIR Culture) @1X10^8 conidia/g – 5 g/lit

T5: Azadirachtin 1500 ppm @ 2 ml/l
T6: Dimethoate 30 EC @ 0.06% (Standard check)
T7: Untreated control
Field experiment was conducted to evaluate the efficacy of entomopathogenic fungus against mustard aphid (*Lipaphis erysimi*) during *rabi*, 2019-20. Three sprays of entomopathogenic fungus (*Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium lecanii*), neem based pesticides (aazadirachtin 1500 ppm) and a chemical insecticide (dimethoate 30EC) were used as standard check 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 one day before and at three, seven and ten days after each spraying. Yield data was recorded per plot basis and converted into quintal/ha.

Table 116 Evaluation of different entomopathogenic fungi against mustard aphid, *Lipaphis erysimi*

Treatments	Pre count	Post treatment count *			Mean of 3 sprays	Reduction over control (%)	Yield (q/ha)
		I^{st} spray	II^{nd} spray	III^{rd} spray			
T1: *Beauveria bassiana* (AAU-J Culture) 10^8 @ 5g/l	21.7	12.21^{abc}	10.93^{bc}	10.45^{b}	11.19^{bc}	54.70	7.10^{ab}
T2: *Metarhizium anisopliae* (AAU-J Culture)10^8 @ 5g/l	22.67	14.51^{c}	12.19^{c}	10.83^{b}	12.50^{c}	49.40	6.85^{bc}
T3: *Lecanicillium lecanii* (AAU – J Culture)10^8 @ 5g/l	22.63	13.33^{bc}	11.26^{bc}	8.86^{b}	10.26^{b}	58.46	6.94^{bc}
T4: *Lecanicillium lecanii* (NBAIR Culture)10^8 @ 5g/l	22.41	11.38^{abc}	9.85^{b}	8.78^{b}	10.0^{b}	59.51	7.35^{ab}
T5: Azadirechtin 1500 ppm @ 2 ml/l	22.93	13.21^{bc}	11.61^{c}	8.95^{b}	11.26^{bc}	54.41	6.56^{c}
T6: Dimethoate 30 EC @ 2 ml/l	22.46	10.03^{a}	7.83^{a}	5.81^{a}	5.91^{a}	76.07	7.60^{a}
T7: Untreated control	22.85	24.31^{d}	25.96^{d}	23.83^{c}	24.70^{d}	-	4.93^{d}
CD =0.05	NS	2.61	1.45	2.44	1.61	-	0.65
CV %	-	12.43	7.60	14.83	7.21	-	5.27

*Mean of three observations

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

Results:

The results in the table 117 indicated that all the treatments were significantly superior in suppressing the aphid population over untreated control plot. It was observed that dimethoate 30 EC @ 2ml/lit at 10 days interval significantly reduced the mean population of aphids (5.91 per 10 cm apical twig) in comparison to other treatments with highest yield of 7.60q/ha. Among the entomopathogenic fungus, *Lecanicillium lecanii* (NBAIR Culture)@ 5g/lit was the next best treatment in reducing the aphid population (10.00 per 10 cm apical twig) with next higher yield of 7.35 q/ha and it was found to be at par with *Beauveria bassiana* (AAU-J Culture) @ 5gm/lit in their efficacy in respect of mean population of aphid (11.19 per 10 cm of apical twig) and yield (7.10 q/ha). However, the rest of the entomopathogenic fungi (AAU local strains viz., *L. lecanii* and *M. anisopliae* were also equally effective after third spray and found to be significantly different from untreated control in reducing the mustard aphids. The lowest yield of mustard (4.93 q/ha) was recorded in untreated control plot with a maximum number of aphid population (24.70 per 10 cm apical twig). The reduction of mustard aphid population over control was maximum (76.07 %) in the plots treated with dimethoate 30 EC @ 2ml/lit followed by *L.lecanii* (NBAIR strain) and *L.lecanii* (AAU culture) @ 5 g/lit with 59.51 and 58.46 per cent, respectively.

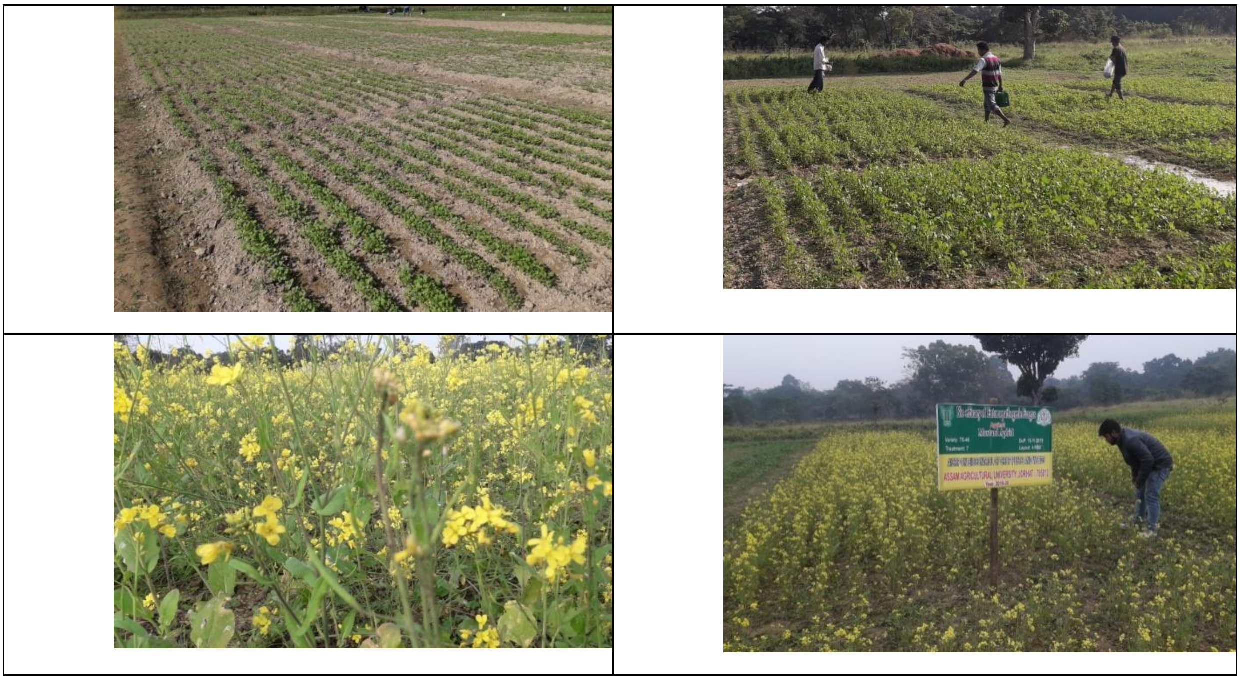


Fig:47 View of Expeimental Plot of mustard

10. GROUNDNUT

10.1 Large scale demonstration of bioagents based IPM module for whitegrub in Ground nut (AAU-Anand)

Objective: To demonstrate bioagent based IPM module for whitegrub management in groundnut

Year of commencement: 2019-20

Location: Farmers' fields of Mahuva Taluk, Bhavnagar district

Area: 100 ha

Methodology/module components:

- Deep summer ploughing and heavy pruning of border trees before onset of monsoon
- On the onset of monsoon border trees of the field were sprayed with imidacloprid 17.8 SL (7ml/ 10 litre water) and chlorpyriphos 20 EC (20 ml/ 10 litre water)
- Enrichment of FYM with bio-pesticide; *Metarhizium anisopliae* 2 kg/ ha
- Seed treatment with chlorpyriphos (20 EC) @ 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 were observed and the yield was computed in the respective treatments.

Collaboration:

NGO – Gram Nirman Samaj (Devaliya)
TKF (Triveni Kalyan Foundation) Mahuva

Table 117. Impact of IPM on larval population of whitegrub and yield of groundnut crop

Treatments	**Larval count/ meter length row**	**Yield (kg/acre)**
IPM module	0.39 ± 0.52	902.02 ± 58.32
Farmers' practice	1.42 ± 1.00	615.46 ± 39.39
z-test	*	*
P value	<0.0001	<0.0001

Results:

Large-scale demonstration was conducted in *Kharif* 2019-20. Significant difference in larval population was observed between IPM module and farmers' practice (Table 117). Similarly, the higher yield was recorded in IPM module. It can be concluded that adoption of bioagents based IPM module will be useful for the effective management of whitegrub in groundnut crop.

FRUIT CROPS

MANGO

11.1 Effect of bio pesticides for management of Mango hoppers, pests *Idioscopus* spp in field condition

11.1.1 DRYSRHU, Ambajipeta

The experiment was carried out in mango garden (variety Totapuri) and aged about 7-10 years in Gokavaram mandal in East Godavari district. The first spray was done on 07.02.2020 and subsequent spray was given at weekly interval. Data on surviving hopper population was transformed into √x+0.5 values before subjecting to analysis of variance. A low hopper population was recorded throughout the observational period. Conventional insecticide, Imidacloprid 17.8 SL and botanical insecticide azadirachtin 10000 ppm recorded nil population of hoppers after second spray. Among the bio-pesticide treatments, *Metarhizium anisopliae* and *Beauveria bassiana* recorded a low hopper population of 0.25 and 0.75 hoppers / tree after second spray. Mango hoppers population was low (3.50 - 4.75) in the untreated tree during the experimental period.

Table 118: Field evaluation of bio pesticide formulations against mango hoppers, *Idioscopus* sppin Andhra Pradesh (2019-20)

Treatments	**Dosage**	**Average hopper population/ per tree (for 4 inflorescence) 7 days after spray**		
		Pre count	1st spray	2nd spray
T1- *Metarhizium anisopliae* (AAU – NBAIR Strain)*	5 g/l	2.25 (1.57)	0.75 (1.05)	0.25 (0.84)
T2- *Beauveria bassiana* (AAU –NBAIR Strain)	5 g/l	2.00 (1.56)	1.75 (1.50)	0.75 (1.06)
T3- *Lecanicillium lecanii* (AAU – NBAIR Strain)	5 g/l	3.50 (1.84)	2.25 (1.64)	2.50 (1.34)
T4- Azadirachtin 10000 ppm	1 ml/l	2.75 (1.57)	0.50 (0.92)	0.00 (0.71)
T5- Imidacloprid 17.8 SL	0.4 ml/l	3.75 (1.90)	0.00 (0.71)	0.00 (0.71)
T6-Untreated control		3.50 (1.84)	4.25 (2.09)	4.75 (2.20)
SEm		--	0.16	0.29
CD (5%)		--	0.48	0.87

Figures in parenthesis are √x+0.5 transformed values, AAU-Anand Agricultural University

11.1.2 ICAR-CISH, Lucknow

Entomopathogenic fungi *viz*., *Beauveria bassiana* and *Metarhizium anisopliae* formulations were tested for their bio-efficacy against mango hoppers. Significant difference was found between the treatments at 3, 7 and 14 days after the spray (Table). Among the bio pesticides, low incidence of hopper was recorded in *B. bassiana* (NBAIR formulation) which registered 6.23 hoppers/ panicle at 7 days after spraying. Efficacy of *B. bassiana* (CISH formulation) and *M. anisopliae* (NBAIR formulation) was in parity with each other (Table 119).

Table 119: Efficacy of bio-pesticides on mango hoppers during the year 2019

Treatments	Before spray	3 DAS	7 DAS	14 DAS	21 DAS
Beauveria bassiana (NBAIR culture) @1x10^8 spores/g @ 5g/lit	17.23 (4.65)	8.00 ^{ab} (3.33)	6.23 ^{a} (2.98)	7.75 ^{ab} (3.28)	4.52 (2.59)
Beauveria bassiana (CISH culture) @1x10^8 spores/g @ 5g/lit	17.90 (4.73)	7.56 ^{ab} (3.21)	7.88 ^{ab} (3.29)	6.63 ^{ab} (2.86)	6.63 (2.94)
Metarhizium anisopliae (NBAIR culture) @1x10^8 spores/g @ 5g/lit	14.33 (4.28)	7.00 ^{ab} (3.14)	7.08 ^{ab} (3.09)	9.53 ^{ab} (3.45)	6.08 (2.88)
Azadirachtin 1500 ppm @ 2ml/lt	16.00 (4.50)	2.70 ^{a} (2.13)	1.33 ^{a} (1.41)	3.00 ^{a} (2.16)	3.77 (2.41)
Imidacloprid 0.005% (CISH POP)	15.33 (4.41)	7.50 ^{ab} (3.23)	4.67 ^{a} (2.52)	4.33 ^{a} (2.55)	3.33 (2.25)
Untreated control	14.07 (4.25)	18.75^{c} (4.60)	27.92 ^{c} (5.59)	16.20 ^{c} (4.52)	12.33 (3.95)
LSD (0.05%)	-	4.884	5.219	4.488	NS

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 in Tukey's honesty test.

11.2 Bioefficacy of Entomopathogenic fungi formulations in suppression of mango leaf webber

11.2.1 ICAR-CISH, Lucknow

Entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* formulations were tested for its bio-efficacy against mango leaf webber. Significant difference was found between the treatments at 7, 15 and 21 days after the spray (Table 120). All the entomopathogenic fungi reduced the incidence of leaf webber significantly.

Table 120 Bio-efficacy of Entomopathogenic fungi against mango leaf webber during 2019

Treatments	**Mean number of live webs/tree**			
	Before spray	**7 DAS**	**15 DAS**	**21 DAS**
Beauveria bassiana (CISH) 1×10^8 @5g/lit	17.35 (4.65)	7.92^{a} (3.31)	5.92^{ab} (2.48)	4.23^{a} (2.18)
Beauveria bassiana (NBAIR) 1×108 @ 5g/lit	14.83 (4.34)	6.67^{a} (2.58)	4.58^{ab} (2.24)	3.92^{ab} (2.09)
Metarhizium anisopliae (NBAIR) 1×10^8 @5g/lit	16.62 (4.55)	8.08^{a} (3.33)	6.92^{ab} (3.10)	5.00^{a} (2.72)
Lambda-Cyahalothrin @ 0.1%	13.73 (4.21)	2.33^{a} (1.72)	1.20^{a} (1.13)	0.00^{a} (0.50)

Untreated control	16.23 (4.52)	21.33[a] (5.10)[b]	13.42[b] (4.14)	12.50[b] (4.02)
LSD (0.01)	10.39	6.11	4.22	3.38

DAS- Days after spraying; Values in the parenthesis are square root transformed √x+0.5; same letters in the column are not significantly different in Tukey's honesty test

11.3 Biodiversity of bio-control agents from mango ecosystem

11.3.1 ICAR-CISH, Lucknow

Insect predators' population in relation to hopper and thrips infestation was recorded on mango during reproductive phase of the crop. Peak hopper population was noted during 15th SMW with 13.5 hoppers/sweep. Maximal thrips population was observed all through 17th SMW having 55.6 thrips/trap. In accordance, natural enemies' prevalence as well exhibited density dependent in the habitat with their hosts *i.e.,* hoppers and thrips incidence. Among the natural enemies, spider population was elevated during 20th SMW with 0.4 / tree. Coccienellids inhabitants were found as high as 3.45 adults/ tree at some point in 15th SMW. Coccinellids *viz., Coccinella septempunctata, Cheilomenes sexmaculata, Chilocorus rubidus* and *Scymnus* sp. were observed feeding on mango hoppers; amongst most abundant and spectacular was *Coccinella septempunctata.* Peak population of Hoverflies were observed through 19th SMW, registering with 4.8/tree, and peak Chrysopid population was noticed during 17th SMW which was recorded 1.7 adults /tree (Table 121).

Table 121. Co-existing predator population and their dynamics with the pest population in mango ecosystem during 2019

SMW	Hopper (No./ panicle/ sweep)	Thrips (No./trap)	Spider (No./tree)	Coccinellids (No./tree)	Hoverflies (No./tree)	Chrysopids (No./tree)
10	0.80	0.00	0.20	0.00	0.00	0.00
11	4.65	0.00	0.25	0.0	0.00	0.00
12	3.80	0.00	0.20	0.00	0.00	0.00
13	4.45	0.00	0.20	0.30	0.00	0.00
14	3.95	8.25	0.25	0.30	0.80	0.00
15	13.50	8.55	0.30	3.45	2.40	0.00
16	6.60	0.50	0.20	2.20	3.50	0.80
17	6.45	55.60	0.35	0.00	2.60	1.70
18	9.15	21.00	0.25	0.00	4.50	0.50
19	8.35	21.75	0.25	0.00	4.80	0.00
20	3.10	52.20	0.40	0.00	1.80	0.00
21	7.75	50.40	0.35	0.00	1.50	0.00
22	8.60	26.50	0.30	0.00	0.25	0.00
23	1.70	24.00	0.35	0.00	0.00	0.00
24	3.95	14.55	0.35	0.00	0.00	0.00
25	2.10	16.70	0.30	0.00	0.00	0.00

11.4 Potential reduviid predator explored in mango ecosystem

Reduviid predators are the largest terrestrial bugs considered to be potential bio-control agents. This predator belongs to the genus *Sycanus* sp., an assassin bug, was observed in mango ecosystem. The predators are potentially predating on the larvae of mango leaf webber and mango semiloopers in field conditions. In laboratory studies it was found that single adult bug can predate 2-3 rice moth larvae/ hour.

11.5 Habitat manipulation for conservation of bio-agents for management of mango insect pests

11.5.1 ICAR-CISH, Lucknow

Experiment could not be completed as it was vitiated due to failure of inter crops.

11.6 Management studies for inflorescence thrips on mango with bio-pesticides in field conditions

11.6.1 DRYSRHU, Ambajipeta

The spraying experiment was carried out in mango garden (variety Totapuri) and aged about 7-10 years in Gokavaram mandal in East Godavari district. The first spray was done on 26.02.2020 and subsequent two sprays were given at weekly intervals. After second spray, Fipronil treated trees had thrips population of nil followed by bio pesticide *Metarhizium anisopliae* (AAU - NBAIR), Azadirachtin 10000 ppm and *Beauveria bassiana* (AAU - NBAIR) with 0.75, 0.25 and 1.00 thrips /tree, respectively (Table 122). Among the bio-pesticide treatments, *Lecanicillium lecanii* (AAU - NBAIR) had a high thrips population of 2.00 thrips/tree after second spray. In untreated control block a high population of mango thrips ranging from 7.50 to 11.25 was recorded consistently.

Table 122: Field evaluation of bio pesticide formulations against mango thrips

Treatments	**Dosage**	**Average number of thrips per 10 inflorescence per tree**		
		Pre count	1st spray	2nd spray
T1- *Beauveria bassiana*(AAU – NBAIR Strain)	5 ml/l	5.00 (2.34)	1.75 (1.49)	1.00 (1.18)
T2- *Metarhizium anisopliae*(AAU – NBAIR Strain)	5 ml/l	5.25 (2.34)	1.50 (1.40)	0.25 (0.84)
T3- *Lecanicillium lecanii*(AAU – NBAIR Strain)	5 ml/l	8.00 (2.87)	3.50 (1.98)	2.00 (1.58)
T4- Azadirachtin 10000 ppm	5 ml/l	4.75 (2.27)	2.50 (1.72)	0.75 (1.06)
T5- Fipronil	2 ml/l	6.25 (2.57)	1.75 (1.49)	0.00 (0.71)
T6- Untreated control	5 g/l	7.50 (2.80)	10.50 (3.31)	11.25 (3.43)
SEm	-		0.11	0.11
CD (5%)	-		0.33	0.32

*Fig in parenthesis are √x+0.5 transformed values, AAU- Anand Agricultural University

12. GUAVA

12.1 Evaluation of bio-agents against root-knot nematode infection in guava under controlled conditions

12.1.1 ICAR-CISH, Lucknow

Since, the experiment is still going on and final results cannot be presented now. Very little growth of plants taken place in a period of 90 days due to severe cold. Total plant weight was recorded < 0.3 g. Nematode activity was also slow as evident from recovery of 1600 J2 in soil from inoculated control and no egg-masses on galls. The second set of three replicates for all the treatments was terminated 135 days after transplanting. It was severe winter period and plant could not grow normal in any treatment. During this period minimum - maximum temperatures ranged during October 17-31 ˚C, November 14-31 ˚C, December 4-27 ˚C, January 4-24 ˚C, February 7-29 ˚C and March 15-30 ˚C, respectively. Nematode activity was still slow, however, galls were fully developed and few egg-masses were formed. The third set of three replicates for all the treatments will be terminated on April 21, 2020 and the data will be presented after analysis.

Table 123: Data for termination on January 22, 2020

Treatments	Shoot height (cm)	Shoot weight (g)	Root weight (g)	RKI (0-4 scale)	No. of J2/g soil
Purpureocillium lilacinum @ 10^6	7.13	0.20	0.06	0.25	0.2
Purpureocillium lilacinum @ 10^7	6.96	0.17	0.07	0.33	0.1
Purpureocillium lilacinum @ 10^8	7.20	0.13	0.06	0.33	0.1
Pochonia chlamydosporia @ 10^6	5.90	0.13	0.04	0.25	0.1
Pochonia chlamydosporia @ 10^7	6.16	0.13	0.05	0.33	0.2
Pochonia chlamydosporia @ 10^8	6.46	0.17	0.03	0.08	0.2
Bacillus sp. @ 10^6	6.76	0.13	0.04	0.16	0.3
Bacillus sp. @ 10^7	6.30	0.13	0.04	0.33	0.1
Bacillus sp. @ 10^8	7.16	0.17	0.05	0.58	0.1
Carbofuran 3G @ 200 mg	6.86	0.13	0.04	0.03	0.1
Inoculated control	6.63	0.17	0.06	0.33	0.8
Uninoculated control	7.70	0.20	0.06	0.00	0.0

Table 124: Data for termination on March 07, 2020

Treatments	Shoot Length (cm)	Shoot Weight (g)	Root weight (g)	RKI (0-4 scale)	No. of J2 in soil
Purpureocillium lilacinum @ 10^6	10.9	0.50	0.20	0.33	0.1
Purpureocillium lilacinum @ 10^7	11.6	0.46	0.20	0.50	0.2
Purpureocillium lilacinum @ 10^8	9.8	0.46	0.13	0.15	0.1
Pochonia chlamydosporia @ 10^6	9.0	0.36	0.13	0.25	0.2
Pochonia chlamydosporia @ 10^7	7.93	0.26	0.17	0.06	0.1
Pochonia chlamydosporia @ 10^8	13.26	0.80	0.26	0.23	0.2
Bacillus sp. @ 10^6	12.60	0.70	0.23	0.58	0.3
Bacillus sp. @ 10^7	11.50	0.56	0.20	0.33	0.2
Bacillus sp. @ 10^8	12.16	0.53	0.13	0.15	0.1
Carbofuran 3G @ 200 mg	10.00	0.43	0.16	0.15	0.1
Inoculated control	11.46	0.46	0.13	1.50	0.9
Uninoculated control	12.83	0.93	0.40	0.00	0.0

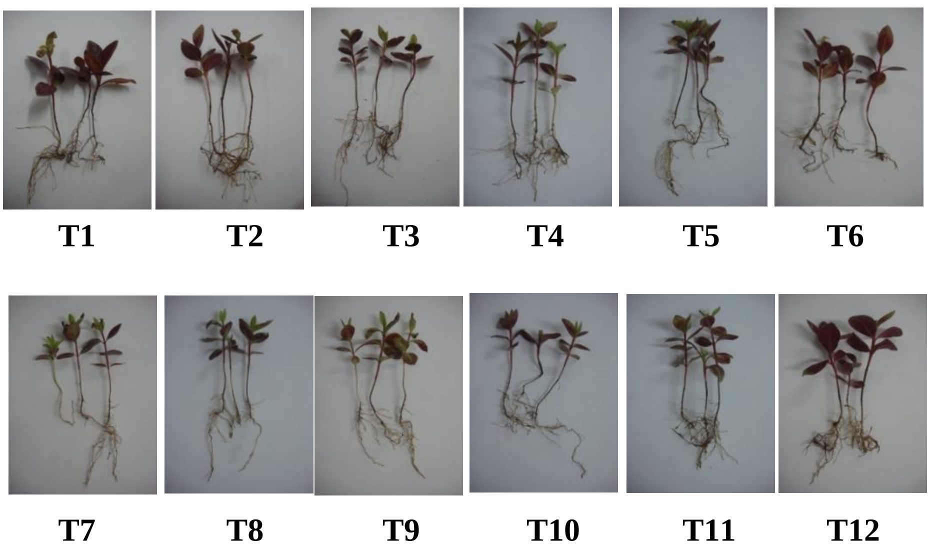


Fig 48: Seedling growth in different treatments

12.2 Biological control of guava mealy bug and scales using entomopathogens

12.2.1 SKUAST, Jammu

Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, along with Azadirachtin 10000 ppm were assessed against guava mealybug and scale. Significantly highest (45.88%) reduction in mealybug as well as scale population (44.56%) was recorded in *B. bassiana* spraythat was at par with that of azadirachtin spray (44.86 and 41.83% reduction in mealybug and scale population respectively) at 7 DAS (Table 125). At 3 DAS mealybug and scale population was significantly lowest in azadirachtin spray (21.2 and 6.1 number of mealybug and scales per guava leaf respectively). Significantly highest mealybug and scales population was recorded in untreated control.

Table 125 Percent reduction in Mealy bug nymphs and adults

Treatments	Pre spray count	Post spray count (mean no. / leaf)		Reduction (%) at 7 DAS
		3 DAS	7 DAS	
B. bassiana (NBAIR-Bb-5a) @ 5 g/L	40.4	34.9	21.7	45.88 (42.61)
Metarhizium anisopliae (NBAIR-Ma-4) @ 5 g/L	38.9	32.8	26.4	31.72 (34.19)
Lecanicillium lecanii (NBAIR-VI-22) @ 5 g/L	37.3	29.6	25.1	32.67 (34.80)
Azadirachtin 10000 ppm @ 1 ml/L	39.8	21.2	21.7	44.86 (42.02)
Untreated Control	40.1	41.3	41.9	-
CD at 5%	N.S.	5.69	4.54	(3.06)

Figures in parenthesis are arc-sine transformed values, DAS – Days After Spray

Table 126:- Percent reduction in Guava Scales

Treatments	Pre spray count	Post spray count (mean no. / three leaves)		Reduction (%) at 7 DAS
		3 DAS	7 DAS	
B. bassiana (NBAIR-Bb-5a) @ 5 g/L	13.1	11.6	7.3	44.56 (41.85)
Metarhizium anisopliae (NBAIR-Ma-4) @ 5 g/L	10.6	7.3	7.0	34.08 (35.68)
Lecanicillium lecanii (NBAIR-VI-22) @ 5 g/L	12.2	10.8	7.5	38.69 (38.43)
Azadirachtin 10000 ppm @ 1 ml/L	10.8	6.1	6.3	41.83 (40.27)
Untreated Control	12.0	12.3	12.7	-
CD at 5%	N.S.	3.09	2.39	(2.62)

Figures in parenthesis are arc-sine transformed values, DAS – Days After Spray

13.AONLA

13.1Biological control of anola mealy bug and scales using entomopathogens

SKUAST, Jammu

Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, along with Azadirachtin 10000 ppm were assessed against Aonla mealybug. Significantly highest percent reduction in scale population was recorded in Azadirachtin spray (46.01% reduction) followed by *B. bassiana* spray (34.43% reduction) at 7 DAS. At 3 DAS mealy bug population was significantly lowest in Azadirachtin spray (4.93 mealybug / 10 cm twig). Significantly highest mealy bug population was recorded in untreated control (8.93 mealy bugs / 10 cm twig).

Table 127:- Percent reduction in mealybug nymphs and adults

Treatments	Pre spray count	Post spray count (mean no. / 10 cm twig)		Reduction (%) at 7 DAS
		3 DAS	7 DAS	
B. bassiana (NBAIR-Bb-5a) @ 5 g/L	8.33	7.53	5.47	34.43 (35.91)
Metarhizium anisopliae (NBAIR-Ma-4) @ 5 g/L	7.67	7.13	6.07	20.89 (27.17)
Lecanicillium lecanii (NBAIR-VI-22) @ 5 g/L	8.13	7.53	6.07	24.82 (29.82)
Azadirachtin 10000 ppm @ 1 ml/L	7.80	4.93	4.20	46.01 (42.69)
Untreated Control	8.40	8.60	8.93	-
CD at 5%	N.S.	1.24	1.02	(2.35)

Figures in parenthesis are arc-sine transformed values, DAS – Days After Spray

14. APPLE

14.1 Management of apple root borer using *Metarhizium anisopliae*

YSPUHF, Solan

A large scale demonstration on efficacy of *Metarhizium anisopliae*for the management of apple root borer, *Dorysthenes hugelii* in apple (cv Royal Delicious) was conducted in Shimla, Kinnaur, Sirmaur and Lauhal & Spiti districts covering an area of 5h and 11 orchards. *Metarhizium anisopliae* (10^8 conidia/g) was applied @ 30g/ tree basin mixed in well rotten farm yard manure during July- August i.e. at the time of egg hatching and emergence of new/young grubs. Chemical treatment comprising of chlorpyriphos 20Ec (0.06%) was also applied maintained for comparison. The details of the locations where the demonstrations were laid are given below:

SN	Location	Number of orchards
1	Rekongpeo, district Kinnaur	3
2	Kaja, District Lauhal & Spiti	2
3	Kotkhai and Rohru, district Shimla	5
4	Rajgarh and Shillai district Sirmaur	3
	Total	11

The observations on the grub mortality and feedback from the farmers were collected during November, 2019 at the time of basin preparation. *Metarhizium anisopliae* treatment resulted in 62.1 to 73.4 per cent mortality of the apple root borer grubs in different orchards, while in chlorpyriphos (0.06%) treated plants the grub mortality was 77.3 to 84.5%.

14.2 Evaluation of some biocontrol agents against leopard moth, *Zeuzera multistrigata* in apple

Biocontrol agents namely *Beauveria bassiana*, *Metarhizium anisopliae* (each at 5g/L of 10^8 conidia/g; 10ml/gallery), *Steinernemma feltiae*, *Heterorhabditis bacteriophora* (each at 2500 and 5000IJs/gallery) and azadirachtin (2ml/L of 1500ppm; 10ml/gallery) with standard check chlorpyriphos (0.04%) and water as untreated control and were evaluated against leopard moth, *Zeuzera multistrigata* in apple (cv Royal Delicious). Each treatment solutions were injected in to the live insect galleries with the help of a syringe (without needle) which was then sealed with clay. After 10 days the trees were inspected and the opened galleries were closed again. The data on live and dead galleries were recorded after one month. The galleries reopened by the pest were counted as live, while those not opened as dead. The data were used to calculate the per cent mortality in each treatment and subjected to analysis of variance after arcsine transformation. Data presented in table 2 reveal that chlorpyriphos (0.04%) was the most effective treatment resulting in 100 per cent mortality of the pest. Among different biocontrol agents evaluated, *Heterorhabditis bacteriophora* (5000IJs/gallery) was the most effective resulting in 77.8 per cent mortality followed by *Steinernemma feltiae* (5000IJs/gallery) and azadirachtin (2ml/L of 1500ppm; 10ml/gallery) (66.7% each). Other treatments were not very effective and resulted in 33.3 to 44.4 per cent pest mortality; in control no pest mortality was recorded.

Table 128 Evaluation of some biocontrol agents against leopard moth, *Zeuzera multistrigata* in apple

Treatment	Mortality (%)
Beauveria bassiana (5g/L of 10^8 conidia/g; 10ml/gallery)	33.3 (35.2)
Metarhizium anisopliae (5g/L of 10^8 conidia/g; 10ml/gallery	44.4 (41.7)
Steinernemma feltiae (2500IJs/gallery)	33.3 (35.2)
Steinernemma feltiae (5000IJs/gallery)	66.7 (54.7)
Heterorhabditis bacteriophora (2500IJs/gallery)	44.4 (41.7)
Heterorhabditis bacteriophora (5000IJs/gallery)	77.8 (66.5)
Azadirachtin (2ml/L of 1500ppm; 10ml/gallery)	66.7 (54.7)
Chlorpyriphos (0.04%; 10ml/gallery)	100 (90.0)
Control (water, 10ml/Gallery	0.0 (0.0)
CD (0.05)	(15.3)
CV	21.4

Figures in parantheses are arc sine transformed values

PLANTATION CROPS

15. COCONUT

15.1 Surveillance of rugose whitefly in coconut and assessing the population of natural bocontrol agents

15.1.1 ICAR-CPCRI, Kayamkuklam

The experiment was initiated in the Kalparaksha (Selection of Malayan Green Dwarf) block at the Regional Station. Observations on the incidence of invasive rugose spiralling whitefly, *Aleurodicus rugioperculatus* on coconut were recorded at monthly intervals. Five whitefly-infested palms were selected and four leaflets were examined for the occurrence and the natural enemies. Data is also interrelated with the weather factors prevailed. *A. rugioperculatus* was found to be very low (1.5 colonies /leaflet) during July-December 2019 and thereafter shot up as high as 4.5 colonies by February 2020 (Fig 1). Parasitism of *A. rugioperculatus* by the aphelinid parasitoid, *Encarsia guadeloupae* is presented (Fig 49). Percentage parasitism by *E. guadeloupae* on RSW colonies decreased from 48% in July 2019 to 22% in February 2020 which encouraged the buildup of RSW colonies in 2020 favoured by weather factors. Weather factors especially relative humidity and rainfall supplemented with parasitism by *E. guadeloupae* on *A. rugioperculatus* played a crucial role in this whitefly dynamics.

Besides *A. rugioperculatus*, the population of Bondar's nesting whitefly, *Paraleyrodes bondari* was found to be higher recording as high as 4.0 colonies per leaflet in the month of September 2019 got reduced subsequently reaching as low as 0.5 colonies on March 2020 (Fig.50). Competitive displacement of *A. rugioperculatus* by the *P. bondari* during 2019 and subsequent replacement during January-March 2020 favoured by weather factors and parasitism is well documented. Further survey revealed the non-native nesting whitefly, *Paraleyrodes minei* that co-existed with *P. bondari* and *A. rugioperculatus* during 2018 was not observed during the period under report and was completely displaced by the other exotic whitefly species.

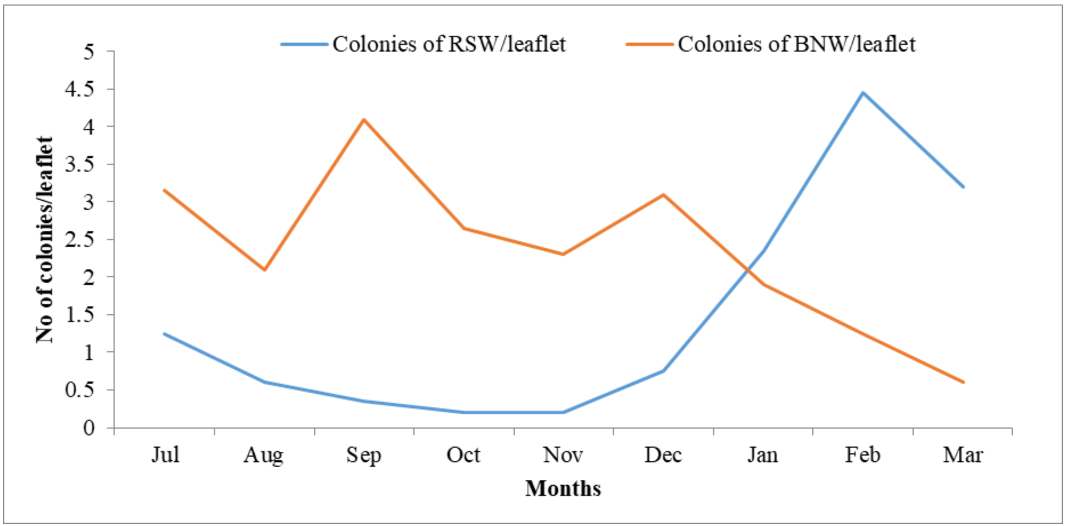


Fig.49. Modulation of exotic whitefly population on coconut palms

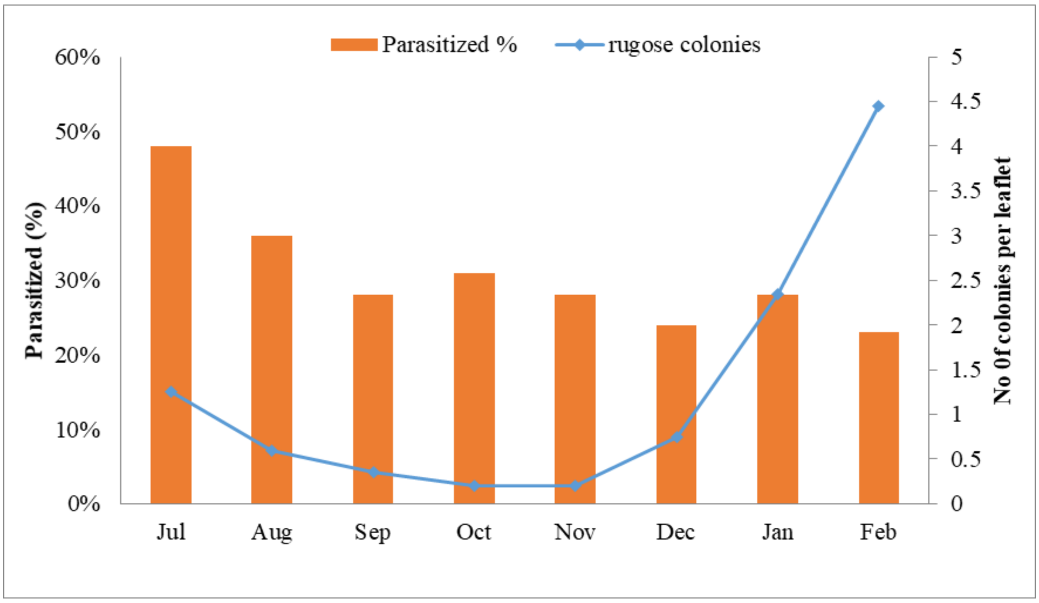


Fig 50. Parasitism of *A. rugioperculatus* by *Encarsia guadeloupae*

Weather factors *versus* whitefly population

Maximum temperature, relative humidity, rainfall and the difference between maximum and minimum temperature was correlated with *A. rugioperculatus* population (Fig 51). *A. rugioperculatus* population was found to be significantly and positively correlated with maximum temperature (r=0.78) and negatively correlated with relatively humidity (r=-0.85) and rainfall (r=-0.70). Thus, both weather factors and parasitic potential of the *E. guadeloupae* play a critical role in the population dynamics of *A. rugioperculatus*.

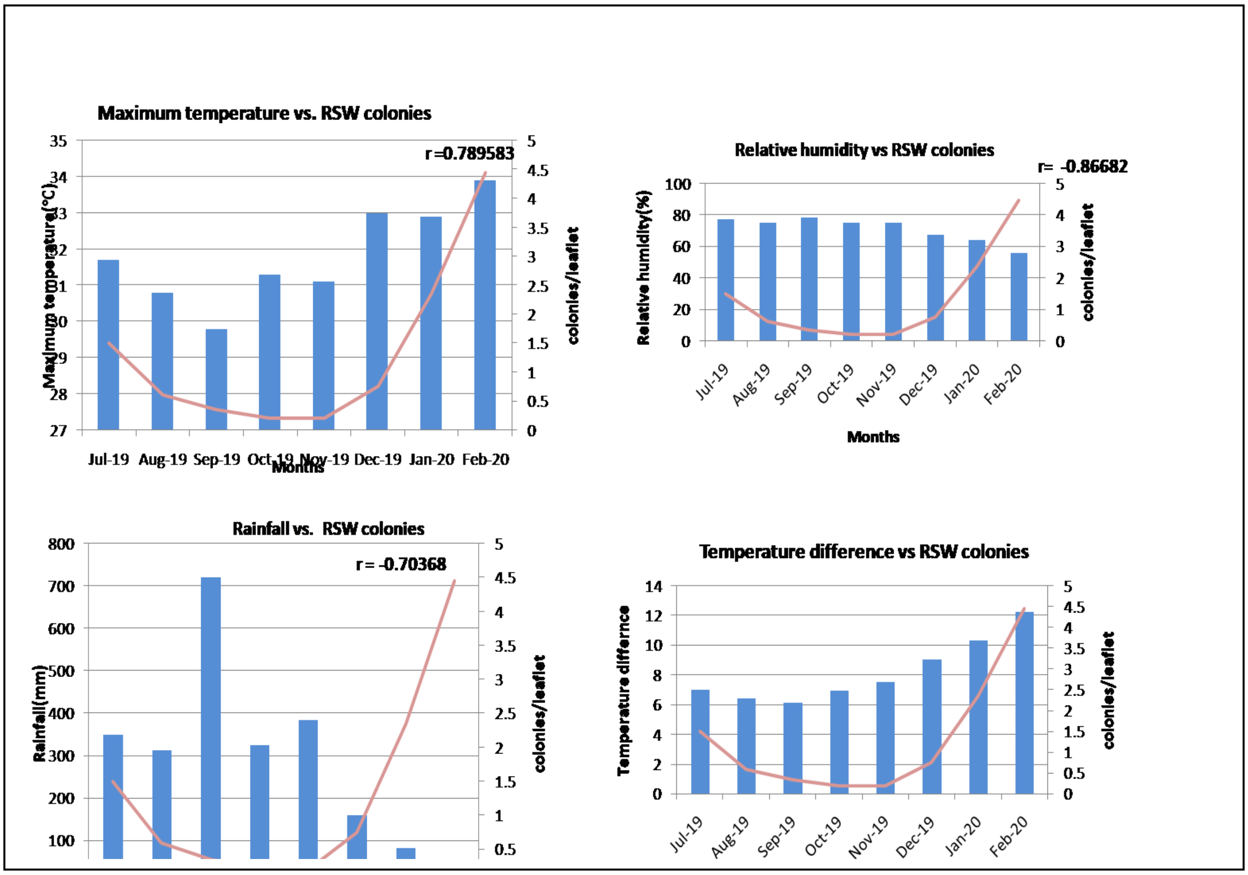


Fig. 51. Weather factors versus *A. rugioperculatus* population

15.1.2 RARS, Kumarakom

Rugose spiralling whitefly population was very less, so observations on surveillance was recorded with respect to another emerging invasive Bondar's nesting whitefly *Paraleyrodes bondari* from April 2019. In Kumarakom, *P. bondari* infestation was noticed to be in a medium range from April to June 2019 followed by a slight decline in July with an average of 9.60 live colonies/ leaflet. Thereafter, gradual increase was noticed in the colony count with a maximum of 24.85 colonies/leaflet recorded in February. Highest pest intensity was noticed in March (80.32%) and the least in August (29.41%) which might be subjected to the heavy rain and flood occurred then.

Infestation was observed to follow an increasing trend from September 2019 onwards. Decreasing trend was recorded in the number of live colonies from May, 2019 onwards and sudden increase was noticed during in January, 2020 at Moncompu and Vyttila. Rise in colony count might be owing to the increased mean temperature and the slight showers received might have reduced the count in March. However, intensity of damage was found to be the highest in March in both the stations.

Table 129 Severity of infestation of Bondar's nesting whitefly at three different locations during 2019-20

Month	Infestation (%)	Intensity of damage (%)	Live colonies /leaflet	Severity of infestation
Location 1: Kumarakom				
April 2019	58.63	55.83	13.35	Medium
May 2019	61.89	54.96	14.10	Medium
June 2019	63.83	55.20	12.60	Medium
July 2019	47.44	36.91	9.60	Low
August 2019	45.06	29.41	10.80	Medium
September 2019	59.51	39.22	11.15	Medium
October 2019	59.74	42.35	12.75	Medium
November 2019	64.38	44.33	13.20	Medium
December 2019	66.79	44.15	14.80	Medium
January 2020	69.90	61.81	21.55	High
February 2020	76.36	73.69	24.85	High
March 2020	80.48	80.32	24.45	High
Location 2: Moncompu				
April 2019	48.72	39.78	11.55	Medium
May 2019	48.66	36.06	8.80	Low
June 2019	56.28	43.59	7.70	Low
July 2019	49.67	40.36	7.85	Low
August 2019	43.40	33.70	6.95	Low
September 2019	49.40	32.36	5.20	Low
October 2019	46.25	36.23	5.90	Low
November 2019	42.90	40.27	5.15	Low
December 2019	44.99	40.55	6.55	Low
January 2020	58.50	43.00	11.35	Medium
February 2020	66.30	60.27	13.85	Medium
March 2020	67.41	75.29	10.05	Medium
Location 3: Vyttila				
April 2019	56.58	40.67	9.30	Low
May 2019	41.67	33.04	7.80	Low
June 2019	47.92	43.75	7.30	Low
July 2019	44.64	40.97	5.40	Low
August 2019	39.40	35.33	5.85	Low
September 2019	60.33	51.91	6.15	Low
October 2019	50.23	37.82	4.65	Low
November 2019	53.97	34.72	4.75	Low
December 2019	54.42	39.07	4.50	Low
January 2020	73.72	54.23	10.25	Medium
February 2020	75.96	56.68	11.80	Medium
March 2020	77.96	78.71	8.55	Low

15.1.3 DRYSRHU, Ambajipeta

The RSW population was collected from the variety East coast tall of 10 to 15 years at research farm of HRS, Ambajipeta. The survey revealed maximum mean number of spirals / leaflet, mean number of nymphs /leaflet, mean number of pupae /leaflet and mean no. of adult RSW/ four leaflets was 18.65-27.54, 36.21 to 68.97, 22.23 to 36.15 and 35.57 to 82.98, respectively during January to March 2020 (Table 121). Natural parasitism of *E. guadeloupae* was nil, low spiders population (0.25/ four leaf lets) and predator *Dichochrysa astur* (0.50/ /four leaf lets) was recorded.

Correlation between mean number of spirals and weather parameters shows that the spiral number is non-significant and negatively correlated with maximum temperature (r=-0.181) and rainfall (r=-0.069) (Table 122). A significantly positive correlation was observed with morning relative humidity (r=0.563) and evening RH (R=0.397) while number of rainy days were significant and negatively correlated with number of spirals (r = -0.301) (Table 130). Mean number of adults were correlated as negatively non-significant with maximum temperature (r=-0.056) and rainfall (r=-0.147) while number of rainy days were significant and negatively correlated with number of spirals (r=-0.548). A significantly positive correlation was observed with morning RH (r=0.711) and evening RH (R=0.683). However, minimum temperature and number of adults had a positive non-significant correlation (r=0.193).

Table 130. Effect of abiotic factors on rugose spiralling whitefly from April2019 to March 2020

Month	Temperature (^{0}C)		RH (%)		Rain fall (mm)	Mean No. of spirals / leaflet	Mean No. of nymphs /leaflet	Mean No. of pupae /leaflet	Mean no. of adult RSW/ four leaflets
	Min.	Max.	Morning	Evening					
April'19	24.7	35.4	53.8	89.6	0.0	23.02	16.46	13.78	19.64
May'19	27.6	37.0	52.0	86.3	0.0	13.18	7.11	10.28	7.58
June'19	26.8	34.9	49.8	81.5	0.0	6.25	2.62	3.35	1.11
July'19	26.0	33.1	58.6	85.2	120.0	0.0	0.0	0.0	0.0
August'19	25.8	32.8	65.2	85.4	169.7	0.0	0.0	0.0	0.0
September'19	25.4	31.9	69.7	87.8	218.2	4.89	7.44	4.13	9.11
October'19	24.1	31.0	74.0	91.8	311.2	5.25	6.34	6.54	5.19
November'19	21.8	31.8	59.1	98.9	0.0	7.74	6.94	7.48	6.49
December'19	19.6	29.5	60.9	98.4	0.0	13.38	13.83	10.23	12.82
January 2020	19.9	29.6	65.5	94.2	0.0	18.65	36.21	22.23	35.57
February 2020	19.7	30.9	57.4	88.5	0.0	25.11	62.46	36.35	84.05
March 2020	21.9	34.1	51.7	97.9	0.0	27.54	68.97	36.15	82.98

A significantly positive correlation was observed between mean number of nymphs and morning RH (r=0.71), evening relative humidity (r=0.68) and maximum temperature (r = 0.28). However, non-significant negative correlation was observed with minimum temperature (r=-0.22) and rainfall (r = -0.11) and number of rainy days (r=-0.22). Rainfall and number of adults had non-significant negative correlation (r=0.11). Mean number of pupae were negative and non-significantly correlated with morning RH (r=0.01), evening RH (r=-0.04) and rainfall (r = -0.02) while a significantly positive correlation was observed with maximum temperature (r=0.69), minimum temperature (r=0.25) and rainy days (r =0.30).

Table 131. Correlation coefficient for weather parameters and *A. rugioperculatus* life stages

	Max. Temp	Min. Temp	Morning RH	Evening RH	Rainfall	Rainy days
Egg spirals	-0.181^{NS}	0.12^{NS}	0.56^{**}	0.39^{**}	-0.06^{NS}	-0.30^{*}
Adults	-0.05^{NS}	0.19^{NS}	0.71^{**}	0.68^{**}	-0.14^{NS}	-0.54^{**}
Nymphs	0.28^{*}	0.22^{NS}	0.49^{**}	0.42^{**}	-0.11^{NS}	-0.22^{NS}
Pupae	0.69^{**}	0.25^{*}	-0.01^{NS}	-0.04^{NS}	-0.02^{NS}	0.30^{*}

*Correlation is significant at 0.05%; **Correlation is significant at 0.01%.

15.1.4 TNAU, Coimbatore

Rugose spiralling whitefly *Aleurodicus rugioperculatus* was observed in various Districts in Tamil Nadu *viz.*, Coimbatore, Tirupur, Erode, Theni, Thajavur, Cuddalore, Kanyakumari, Tiruvarur, Tirunelveli and Dindigul. The parasitization by *Encarsia guadeloupae* rangedbetween 25.00-72.00% on coconut gardens and a predator *Mallada boninensis* was seen in all the coconut gardens (Table 132). Other natural natural *viz.*, *Cybocephalus* spp., *Cryptolaemus montrouzieri* Muls., *Chilocorus nigrita* (Fabricius), *Cheilomenes sexmaculata* (Fab.),*Curinus coeruleus* (Mulsant), *Mallada astur* (Banks), *Chrysoperla zastrowi sillemi* (Esben-Petersen), praying mantis and spiders were also recorded.

Table 132. Occurrence of rugose spiralling whitefly and its natural enemies

Date of survey	**Location**	**GPS coordinates**	**RSW population in ≥five fronds)**	***Encarsia guadeloupae* (%)**	***Mallada* sp /leaf**
20.06.19	Vellarachal	11.014; 77.696	20	35	1
17.07.19	Arachalur	11.141; 77.698	27	25	1
26.07.19	Thalavadi	11.748; 76.907	55	61	2
08.08.19	kundadam	10.877; 77.449	60	50	1
22.09.19	Thippampatti	10.677; 77.133	60	55	1
23.09.19	Rakalpavi	10.595; 77.190	20	44	2
	R.Vellur	10.555; 77.198	22	55	1
	Kongalnagaram	10.646; 77.197	17	58	1
	Chinnavalavadi	10.582; 77.240	25	42	2
	Periyavalavadi	10.552; 77.179	30	55	1
23.10.19	Kuppanoor	10.968; 76.844	24	47	1
	Sadivayal	10.562; 76.881	34	54	2

15.11.19	Kalangal	10.996; 77.139	95	32	1
	Kollarpatti	10.626; 77.111	18	72	1+Dragonflies
11.12.19	Kosavampalayam	10.778; 77.459	26	60	2
	Sengodampalayam	10.981; 77.472	35	54	1
16.12.19	Sinthuluppu	10.761; 77.203	22	68	1
18.12.19	Mettukadai	11.189; 77.471	29	65	2
19.12.19	Vattamalaipalayam	11.091; 6.998	85	42	1
06.01.20	Vedapatti	11.000; 76.876	40	50	1
09.01.20	Mohavanur	10.811; 77.198	25	54	1 +Spiders
18.01.20	Kovilputhur	11.346; 77.164	12	55	2
	Allathukombai	11.479; 77.289	10	60	2
	Karratupalayam	11.426; 77.338	11	55	2
	Modachur	11.445; 77.436	10	50	1
13.02.20	Thottampatti	10.975; 77.355	95	45	1
	Senjeriputhur	10.805; 77.272	75	50	1
18.02.20	Thollampalayam	11.226; 76.891	45	55	1
	Vellamadai	11.151; 76.984	40	52	2
12.03.20	Puttuviki	10.984; 76.940	100	55	1
	Patchaplayam	10.874; 76.931	100	58	1
	Kuttigoundanpathi	10.831; 76.905	100	55	2
	Rottigoundanur	10.871; 76.898	100	59	2

15.1.5 KAU, Thrissur

Surveillance of rugose whitefly population and their natural enemies was carried out in Thrissur and Palghat districts from November 2019 to March, 2020 and incidence was widespread. The build-up of pest started in November, 2019 possibly due to the delayed withdrawal of the South West monsoon. The whitefly infestation broadly followed the pattern observed in 2018-19 though the severity of infestation was high well into March, unlike in previous years when it had declined by January.

Mean parasitism by *Encarsia guadeloupae* remained relatively low throughout the study period, ranging from 28.64-80.18% at Palakkad and from 35.72 to 62.10& at Thrissur and never reached 90% at either of the locations. This can be seen as a continuation of the declining trend in parasitism first observed during 2018. In 2017-18, 92% parasitism was observed as early as November while it took longer time in 2018-19 to reach similar levels and it peaked at around 60 to 80 % in the current year. The foremost reason for the continued decline in parasitism could be the presence of the two alien species of whiteflies, *viz.*,*Paraleurodes bondari* and *P. minei*, which are hardly parasitized by *E. guadeloupae.* The significance of the above findings and their impact on the conservation biocontrol currently being practiced in the state need be assessed carefully.

Table 133. Severity of infestation and mean parasitism of rugose whitefly at KVK campus in Thrissur District

Palms	7-11-19		22-11-19		6-12-19		23-12-19		6-1-2020		22-1-2020		6-2-2020		26-2-2020		10-3-2020	
	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)
P1	H	38.99	S	23.43	S	21.94	S	19.85	S	14.99	H	67.63	H	38.54	H	50	H	50.34
P2	H	16.75	S	57.42	S	37.50	S	36.21	H	49.19	H	56.01	M	47.76	H	49.99	H	87.70
P3	M	51.13	H	47.84	H	60.27	H	57.87	H	71.74	M	100	M	89.2	M	47.39	H	85.71
P4	H	48.22	H	96.43	S	52.5	H	48.24	M	79.89	S	16.54	H	35.71	H	31.25	S	6.25
P5	M	44.28	S	85.41	S	77.91	S	50.38	H	41.66	S	3.57	H	42.42	S	0	S	59.58
Mean parasitism		38.65		62.10		50.02		42.57		51.49		48.75		50.72		35.72		57.91

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)

Table 134. Severity of infestation and mean parasitism of rugose whitefly at Alathur in Palakkad District

Palms	29-11-19		12-12-19		30-12-19		14-1-2020		30-1-2020		16-2-2020		2-3-2020		12-3-2020	
	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)	Severity	Parasitism (%)
P1	S	68.15	S	80.22	S	48.73	M	90.78	H	33.61	M	46.42	H	14.91	M	47.29
P2	M	90.83	S	44.77	H	68.25	M	51.02	H	59.57	M	80.67	H	19.44	L	76.30
P3	H	73.68	S	66.66	H	51.08	H	37.5	H	70.11	H	12.69	M	42.59	M	21.15
P4	L	98.8	S	76.56	S	49.67	H	32.37	S	25.65	S	10	M	24.22	H	31.01
P5	S	69.44	S	12.5	H	50	S	17.85	S	25	S	16.66	H	42.04	M	49.89
Mean parasitism		80.18		56.14		53.54		45.90		42.78		33.28		28.64		45.12

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)

15.1.6 KAU, Vellayani

In Location I, *Aleurodicus rugioperculatus* population was moderate to severe in June gradually raised to severe in September with a fall in November (Table 135). The population was again severe in December 2019 to February, 2020 with a narrow decline in March, 2020. The corresponding parasitism levels were 33.33 to 50.00% in June, 2019 which increased to 41.77 % in September with rise in November (75.72 %). Parasitism declined to 58.66%in December, 2019 with a gradual rise in the subsequent months. During the months in which parasitism was low the dominating whitefly species was not *A. rugioperculatus*. Species displacement was noted during these months where in *Paraleyrodes minei* and *P.bondari* outnumbered *A.rugioperculatus*.

Population of *A.rugioperculatus*was heavy to severe in Location 2 during June 2019 which declined (Low) in September 2019 and remained moderate in December, 2019 to January, 2020. The pest population slowly started increasing in March (Moderate to severe). The parasitism level was 62.50 % in June 2019 which declined to 38.40 % in September which gradually increased to 69.16 in November, 2019 and thereafter a decline to 56.84% in March, 2020. The period of low parasitism coincided with the dominance of other species such as *P. minei* and *P. bondari*. In the Location 3 population of *A.rugioperculatus* was moderate throughout the period of observation with a decline during December, 2019 and regained the moderate level thereafter. Extent of parasitism was 30.26 to 59.70% and low parasitism due to dominance of nest whiteflies.

15.1.7 ICAR-NBAIR, Bengaluru

Survey programme was carried in different districts in Karnataka during the reporting period to assess the infestation and natural enemies on coconut as well as other host plants. RSW infestation in Karnataka, ranged from 0.0 to 8% insurvey location and it's was peak during April to May in coastal tracts, reduced over the time. However, RSW infestation meagre (less than 2%) in interior districts like Mysore, Mandya, Ramanagara and Bengaluru rural which is very negligible. Besides RSW, infestation of three other invasive whitefly species i.e. Bondar's nesting whitefly, *Paraleyrodes bondari*, nesting whitefly, *Paraleyrodes minei* and palm infesting whitefly *Aleurotrachelus atratus* were noticed during survey programme. All these invasive believed to be Neotrophical origin, highly polyphagous and coconut is seems to be preferred host. These whitefly species are coexistence RSW population even in the same colony.

Fig 52. Palm infesting whitefly, *Aleurotrachelus atratus* on coconut at Pandavapura taluk, Mandya district

New invasive whiteflies on coconut: In this report, the brief details of new invasive whiteflyspecies, its distribution, infestation level, host ranges and its natural enemies was given below in brief.

Palm infesting whitefly, *Aleurotrachelus atratus*is a Neotropical whitefly originallydescribed from Brazil. In India, it was recorded February during 2019 at Karnataka on coconut (Selvaraj *et al*., 2019). Pupariaare black with a long marginal white wax fringe and dorsal wax filaments that often completely cover the insect. Adults differ from the recently invaded whiteflies infesting coconut palm; life stages were smaller than *A.rugioperculatus* but larger than *P. bondari* and *P. minei* and without anywavy marking on the wings. Theintensity and severity is more on coconut palm than the ornamental palm and so far its occurrence was limited to few districts in Karnataka. The intensity & severity of this whitefly oncoconut was about 10-60% of leaflets per frond per palm. No natural parasitization was observed either by any indigenous or its known parasitoids but four species of predators' *viz.,Dichochrysa astur*, *Cybochephalus* spp., *Chilocorus nigrita* and *Jauravia pallidula* werefound feeding on this invasive species.

Fig 53

Bondar's nesting whitefly, *Paraleyrodes bondari* is a native of the Neotropical region. InIndia, first incidence was reported on coconutpalms from Kerala during 2018 (Josephrajkumar *et al.*, 2019) and subsequently ICAR-NBAIR recorded in Karnataka. The polyphagous nature and its infestation was rangedfrom 4-7 colony/leaflet and its infestation higher when RSW in demising trends and it was observedthat co-existence of *P. bondari, P. minei*&*A. rugioperculatus* on coconut palms. Natural enemies such as some grubs of coccinellid beetles were noticed around the BNW colony; however, no parasitoid was recorded in India so far.

Nesting whitefly, *Paraleyrodes minei*wasfirst reported on coconut in Kerala during 2018 by ICAR-CPCRI and subsequently, ICAR-NBAIR recorded in northern Karnataka and off late its occurrence noticed in Mysore, Mandya, Ramanagara, Rural and Urban Bengaluru districts in Karnataka. Its infestation was ranged from 2-4 colony/leaflet and found that simultaneous coexistence of *P. bondari*&*P. minei, A. atratus* and *A. rugioperculatus* in most of the coconut leaflets. *P. minei* found to colonize on coconut, guava and many other economically important crop plants in India. So far, no natural parasitism is recorded either by any indigenous or its known parasitoids.

Fig. 54. *Paraleyrodes bondari*and ***Paraleyrodes minei***

Table 135. Number of *A. rugioperculatus* live colonies and natural parasitism (%) in Thiruvananthapuram (Location I &II) during 2019-2020

Palm No.	June 19		July 19		Aug19		Sept 19		Oct 19		Nov 19		Dec 19		Jan 2020		Feb 20202		March 2020	
	No.of colonies	Parasitism (%)	No.of colonies	Parasitism (%)	No.of colonies	Parasitism (%)	No.of colonies	Parasitism (%)	No.of colonies	Parasitism (%)	No.of colonies	Parasitism (%)	no.of colonies	Parasitism (%)	No.of colonies	Parasitism (%)	No.of colonies	Parasitism (%)	No.of colonies	Parasitism (%)
Location-I																				
P1	11.5	35.29	10.75	22.5	16.5	37.50	16.75	27.27	2.5	50.00	8.25	81.81	6	88.23	15.75	58.06	15.5	56.00	12.5	78.81
P2	5.25	50.00	9.00	50.00	17.00	44.44	8.25	33.33	5.25	57.14	13.5	60.00	13.5	50.00	12.75	40.00	13.5	57.14	6.5	65.00
P3	4.25	50.00	9.25	28.57	18.5	45.16	10.25	55.00	13	65.00	10.25	66.66	12.25	55.55	18.25	51.85	12.5	65.00	9.5	66.66
P4	4	44.44	11.00	100	4.75	0.00	10.00	62.50	5.25	74.07	10.0	83.33	12.25	41.17	3.75	50.00	15.5	63.07	9.00	72.33
P5	14.25	33.33	17.5	62.50	13.00	16.60	11.5	30.76	28.75	64.40	13.25	86.84	12.5	58.33	5.5	16.66	14	64.40	12.5	56.50
Mean		42.61		52.71		28.74		41.77		62.12		75.72		58.66		43.31		61.12		67.86
	M		H		S		S		M		M		S		S		S		H	
Location-II																				
P1	8.25	53.84	7.5	50.00	5.00	50.00	3.75	71.42	8.00	66.66	5.25	33.33	3.75	33.33	7.00	41.67	6.50	52.80	6.5	60.00
P2	23.25	69.66	11.75	59.61	6.25	25.00	3.25	33.33	5.5	50.00	4.50	100	5.00	50.00	7.00	50.00	7.00	60.00	8.50	61.67
P3	20.5	49.42	13	54.31	3.5	33.33	3.00	42.85	27.0	67.27	3.50	62.50	4.25	50.00	6.00	14.28	4.00	35.20	6.5	50.00
P4	5.00	79.16	4.5	71.42	3.25	16.66	2.50	0.00	9.75	62.16	3.25	83.33	6.75	57.14	7.50	61.54	6.50	68.00	9.00	62.56
P5	9.00	60.46	7.75	66.67	2.5	0.00	2.00	44.44	8.75	58.33	5.00	66.66	7.25	42.10	4.00	28.57	5.50	50.00	6.5	60.00
Mean		62.50		6.40		28.86		38.40		60.88		69.16		46.51		39.21		53.2		56.84
	H		H		M		L		H		M		M		M		M		M	

Low (3 infested leaflets/frond); M (4to7 infested leaflets/frond) ;H (>10 infested leaflets/frond); S (>10infested leaflets/frond with sooty mould)

Table 136. Number of *A. rugioperculatus* live colonies and natural parasitism (%) in Thiruvananthapuram (Location 3) during 2019-2020

Palm No.	**June 2019**		**July 19**		**Aug 19**		**Sept 19**		**Oct 19**		**Nov 19**		**Dec 19**		**Jan 2020**		**Feb 2020**		**March 2020**	
	no.of coloni	Parasitism (%)	no.of coloni	Parasitism (%)	No.of coloni	Parasitism (%)	no.of coloni	Parasitism (	no.of coloni	Parasitism	no.of coloni	Parasitism	no.of coloni	Parasitism	No.of coloni	Parasitis	no.of coloni	Parasitism	no.of coloni	Parasitism
P1	4.5	55.55	5.75	43.75	2.5	26.86	2.5	35.40	12.5	47.77	8.00	50.00	3.75	52.00	5.5	58.28	6.5	60.45	8.5	62.86
P2	7.25	58.33	5.75	50.00	3.75	40.45	2.75	36.36	6.5	33.33	4.00	33.33	2.75	50.00	7.00	57.14	6.5	55.40	7.00	60.00
P3	8.25	64.00	4.5	50.00	3.5	50.00	2.00	25.00	5.25	20.00	5.00	20.00	3.5	25.00	4.5	50.00	7.00	75.00	6.50	70.00
P4	10.0	42.02	5.5	50.00	2.75	33.35	2.5	26.56	4.25	33.33	3.25	20.00	3	0.00	5.5	22.86	6.25	50.00	6.50	55.68
P5	6.25	38.88	6.75	38.46	2.75	32.46	3.00	28.00	8	33.33	2.5	100.00	3	50.00	4.00	28.57	5.50	33.56	9.00	50.00
Mean		51.75		46.44		36.62		30.26		33.55		44.66		35.4		43.37		54.88		59.70
M			M		L		M		M		M		L		M		M		M	

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)

Table 137 Population of whitefly stages with the corresponding weather data

Month	Max. Temp. (^{0}C)	Min. Temp. (^{0}C)	RH (morning)	RH (evening)	Location I		Location II		Location III	
					Adults	Nymphs	Adults	Nymphs	Adults	Nymphs
June 2019	32.0	25.2	91.7	79.2	6.9	1.8	16.9	15.3	7.8	6.2
July 2019	32.0	25.8	76.3	66.1	6.6	10.6	7.3	8.2	5.0	3.8
August 2019	30.9	25.2	90.6	80.7	5.1	2.3	2.1	0.9	1.6	0.3
September 2019	30.8	23.9	92.8	78.6	9.0	6.6	1.9	1.1	1.6	0.6
October 2019	31.1	24.5	91.5	75.3	6.2	13.0	5.2	8.1	4.5	5.0
November 2019	31.0	24.4	91.2	70.0	6.6	2.3	0.4	2.1	2.6	2.4
December 2019	32.2	24.1	85.4	70.2	5.2	6.3	1.7	2.0	2.2	0.9
January 2020	32.0	23.2	85.9	67.4	6.9	1.3	4.8	2.6	3.7	3.0
February 2020	32.8	22.8	91.7	60.5	7.5	3.0	5.2	4.6	4.2	4.0
March 2020	33.2	23.3	89.4	58.8	7.9	3.6	6.0	5.5	5.5	5.1

15.2 Efficacy of biorationals on the bio-suppression of rugose spiralling whitefly

15.2.1 ICAR-CPCRI, Kasaragod

Four treatments were superimposed with ten palms per treatment and sampling made on four leaflets per palm. The treatments include conservation biological control, application of *Isaria fumosorosea*, application of neem oil 0.5% and water spray. Two sprays were undertaken at fortnightly intervals and observations were recorded one-month and two-months after superimposition of treatments. Under good nutrition management, it was found that palms treated with neem oil (5%) and water spray could reduce the RSW population significantly and closely followed by *Isaria fumosorosea*-treated palms (56.7%) (Table 138). The least reduction was observed on palms exposed to conservation biological control. Under natural suppression about 36.3% reduction could be obtained in a period of two months. Good management is very important in recouping palm health and reduces pest impact.

Table 138 Efficacy of biorationals on the bio-suppression of rugose spiralling whitefly

Treatments	**RSW population (No.)**				
	Pre-treatment	30 DAT	Reduction (%)	60 DAT	Reduction (%)
Conservation biological control	4.05	3.03	25.19	2.58	36.30
Isaria fumosorosea	7.16	2.53	64.66	3.10	56.70
Neem oil 0.5%	4.78	1.38	71.13	1.35	75.76
Water spray	6.40	1.83	71.41	1.88	70.63

DAT-Days after treatment

15.2.2 YSRHU, Ambajipeta

The experiment was carried out ondwarf variety (Ganagabondam)about 9 years old and average incidence was varied from moderate to severe infestation at HRS, Amabajipeta. There was a gradual increase in number of leaves infested with RSW and also leaflets infested with RSW throughout the experimental period. The first spray was given on 20th January, 2020 and subsequent spray at 15 days interval. Data on survival of various stages of whitefly population were transformed into $\sqrt{x+0.5}$ values before subjecting to analysis of variance. There was no significant difference in various stages of RSW in the pretreatment count and no natural parasitism of parasitoid *E, guadeloupae* was observed (Table 139).

After 15 days of treatment imposition,the lowest number of egg spirals were recorded in *I. fumosorosea* sprayed treatment (9.45 egg spirals) along with RSW infested leaflets. A high number of egg spirals were observed in natural conservation of *E. guadeloupae* treatment. However the nymphal and adult population was observed to be low in neem oil treatment and *I. fumosorosea* treated palms had low impact on these two stages of RSW . The number of number of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet were found to be very low in all treatments including natural conservation of *E. guadeloupae* treatment (Table 5).The number of parasitized nymphs (live

& blackened) & nymphs with parasitoid emergence holes/leaflet and aborted nymph/pupae were nil.

Table 139 Rugose spiralling whiteflypopulation before treatments imposition at HRS, Ambajipeta

Treatments	RSW infested leaves /palm	Infested leaflets /leaf (4 leaves/palm)	Number of live population/leaflet		
			Egg spirals	nymph	adult
T_1-Natural conservation of *E.guadeloupae*	62.49 (7.92)	71.03 (8.42)	14.70 (3.89)	32.35 (5.56)	29.98 (5.52)
T_2-*I.fumosorosea* spray	74.09 (8.63)	56.47 (7.48)	15.12 (3.95)	33.47 (5.80)	33.11 (5.77)
T_3-Neem oil spray	73.39 (8.57)	89.82 (9.49)	15.23 (3.96)	31.07 (5.61)	37.61 (6.12)
T_4-Water spray	73.91 (8.61)	77.33 (8.74)	14.97 (3.93)	35.57 (5.99)	30.24 (5.52)
SEm	NS	NS	NS	NS	NS
CD (5%)	-	-	-	-	-

*Fig in parenthesis are $\sqrt{x+0.5}$ transformed values

At 15 days after second spray, the lowest number of egg spirals were recorded in neem oil and *I. fumosorosea* sprayed treatment (8.63 and 9.65 egg spirals). The lowest no RSW infested leaflets /leaf (from 4 sample leaves/palm was observed in *I. fumosorosea* sprayed treatment. A high number of egg spirals were observed in natural conservation of *E. guadeloupae* and water spraytreatment. However the nymphal and adult population was observed to be low in neem oil as compared to other treatments. The number of number of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet and aborted nymph/pupae were found to be very low in all treatments including natural conservation of *E. guadeloupae* without any significant difference (Table 140).

Table 140 Rugose spiralling whitefly population at 15 days after first spray at HRS, Ambajipeta

Treatments	**RSW infested leaves /palm**	**Infested leaflets /leaf (4 leaves/palm)**	**Number of live population/leaflet**			**Number of parasitized nymphs /leaflet**
			Egg spirals	**Nymph**	**Adult**	
T_1-Natural conservation of *E.guadeloupae*	83.42 (9.15)	83.50(9.16)	17.95 (4.29)	27.01 (5.23)	28.29 (5.36)	0.48 (0.98)
T_2-*I.fumosorosea* spray	87.52 (9.37)	66.00 (8.08)	9.45 (3.15)	30.80 (5.53)	41.60 (6.40)	0.51(1.00)
T_3-Neem oil spray	87.97 (9.39)	91.00 (9.56)	12.44 (3.59)	21.15 (4.65)	8.02 (2.87)	0.55(1.02)

T_4-Water spray	91.88 (9.61)	82.00 (9.07)	14.98 (3.98)	39.06 (6.23)	29.98 (5.52)	0.51 (1.00)
SEm	NS	0.19	0.08	0.16	0.28	NS
CD (5%)	-	0.56	0.25	0.47	0.82	-

*Fig in parenthesis are √x+0.5 transformed values

Table 141 Rugose spiralling whitefly population at 15 days after second spray at HRS, Ambajipeta

Treatments	RSW infested leaves /palm	Infested leaflets /leaf (4 leaves/palm)	Number of live population/leaflet			Number of parasitized nymphs /leaflet	Aborted nymph/ pupae
			Egg spirals	nymph	adult		
T_1-Natural conservation of *E.guadeloupae*	93.45 (9.69)	90.50 (9.53)	15.71 (4.02)	33.11 (5.77)	30.24 (5.52)	0.48 (0.98)	0.53 (1.01)
T_2-*I.fumosorosea* spray	90.72 (9.55)	71.00 (8.44)	9.67 (3.13)	25.32 (5.08)	37.61 (6.12)	0.51 (1.00)	0.44 (0.96)
T_3-Neem oil spray	93.18 (9.67)	92.50 (9.62)	8.63 (3.01)	10.35 (3.21)	7.99 (2.88)	0.55 (1.02)	0.59 (1.04)
T_4-Water spray	97.28 (9.88)	85.00 (9.24)	15.12 (3.95)	42.04 (6.44)	39.60 (6.30)	0.51 (1.00)	0.51 (1.00)
SEm	NS	0.12	0.11	0.26	0.29	NS	NS
CD (5%)	-	0.36	0.32	0.75	0.84	-	-

*Fig in parenthesis are √x+0.5 transformed values

15.2.3 TNAU, Coimbatore

RSW nymphs was minimum (13 nymphs/leaflet) were seen in the coconut trees sprayed with neem oil 0.5% followed by 14 nymphs in water spray and *Isaria fumosorosea* (pfu-5) @ $1x10^8$ cfu/ml. In case of natural conservation of *Encarsia guadeloupae,* 22 nymphs /leaflet) was observed (Table 133). Parasitized nymphs were significantly more in *E. guadeloupae* (natural conservation) than in *I.fumosorosea*, neem oil and water spray on 15^{th} day after 2^{nd} spraying. On 60^{th} day after 2^{nd} spraying, nymphal population was drastically reduced in *E. guadeloupae* (natural conservation) (20 nymphs) when compared with *I. fumosorosea,* water spray (39.0 nymphs) and neem oil (44.0 nymphs). Parasitized nymphs in *E. guadeloupae* (natural conservation) and neem oil were same (14.0 nymphs) and higher than in *I. fumosorosea* (10.0 nymphs) and foliar water spray (13.0 nymphs) on 60^{th} day after 2^{nd} spraying.

15.2.4 KAU, Thrissur

An experiment was conducted in farmer's field at Alathur in Palakkd district during November 2019 to February 2020 to evaluate the efficacy of *Isaria fumosorosea* in managing whitefly infestation on coconut. Pre-treatment observations live colonies /leaflet, per cent leaflets infested with RSW,No. of nymphs/ leaflet and No. of parasitized nymphs/leaflet were not varied significantly. The results revealed that number of live colonies /leaflet was ranged from 13.0 to 16.0 and per cent leaflets infested with RSW were ranged from 39.26 to 41.18%.

Post treatment observation at 15 days after treatment revealed the least number of live colonies (6 live colony) /leaflet was recorded with neem oil treated palm followed by 7 live colony/leaflet) in *I. fumosorosea* treated palm. Similarly, per cent leaflets infested with RSW were least (29.4%) in *I. fumosorosea* followed by 30.2% in neem oil treated palm. The parasitized nymphs were also significantly across the treatment.

At 60 days after treatment, there was significant difference among the treatments at different intervals after two rounds of sprays, the sprayed palms had significantly lower number parasitized whitefly than in unsprayed trees. The per cent leaflets infested with RSW were least (33.4%) in natural conservation of *E. guadeloupae* followed by 37.8% in *I. fumosorosea* treated palm.

Table 142 Biological suppression of rugose spiralling whitefly in coconut at TNAU, Coimbatore during 2019-20

Treatments	Pre treatment				15^{th} day after 2^{nd} spray				60^{th} day after 2^{nd} spray			
	Leaflets infested with RSW (%)	No. of live colonies /leaflet	No. of nymphs /leaflet	No. of parasitized nymphs /leaflet	Leaflets infested with RSW %	No. of live colonies /leaflet	No. of nymphs /leaflet	No. of parasitized nymphs /leaflet	Leaflets infested with RSW %	No. of live colonies /leaflet	No. of nymphs /leaflet	No. of parasitized nymphs /leaflet
T_1-Natural conservation of *E.guadeloupae*	41.18 (39.90)	14.00 (3.74)	26.00 (5.10)	12.00 (3.46)	35.3 (36.43)d	13.00 $(3.61)^{d}$	22.00 $(4.69)^{c}$	14.00 $(3.74)^{d}$	33.4 $(35.28)^{a}$	10.00 $(3.16)^{a}$	20.00 $(4.47)^{a}$	14.00 $(3.74)^{a}$
T_2-*I.fumosorosea* spray	40.28 (39.37)	13.00 (3.46)	24.00 (4.90)	11.00 (3.32)	29.4 $(32.81)^{a}$	7.00 $(2.65)^{b}$	14.00 $(3.74)^{b}$	2.00 (1.41)a	37.8 $(37.92)^{b}$	18.00 $(4.24)^{b}$	36.00 $(6.00)^{b}$	10.00 $(3.16)^{c}$
T_3-Neem oil spray	40.94 (39.76)	16.00 (4.00)	21.00 (4.58)	10.00 (3.16)	30.2 $(33.32)^{ab}$	6.00 $(2.45)^{a}$	13.00 (3.61)a	3.00 $(1.73)^{b}$	38.3 $(38.21)^{bc}$	21.00 $(4.58)^{c}$	44.00 $(6.63)^{d}$	14.00 $(3.74)^{a}$
T_4-Water spray	39.26 (38.87)	15.00 (3.87)	22.00 (4.69)	12.00 (3.46)	31.7 $(34.24)^{b}$	9.00 $(3.00)^{c}$	14.00 $(3.74)^{b}$	4.00 (2.00)c	40.7 $(39.62)^{c}$	22.00 $(4.69)^{d}$	39.00 $(6.24)^{c}$	13.00 $(3.61)^{b}$
SEd	NS	NS	NS	NS	0.398	0.020	0.031	0.016	0.567	0.027	0.063	0.022
CD(P=0.05)	NS	NS	NS	NS	0.992	0.047	0.072	0.037	1.451	0.061	0.146	0.051

Figures in parentheses are arcsine transformed values (Leaflets infested with RSW) and square root transformed values (No. of live colonies, nymphs and parasitized nymphs);Means followed by a common letter in a column are not significantly different by DMRT Values are mean of ten replications

Table 143 Effect of different treatments on population of rugose whitefly and extent of parasitism at KAU, Thrissur during 219-20

Treatment	No of healthy rugose whitefly colonies*						No of parasitized rugose whitefly colonies*					
	Pre count	13 DAS1	15 DAS2	20 DAS2	40 DAS2	60 DAS2	Pre count	13 DAS1	15 DAS2	20 DAS2	40 DAS2	60 DAS2
T1-Natural conservation	0.70 (1.13)	5.15 (1.64)	3.45 (1.57)	2.32 (2.19)	3.07 (2.04)	4.66 (2.05)	11.50 (2.89)	1.025 (3.35)	10.77 (2.76)	12.35 (3.20)	11.07 (3.21)	12.12 (3.15)
T2- *I. fumosorosea*	1.15 (1.12)	1.57 (1.26)	1.80 (1.33)	4.97 (2.23)	6.60 (1.98)	2.45 (1.43)	9.32 (3.04)	8.87 (2.91)	7.30 (2.44)	18 (2.72)	10.75 (3.12)	8.37 (2.92)
T3 – Neem oil (0.5%)	0.77 (1.10)	1.10 (1.10)	0.85 (1.07)	4.97 (2.08)	2.57 (1.88)	3.32 (1.84)	12.45 (3.36)	11.50 (3.21)	6.12 (2.23)	7.20 (2.41)	6.70 (2.42)	8.02 (2.79)
T4 – Water spray	0.80 (0.97)	1.17 (1.14)	0.85 (1.31)	5.62 (1.26)	3.77 (1.59)	2.77 (1.74)	10.45 (2.52)	8.55 (2.26)	7.75 (2.24)	5.87 (2.31)	9.20 (2.81)	8.02 (2.81)
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* mean of 40 observations. Values in parenthesis are square root transformed values.

Table 144 Effect of different treatments on population of nesting whitefly and extent of parasitismat KAU, Thrissur during 219-20

Treatment	No of healthy nesting whitefly colonies*						No of parasitized nesting whitefly colonies*					
	Precount	13DAS 1	15DAS 2	20DAS 2	40DAS 2	60DAS 2	Precount	13DAS 1	15DAS 2	20DAS 2	40DAS 2	60DAS 2
T1-Natural conservation	0.27 (0.81)	1.12 (1.15)	1.32 (1.14)	0.27 (0.84)	0.20 (0.81)	0.53 (0.90)	0.17 (0.85)	0.30 (0.85)	1.45 (1.20)[a]	0.0 (0.70)	0.17 (0.78)	0.0 (0.70)
T2-*I. fumosorosea*	0.25 (0.85)	0.37 (0.90)	0.30 (0.87)	2.10 (1.28)	0.50 (0.95)	0.07 (0.74)	0.25 (0.78)	0.10 (0.76)	0.100 (0.76)[b]	0.30 (0.85)	0.0 (0.70)	0.07 (0.74)
T3 – Neem oil (0.5%)	0.80 (0.97)	0.17 (0.76)	0.02 (0.75)	0.72 (1.00)	0.75 (1.05)	0.15 (0.78)	0.0 (0.70)	0.0 (0.70)	0.0 (0.70)[b]	0.0 (0.73)	0.25 (0.81)	0.25 (0.83)
T4 – Water spray	0.47 (0.94)	0.22 (0.82)	0.05 (0.70)	1.02 (0.87)	0.90 (1.29)	0.75 (1.04)	0.15 (0.84)	0.10 (0.76)	0.0 (0.70)[b]	0.22 (0.79)	0.02 (0.72)	0.02 (0.72)
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	0.353	NS	NS	NS

* mean of 40observations. Values in parenthesis are square root transformed values.

15.2.5 KAU, Vellayani

Treatments evaluated were *Encarsia guadeloupae (*natural conservation), foliar spray of *Isaria fumosorosea* (pfu-5) @ 1x10^8cfu/ml, foliar application of neem oil 0.5% (neem oil 5 ml+ soap powder 10g /litre of water, foliar water sprayduring December 2019 – March 2020 in Vellayani ecosystem. The sprayings were done twice at 15 day interval. Observations were recorded on number of live spiral colonies, number of pupae per spiral, number of parasitized pupae, 15 days and 60 days after spraying. Total number of leaves/palm, number of infested leaves/palm, total number of leaflets per leaf, number of infested leaflet/ leaf was also observed.

After 60 days of treatment, percentage reduction in number of spirals was maximum in water spray (37.01%) followed by natural conservation 27.18%). Palms treated with *Isaria* had 27.18 % reduction in live spirals. Neem oil 0.5 % was least effective (20%). Reductioninpopulation of adults was higher in water spray (25.2%) followed by natural conservation of parasitoids (24.64 %). *Isaria* could reduce the population by 23.67 % while neem oil 0.5% was less effective (12.61%). *Isaria* treatment was effective in reducing the number of pupae (42.18%) followed by neem 0.5% (34.21 %). Corresponding reduction in water spray was only 20 % in conservation method and 9.17 % in water spray. However, parasitisation was found to be greatly reduced when treated with *Isaria* treatment (68.8 %). Water spray and neem oil 0.5% did not affect the parasitisation efficacy of *Encarsia*.

The reduction in infestation noted as per the count of infested leaves before and after treatment (60DAS) revealed that *Isaria* could cause 38.48 % reduction in infestation followed by water spray treatment (30.64%). On comparison of the infestation on leaflets also water spray was found to be effective as it caused 30.64 % reduction in infestation.

Table 145 Effect of treatments biosuppression of RSW at KAU, Vellayani during 2019-20

	Pre-count	15 DAS	60 DAS	Reduction(%)
Mean number of live spirals / 4 leaves				
Natural conservation	9.20	9.17	6.37	30.76
Isaria fumosorosia	10.08	7.12	7.34	27.18
Neem oil 0.5%	6.25	4.12	5.00	20.00
Water spray	5.62	5.45	3.54	37.01
CD @ 5%	NS	NS	NS	-
Mean number of adults				
Natural conservation	6.41	6.04	4.83	24.64
Isaria fumosorosia	5.83	0.91	4.45	23.67
Neem oil 0.5%	3.33	2.33	2.91	12.61
Water spray	2.50	1.70	1.87	25.20
CD @ 5%	NS	2.83	NS	-
Mean number of pupae				
Natural conservation	4.50	3.70	3.75	20.00
Isaria fumosorosia	4.67	1.45	2.70	42.18
Neem oil 0.5%	3.04	2.12	2.00	34.21

Water spray	2.29	1.66	2.08	9.17
CD @ 5%	NS	NS	NS	-
Mean number of parasitized pupae				
Natural conservation	1.91	1.87	1.45	24.08
Isaria fumosorosia	2.50	0.95	0.83	68.8
Neem oil 0.5%	0.58	1.00	0.79	-26.0
Water spray	0.62	0.75	0.70	-11.42
CD @ 5%	NS	NS	NS	-

Table 146 Effect of biological measures in spiralling whitefly suppression during 2019-20 at KAU, Vellayani

Treatments	**Total no.of leaves /palm**			**Infested leaves /palm**			**Infestation reduction (%)**
	Pre-count	**15 DAS**	**60 DAS**	**Pre count**	**15 DAS**	**60 DAS**	**60DAS**
T1-Natural conservation	17.66	17.50	18.5	15.50	15.50	16.33	7.53
T2-*Isaria fumosorosea*	17.33	17.33	18.33	15.16	15.00	10.66	38.48
T3-Neem oil	12.66	12.66	13.66	10.16	13.00	11.33	10.50
T4-Water Spray	16.33	9.33	13.16	10.16	6.16	12.50	30.64
Treatments	Total no.of leaflets /palm			Infested leaflets /palm			Reduction (%)
T1-Natural conservation	206.00	206.00	208.33	196.66	202.00	205.0	0.00
T2-*Isaria fumosorosea*	219.33	217.0	222.0	202.66	179.33	188.3	14.14
T3-Neem oil	245.66	245.0	245.66	212.16	201.66	208.3	15.2
T4-Water Spray	212.16	201.66	208.3	158.33	155.16	160.0	24.79

15.2.6 RARS, Anakapalle

Experiments were conducted with entomopathogenic fungi, *Isaria fumosorosea* (NBAIR-Pfu-5) two sprayings at 15 day interval in two coconut orchards at Venkataraopeta, Srikakulam district and Kumili, Vizianagaram district during November -December, 2019). Data on reduction of rugose spiraling whitefly incidence before and after spraying was recorded upto 60 days after treatment. During November 2019, no natural parasitism of *Encarsiaguadeloupae*was observed and subsequently released the parasitoid, *Encarsia guadeloupae* for augmentation after first spraying of *Isaira* fungus. Good establishment of parasitoid, *E. guadeloupae* was observed during February, 2020 in coconut plantation with banana as intercrop which was inoculated during November, 2019. During February, 2020, it was observed that natural occurrence of this fungus *Isaria fumosorosea* on different life stages of rugose spiralling whitefly. The population was reduced significantly with two sprays of *I. fumosorosea* (NBAIR- Pfu 5) during November 2019 and December, 2019 with one inoculative release of *E. guadelouape* during November 2019. Per cent reduction in whitefly intensity was observed high (71.01% &75.51%) after two sprays than one spray

(36.74% & 58.22 %) due to parasitization by *E. guadeloupae*released after first spraying of *I. fumosorosea*. Farmers expressed satisfaction and interested to purchase the fungi for management of coconut whitefly. Collected parasitoid, *E. guadeloupae* from established coconut orchards and redistributed in new coconut orchard severely infested with RSW where the natural parasitism less or nil.

Table 147 Biological control of coconut rugose whitefly using entomopathogenic fungi, *Isaria fumosorosea* at RARS, Anakapalle

Location	Pre-treatment			15 days after first spray		15 days after second spray			Reduction (%)	
	Infestation (%)	Intensity (%)	Live colonies /leaflet	Intensity (%)	Live colonies	Infestation (%)	Intensity (%)	Live colonies/ leaflet	After one spray	After two sprays
Srikakulam	69.12	82.05	45.7	51.9	10-20 (13.0)	7.14	20.09	10-20 (11.0)	36.74	75.51
Vizianagaram	32.51	46.22	53.2	19.31	10-20 (12.0)	7.55	13.4	<10 (9.0)	58.22	71.01

15.2.7 ICAR-NBAIR, Bengaluru

Pre-treatment observation on number life stages/10 cm of leaflet was ranged from 52.48-59.40 live stages of rugose spiralling whitefly. At 7 days after treatment, the RSW population reduced significantly with maximum mortality (43.58%) on neem oil treatment which was on par with foliar application of *Isaria fumosorosea* (41.25%). However, the maximum mortality (61.95%) *Isaria fumosorosea* and which was on par with neem oil (58.26%) at 14 days after first spray. The higher mortality in *I. fumosorosea* treatment as compared to 7 DAT could be fungus need to establish and kill the whitefly. Similarly after second spray, mortality in RSW was significantly higher (73.87%) in *I. fumosorosea* and 69.29% in neem oil as compared to other treatment (Table). Mortality increased over the time interval and minimum two spray either of *I. fumosorosea* and neem oil. No significant effect of *Isaria fumosorosea* and neem oil on *Dichochrysa astur* and *Encarsia guadeloupae* were observed (Table 148).

Table 148. Field evaluation of *Isaria fumosorosea* (ICAR-NBAIR Pfu-5) in coconut at Nelamangala, Bengaluru during 2019-20

Treatment	**Mean mortality/natural parasitism (%)during 2019**				
	First spray			**Second Spray**	
	Pre-Count*	**7 DAT**	**14 DAT**	**7 DAT**	**14 DAT**
T1-Natural Conservation of *E.guadeloupae*	52.48	29.68^{b}	36.22^{b}	46.37^{b}	55.82^{b}
T2-*Isaria fumosorosea*@ 5 g/litre	59.40	41.25^{a}	61.95^{a}	57.42^{a}	73.87^{a}

T3-Neem oil @ 0.5%	53.28	43.58[a]	58.26[a]	59.81[a]	69.29[a]
T4-Water Spray	54.90	24.37[c]	29.83[c]	35.62[c]	37.02[c]
LSD (0.05%)	NS	3.23	10.40	4.29	6.37

*Number life stages/10 cm of leaflet, NS- non significant

Table 149. Effect of *Isaria fumosorosea* (ICAR-NBAIR Pfu-5) on natural enemies in coconut ecosystem at Nelamangala, Bangalore (2019-2020)

Treatment	Predators (*Dichochrysa astur*)/frond			Parasitoid, *Encarsia guadeloupae* Parasitism (%)	
	Pre-count	After 1st spray	After 2nd spray	After 1st spray	After 2nd spray
T1-Natural Conservation of *E.guadeloupae*	4.38	4.53	4.65	81.35	83.68
T2-*Isaria fumosorosea*@ 5 g/litre	3.85	3.34	4.68	77.52	79.68
T3-Neem oil @ 0.5%	4.25	4.62	4.58	75.29	78.59
T4-Water Spray	3.91	3.68	5.04	84.69	81.72
LSD (0.05%)	NS	NS	NS	NS	NS

NS- Non significant

Table 150. Biological suppression of Bondar's nesting whitefly in coconut (KAU, Kumarakom)

Treatment	Pre-count*				10 days after spraying			
	Infestation (%)	Intensity (%)	Live colonies/ leaflet	Live nymphs/ leaflet	Infestation (%)	Intensity (%)	Live colonies/ leaflet	Live nymphs/ leaflet
T1	77.47 (8.85)	94.18 (9.75)	9.35 (3.19)	7.27 (2.61)	76.01 (8.74)	93.38 (9.71)	11.45 (3.52)	7.90 (2.88)
T2	89.64 (9.48)	93.30 (9.68)	9.42 (3.22)	7.47 (2.89)	88.51 (9.45)	89.38 (9.49)	7.25 (2.86)	6.42 (2.70)
T3	77.41 (8.84)	93.48 (9.71)	9.27 (3.20)	7.57 (2.88)	64.55 (8.06)	86.70 (9.36)	8.20 (3.03)	6.45 (2.70)
T4	79.46 (8.96)	93.94 (9.74)	9.50 (3.24)	7.42 (2.85)	72.49 (8.55)	91.88 (9.64)	8.40 (3.06)	6.90 (2.70)
CD (0.05)	NS	NS	NS	NS	0.56	NS	0.22	NS
CV	7.22	4.45	8.10	27.66	7.40	3.40	7.55	21.01

Table 150. contd…

Treatment	20 days after spraying				60 days after spraying				Reduction in intensity over control at 20 DAS
	Infestation (%)	Intensity (%)	Live colonies/ leaflet	Live nymphs/ leaflet	Infestation (%)	Intensity (%)	Live colonies/ leaflet	Live nymphs/ leaflet	
T1	79.51 (8.94)	94.21 (9.76)	13.32 (3.77)	9.40 (3.14)	96.25 (9.85)	98.87 (9.99)	12.00(3.6)	10.12 (3.26)	0.00
T2	72.79 (8.58)	77.51 (8.86)	7.37 (2.90)	5.02 (2.43)	80.49 (8.91)	79.91 (8.90)	6.67(2.77)	6.10(2.60)	17.73
T3	65.54 (8.13)	86.31 (9.34)	8.50 (3.08)	6.87 (2.79)	76.87 (8.82)	88.55 (9.40)	7.85(2.97)	6.82(2.76)	8.38
T4	74.60 (8.68)	91.27 (9.60)	8.20 (3.03)	6.97 (2.76)	78.51 (8.91)	92.21 (9.64)	8.27(3.04)	7.15(2.77)	0.00
CD (0.05)	0.50	0.17	0.18	0.49	0.69	NS	0.15	NS	-
CV	6.30	2.0	6.11	19.07	8.25	10.44	5.32	22.62	-

*Values in parantheses are square root transformed. T1: *Encarsia guadeloupae* natural conservation;T2: *Isaria fumosorosea* (Pfu-5) @ 1×10^8 cfu/ml;T3: Neem oil 0.5 % (Neem oil 5 ml + soap powder 10g/litre);T4: Water spray

16. TEA

16.1 Field evaluation of bio-pesticides against tea red spider mite, *Oligonychus coffeae*

16.1.1 UBKV, Pundibari

All the treatments including EPF preformed significantly better than the control treatment after each spraying. Among the tested fungal bio-pesticides, *Lecanicilium lecani* (NBAIR strain) reduced the mite population better which is statistically at par with Azadirachtin 10000 ppm and *Beauveria bassiana* (NBAIR strain). However, best red mite management was noticed in the plots treated with Spiromesifen 240 SC in all spraying. Significantly highest yield of tea leaves was also recorded in the treatment Spiromesifen 240 SC (6.56 qt/ha) followed by Azadirachtin 10000 ppm (4.49 qt/ha), *Lecanicilium lecani* (4.25 qt/ha) and *Beauveria bassiana* (3.84 qt/ha).

Table 151 Field evaluation of some bio-pesticides against Tea red spider mite, *Oligonychus coffeae*

Treatment	Population of red spider mite/ tea leaf						Leaf yield (Qt./ha)**	Increase over Control (%)
	First spray			Second spray				
	Pre-count	3DAS	7DAS	Pre-count	3DAS	7DAS		
T1-*Lecanicillium lecanii* (NBAIR strain) @ 6g/lit.	5.50 (2.33)*	3.38 (1.82)	1.94 (1.39)	3.88 (1.96)	3.13 (1.75)	1.25 (1.11)	4.25 (2.06)*	51.78
T2-*Beauveria bassiana* (NBAIR strain) @ 6g/lit.	5.19 (2.24)	4.14 (2.04)	3.13 (1.77)	4.19 (2.04)	3.94 (1.98)	2.00 (1.39)	3.84 (1.96)	37.14
T3- Azadirachtin 10000 ppm @ 1ml/lit.	5.56 (2.34)	3.44 (1.84)	1.63 (1.26)	3.10 (1.68)	3.00 (1.72)	1.00 (0.98)	4.49 (2.12)	60.35
T4- Spiromesifen 240SC @ 1ml/lit.	5.13 (2.24)	1.69 1.28)	0.75 (0.85)	2.13 (1.43)	1.38 (1.17)	0.0 (0.71)	6.56 (2.56)	134.28
T5- Control	5.06 (2.22)	6.81 (2.60)	9.50 (3.08)	12.50 (3.53)	13.25 (3.63)	14.50 (3.79)	2.80 (1.67)	-
SEm (±)	0.18	0.12	0.09	0.17	0.08	0.11	0.05	-
CD (at 5%)	N.S.	0.36	0.28	0.52	0.28	0.35	0.16	-
CV (%)	16.16	12.11	10.71	15.96	7.51	14.37	4.94	-

DAS- Days after spray; * Figures in the parenthesis are square root transformed values.**Green tea yield of single plucking after the sprayings

VEGETABLES

17. BRINJAL

17.1 Bio-intensive insect management in brinjal

17.1.1 AAU, Jorhat

Location: Farmers' field, Neul Gaon, Alengmora, Jorhat
Plot size: 200sqm
N:P:K: 50:50:50
Variety: Pusa Puple Long
Date of Planting: 03.10.2019
Replication: 8
Treatments: 3

Treatment details:

T1 = BIPM Package

- Spray of Azadirachtin 1500 ppm @ 2ml/lt
- Spray of *Lecanicillium lecanii* (NBAIR strain) 1x 10^8 spores/ml @ 5g/lt
- Ten releases of *Trichogramma chilonis* multiple insecticide tolerant strain @100,000/ha, at weekly interval from initiation of flowering.
- Use of pheromone traps @ 20 nos/ha
- Mechanical collection and destruction of infested shoot and fruits

T2 = Chemical Control

- Profenophos 50 EC @ 750g *a.i*/ha and lamda cyhalothrin 4.9CS @ 25 g *a*.i/ha

T3: Untreated control (Standard check)

The experiment on the management of shoot and fruit borer *Leucinodes orbanalis* was carried out during *Rabi* 2019-20 at farmer's field. The experimental plots was subdivided into 8 subplots and considered each subplot as individual replication. Observations on per cent infestation of shoots from 10 randomly selected plants from each subplot at weekly interval was recorded after 20 days DAP. Catches *L.orbanalis* from pheromone traps were also recorded and on an average 18.25 adults of *L. orbonalis* was trapped per pheromone traps during the cropping season. Per cent fruit damage and weight of the marketable brinjal per treatment block were recorded at the time of each harvesting. Egg parasitism by *T. chilonis* was also recorded by placing sentinel egg cards of *Corcyra* at ten spots in each treatment block.

Six rounds of alternate spray of profenophos 50 EC @ 750g *a.i*/ha and lamda cyhalothrin @ 25 g *a*.i/ was sprayed at fortnightly interval staring from 25 DAT in farmer's practice. No management practices were followed in untreated check.The yield of marketable fruit per plot at each picking was summed up and converted into q/ha.

Table 152 Effect of BIPM package against *Leucinodes orbanalis* of Brinjal

Treatment	**% shoot damage**		**%fruit damage****	**Parasitism (%) (*Trichogramma* spp.)**	**Yield(q/ha)**
	Pre treatment	Post* treatment			
BIPM	16.52 (3.83)	10.94^{b} (3.30)	12.11^{b} (3.46)	4.5	205.0^{a}
Chemical control	14.80 (3.84)	9.68^{a} (3.11	10.77^{a} (3.26)	2.3	211.5^{a}
Untreated check	14.58 (3.81)	17.95^{c} (4.23)	21.38c (4.62)	3.2	127.84^{b}
CD	NS	0.14	0.34	--	6.35
CV(%)	--	3.06	7.84		3.28

*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: The per cent shoot (9.68) and fruit (10.77) was minimum at farmers practice plot (Chemical control) as against BIPM package where the per cent shoot and fruit damage were 10.94 and 12.11, respectively. The highest shoot and fruit damage was 17.95 and 21.38 per cent recorded in untreated control plot. It was observed that all the treatments were significantly differed from each other in respect of shoot and fruit damage except in yield parameter (Table 152). However, six round of alternate spraying with lamda cyhalothrin @ 25g*a*.i/ha and profenofos 50EC @ 750 g *a.i*/ha at fortnightly interval found superior in reducing the fruit infestation(10.77 %) and contributed maximum yield of 211.5 q/ha of marketable brinjal followed by BIPM package with 205.0q/ha and both the treatments were found to be at par with each other. Minimum yield of 127.84q/ha recorded in untreated control plots. The per cent parasitisation on *Corcyra* sentinel cards by trichogrammatids species in BIPM plots was 4.5 as against 2.3 per cent in chemical control plots.

Fig 55 A view of experimental plot of brinjal

17.1.2 TNAU, Coimbatore

Name of the Farmer : Mr.Dileep
Location : Vattmalaipalayam, Coimbatore Dt.
Brinjal Variety : Vari kathiri
Plot size : 8 X 5 m
Treatmens : 3
Replications : 8

Treatments:

T1: BIPM
Azadirachtin 1500 ppm @ 2ml/lt
Lecanicillium lecanii (NBAIR strain) 1x 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 releases at weekly interval from initiation of flowering.
T2: Chemical Control (Imidacloprid (0.5 ml/lt), Flubendiamide (0.5 ml/ lt) and Dimethoate (2ml/liter)
T3: Untreated control

Results: The fruit damage in brinjal due to *Leucinodes orbonalis* was significantly low (17.82%) in plots sprayed with pesticides followed by 21.80 per cent fruit damage in BIPM plots (Azadirachtin 1500 ppm @2ml/lit (one round of spray) + *L. lecanii* (one round of spray) + *Trichogramma pretiosum* (8 releases) + Pheromone traps @20/ha + Cowpea as bund crop). In the control plot fruit damage was 32.55 per cent. The marketable fruit yield was 12140 kg/ha in BIPM plots while in control plots the yield was 8495 kg/ha. The cost benefit ratio realized in BIPM was 1:3.90 as against 1:4.83 in insecticides treated plots(Table-153).

Table 153 Bio-intensive 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) + *Trichogramma pretiosum* (8 releases) + Pheromone traps @20/ha + Cowpea as bund crop	21.80 (27.78)[a]	34.53	12140 (110.18)[b]	29.98	3.90
T2: Spraying of Imidacloprid (0.5 ml/lt), Flubendiamide (0.5 ml/ lt) and Dimethoate (2ml/lt)	17.82 (24.86)[a]	54.72	13415 (115.80)[a]	36.61	4.83
T3: Control	32.55 (34.71)[b]	-	8495 (92.19)[c]	-	

SEd	**1.463**		**0.005**	**-**	
CD(P=0.05)	**3.073**		**0.011**	**-**	

Means followed by a common letter in a column are not significantly different by DMRT
Figures in parentheses are arcsine transformed values (Damage) and logarithmic transformed values (Yield)
Values are mean of six replications

17.1.3 KAU, Thrissur

The experiment could be initiated only by November, 2019 and is in progress. Results will be presented at the workshop.

Fig 56 Experimental plot forvalidation of BIPM in brinjal

17.1.4 MPKV, Pune

Trial during 2019-20:

This trial could not be conducted during Kharif season 2019-20 due to continuous heavy rains from July, 2019 onwards. Therefore, it is conducted in summer season, 2020. The experiment is laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. The brinjal *var*. ‘Panchganga’is sown on 23.01.2020 in 4.5 x 4.5 m plot size with 90 x 90 cm spacing in RBD with eight treatments replicated thrice.
(The initial treatments are given and this trial is in progress.)

Trials during 2017-18 and 2018-19:

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. Pre-treatment incidence on shoot infestation, post-counts of shoot and fruit infestation were recorded at weekly interval. 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 starting from initiation of treatment application and post counts are presented in Tables 154 and 155. The pooled data for two years are given in Table 156.

Treatments details:

T_1 BIPM	For sucking pests	1:Azadiractin 1500 @2 ml/lit
		2: *Lecanicilium lecanii* (NBAIR strain) 1x 10^8spores/ml@ 5 gm/lit
	For BSFB	1: *Trichogramma chilonis* @ 100,000/ ha, 8-10 releases at weekly interval (6 releases)
		2: *Bacillus thuringiensis* (NBAIR strain) Bt G4 @ 2 ml/ lit
	For ash weevil	EPN (NBAIR) strain @ 2 billion IJS/ ha
	For mealy bug	*Cryptolaemus montrouzieri* @ 5 grub /plants or 1500/ ha
T_2	For tuta	Chlorantraniliprole 18.5 % SC @ 0.4 ml /lit
T_3	--	Untreated control

Table 154 Efficacy of bioagents for management of *L. orbonalis* on Brinjal (2017-18)

Treatment	**Shoot damage %**		**Fruit damage %**		**Yield (q/ha)**
	Pre-count	**Post count**	**No. basis**	**Wt. basis**	
T1 : BIPM i) Azadirachtin 1500 ppm @2 ml/lit. ii) *Lecanicillium lecanii* (NBAIR strain) 1x10^8spores/ml @ 5g/lit. iii) Release of Trichogramma chilonis multiple insecticide tolerant strain @ 100000/ha, 8- releases at weekly interval from initiation of flowering. iv) *Bacillus thuringiensis* NBAII *Bt* G4 2%. **v)** *Cryptolaemus montrouzieri* @ 5 grubs/ plants or 1500/ha twice at 15 days interval	17.98[a] (25.08)	9.16[a] (17.53)	7.82[a] (16.22)	4.61[a] (12.35)	217.46[a]
T2: Chlorpyriphos 0.04%	18.06[a] (25.15)	7.72[a] (16.09)	6.33[a] (14.56)	3.92[a] (11.38)	230.56[a]
T3: Untreated control	17.92[a] (25.04)	27.17[b] (31.31)	42.45[b] (40.65)	41.60[b] (40.15)	165.80[b]
SE±	0.21	0.97	0.55	0.51	9.90
CD at 5%	**NS**	2.95	1.68	1.56	30.04
CV	**2.47**	**12.39**	**6.57**	**7.04**	**13.14**

(Figures in parenthesis are arc sin transformed values)

Table 155 Efficacy of bio-agents for management of *L. orbonalis*on Brinjal (2018-19)

Treatment	Shoot damage %		Fruit damage %		Yield (q/ha)
	Pre-count	Post count	No. basis	Wt. basis	
T1 : BIPM **i)** Azadiractin 1500 @2 ml/lit **ii)** *Lecanicilium lecanii* (NBAIR strain) 1x 10^8spores/ml@ 5 gm/lit **iii)** *Trichogramma chilonis* @ 100,000/ ha, 8 releases at weekly interval **iv)** *B. thuringiensis* (NBAIR strain) Bt G4 @ 20ml/ lit **v)** EPN (NBAIR) strain @ 2 billion IJS/ ha **vi)** *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: Chlorpyriphos 0.04%	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**	**9.65**
CD at 5%	**NS**	**2.24**	**2.41**	**2.40**	**29.27**
CV	**8.26**	**10.07**	**8.75**	**10.29**	**13.67**

(Figures in parenthesis are arc sin transformed values)

Table 156 Pooled data on efficacy of bio-agents for management of shoot and fruit borer, *L. orbonalis*on Brinjal (2017-18 and 2018-19)

Treatment	Shoot damage (%)		Fruit damage (%)		Yield (q/ha)	B: C Ratio
	Pre-count	Post count	No. basis	Wt. basis		
T1 : BIPM i. Azadiractin 1500 @2 ml/lit ii. *Lecanicilium lecanii* (NBAIR strain) 1x 10^8spores/ml@ 5 gm/lit iii. *Trichogramma chilonis* @ 100,000/ ha, 8 releases at weekly interval iv. *Bacillus thuringiensis* (NBAIR strain) Bt G4 @ 2ml/ lit v. EPN (NBAIR) strain @ 2 billion IJS/ ha vi. *Cryptolaemus montrouzieri* @ 5 grub /plants or 1500/ ha	17.25[a] (24.54)	8.64[a] (17.08)	8.93 [a] (17.36)	5.14 [a] (13.09)	212.93 [a]	4.93
T2: Chlorpyriphos 0.04%	17.24 [a] (24.53)	7.14 [a] (15.49)	7.45 [a] (15.80)	4.33 [a] (11.09)	228.45 [a]	5.89

T3: Untreated control	17.14 [a] (24.45)	26.99 [b] (31.30)	41.35 [b] (40.02)	42.05[b] (40.43)	153.09 [b]	4.13
SE±	1.04	1.73	1.37	1.33	19.56	
CD at 5%	NS	5.00	3.97	3.85	56.65	
CV	6.00	11.48	7.95	8.61	13.96	

(Figures in parenthesis are arc sin transformed values)

Results : The pooled results for two years (2017-18 and 2018-19) are presented in Table 156 and thedata on cost of spraying and economics of treatments are given in Tables 157 and 158. It is seen from data that the treatments with chlorpyriphos 0.04 per cent and BIPM were found at par with each other by recording shoot infestation (7.14 % and 8.64%), fruit damage on number basis (7.45% and 8.93 %) and on weight basis (4.33% and 5.14%), respectively.The highest marketable fruit yield (228.45 q/ha) and BC ratio 5.89 was recorded in chlorpyriphos 0.04 per cent treated plots which was at par with BIPM treated plot (212.93 q/ha) with BC ratio 4.95.

Table 157 Economics of biopesticide treatment:

Tr. No.	Treatment	Cost of biopesticides (Rs. lit/kg)	Quantity/ per (L/kg/ha.)	Qty. used/ha for 3 sprays	Cost (Rs./ha)	Labour charges (Rs./ha)	Total cost (Rs./ha)
T_1	Azadiractin 1500 @2 ml/lit : 2 spray	250	2.5 L	5.0 L	1250/	1860/-	3110/-
	Lecanicilium lecanii (NBAIR strain) 1x 10^8spores/ml@ 5 gm/lit : 1 spray	200	2.5 kg	500	500/-	930/-	1430/-
	Trichogramma chilonis @ 100,000/ ha, 8 releases at weekly interval	100	4 card	32	3200/-	1860/-	5060/-
	Bacillus thuringiensis (NBAIR strain) Bt G4 @ 2 ml/ lit	1500	1 L	1L	1500/-	930/-	2430/-
							12030/-
T_2	Farmers practice-chlorpyriphos 0.05%	200/L	1.250 L	3.75	750/-	2790/-	3540/-
T_3	Untreated Control	-	-	-	-	-	-

Table 158 Cost of Spraying

Tr. No.	Treatment	Cost of Cultivat-ion/ ha Rs.	Cost of Spraying Rs	Total cost Rs.	Yield (q/ha)	Rate/ Qt (Rs)	Gross returns (Rs. /ha)	Net return (Rs. /ha)	B: C ratio
T_1	BIPM	74000	12030/-	86030/-	212.93	2000	425860/-	339830/-	4.95
T_2	Farmers practice-chlorpyriphos 0.05%	74000	3540/-	77540/-	228.45	2000	456900/-	379360/-	5.89
T_3	Untreated Control	74000	-	74000/-	153.09	2000	306180/-	232180/-	4.13

17.1.5 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 nematode of brinjal. The experimental field of an area 26 x 18 m in size and it was further divided into three treatments and it was replicated eight times. The experiment was carried out during Kharif season, 2019-20. The Brinjal variety 'Pusa Uttam' was used for the experiment and transplanted at 75X60cm spacing. The first treatment is the biocontrol based component and second treatment was chemical control compare to the untreated control. The experiment was laid out in randomized complete block design.

In the BIPM module, *P. 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 *Trichogramma chilonis* @ 100,000/ha. 8-10 release at weekly interval from initiation of flowering, *Bacillus thuringiensis* NBAIR BtG4 2% Spray (Brinjal Fruit and Shoot Borer) were used. Soil application of *Paecilomyces 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 after treatment. The observation of 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:

Table 159 Effect of different BIPM modules against infestation of *Leucinodes orbonalis* and Brinjal yield

Treatments	% Shoot Damage		% Fruit Damage		% reduction over control	Yield(q/ha)	BC ratio
	Precount	PostCount	Pre count	Post count			
T1	21.10	14.33	20.35	12.12	33.20	210.83	1.78
T2	20.95	7.50	19.55	10.40	54.79	235.65	1.99
T3	21.15	19.10	20.80	20.50	0	171.30	1.44
	C.D.	0.184		0.207		0.165	
	SE(m)	0.055		0.062		0.05	
	SE(d)	0.078		0.088		0.071	
	C.V.	0.905		0.978		0.054	

T1 = BIPM, T2= Chemical control, T3= untreated control

The data in Table-1 indicated that sprays of dimethoate 0.05% was effective by causing lowest shoot (7.5%) and fruit (10.40%) damage and gave maximum yield (235.65 q/ha). However, the BIPM module were the next best treatment showing 14.33% shoot and 12.22% fruit infestation and gave 210.83 q/ha yield. The percent reduction over the control was max chemical control (54.79%) compared to the BIPM module (33.20%).

Table 160 Effect of different IBPM modules against infestation of sucking pestsand Brinjal yield

Treatments	Average no. of sucking pests population/3 leaves							BC ratio
	Aphids		Jassids		White flies		Yield (q/ ha)	
	Pre-Count	Post-Count	Pre-Count	Post-Count	Pre-Count	Post-Count		
T1	13.86	4.50	7.89	2.66	4.80	1.90	220.50	1.86
T2	13.74	3.33	8.54	1.11	5.40	1.00	235.80	1.99
T3	13.11	12.70	8.83	8.01	5.60	5.20	180.20	1.52
C.D.		4.251		0.076		0.114	0.75	
SE(m)		1.284		0.023		0.034	0.226	
SE(d)		1.815		0.033		0.049	0.32	
C.V.		50.105		1.31		2.854	0.237	

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. It is observed from the table 151 that the treatments with dimethoate and BIPM were superior over the untreated control in reducing sucking pests, *viz.*, aphids, jassids, and white flies population. The highest yield (235.80 q/ha*)* was recorded in dimethoate compare to BIPM module (220.5 q/ha.).

Table 161 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)	BC ratio
T1	269.50	181.00	35.24	220.55	1.86
T2	275.80	160.00	41.98	238.88	2.02
T3	280.00	431.00	0.00	175.68	1.48
C.D.	3.032	1.809	0.889	1.39	
SE(m)	0.916	0.546	0.269	0.42	
SE(d)	1.295	0.772	0.38	0.593	
C.V.	0.743	0.474	2.369	0.445	

T1 = BIPM, T2= Chemical control, T3= untreated control

The average initial root-knot nematode population in the field ranged from 269.50 to 280 nematode/200 cm^3 of soil. It is observed from Table 161 that all the treatments were significantly superior over untreated control in reducing the root knot nematode population with increase in the yield at termination of the experiment. However, soil application with furadon was found most effective compare to other treatments with reduction in root-knot nematode population (41.98%) and increase the yield by 35.97%. However, soil application of *Paecilomyces lilacinus*, @ 20 g/m^2 with FYM 15 days prior to transplanting could reduce the root knot nematode population (35.24 %) and increasing the yield 25.54%.

17.2 Bio-efficacy of microbial agents against *Myllocerus subfasciatus* on brinjal

ICAR-IIHR, Bengaluru

Variety: Arka Anand
No. of treatments: 8
No. of replications: Three
Design: RBD

Three sprays of microbial agents and treated check were done. Observations were recorded on the leaf damage scoring (0-10 scale) 0- no damage, 1- 1% leaf damage ……10 =10% leaf damage. The leaf damage scoring was observed both on the older leaves and also the younger leaves. Mean leaf damage/plant was observed before spray and after every spray / treatment.Similarly, number of ash weevil adults were observed on 5 randomly selected plants in each replication. The results reveal that the mean number of ash weevils per plant were significantly lower in treatments *Heterorhabditis indica*@ 2.5 10^9 IJs $ha^{-1}$and*M. Anisopliae* NBAIR followed by *B. bassiana* NBAIR and *B. bassiana* AAU strains (Table 162). They were significantly different form the control check, but not superior over chemical control. Similarly, the leaf damage scoring by ash weevil in different treatments was recorded. The *B. bassiana* NBAIR and *M. anispoliae* AAU strains were showing significantly lower lead damage scoring compared to other treatments (Table 163).

Table 162 Bio-efficacy of microbial agents against *Myllocerus subfasciatus* on brinjal (IIHR)

Sl. No.	Treatments	Mean number of ash weevils per plant				
		Before spray	**After I spray**	**After II spray**	**After III spray**	**Pooled**
T1	*M.anisopliae* oil @ 1 ml/l	3.66 (1.96)	1.66 (1.38)	12.33 (3.51)	5.33 (2.40)	6.44 (2.43)
T2	*M.anispoliae* AAU @ 5 g/l	3.66 (1.96)	0.67 (0.99)	13.00 (3.64)	2.66 (1.71)	7.33 (2.53)
T3	*B.bassiana* AAU @ 5 g/l	3.33 (1.88)	1.00 (1.22)	9.66 (3.18)	2.66 (1.76)	5.44 (2.11)
T4	*M.anisopliae* NBAIR @ 5 g/l	6.66 (2.45)	2.00 (1.42)	10.33 (3.29)	3.66 (2.00)	4.44 (2.05)
T5	*B. bassiana* NBAIR @ 5 g/l	5.00 (2.28)	1.00 (1.09)	9.00 (3.07)	2.66 (1.73)	5.33 (2.23)
T6	*Heterorhabditis indica* @ 2.5 10^9 IJs ha^{-1}	6.00 (2.50)	2.00 (1.42)	15.66 (3.98)	4.33 (2.19)	4.22 (1.96)
T7	Imidacloprid @ 0.5 ml /l	7.33 (2.64)	0.00 (0.70)	6.66 (2.65)	2.00 (1.55)	2.88 (1.63)
T8	Control	4.66 (2.14)	9.00 (2.91)	8.33 (2.92)	5.66 (2.41)	7.66 (2.74)
	CD at 0.05 %	1.48	1.21	0.89	0.8	1.80

Figures in paranthesis are Sqrt (x+o.5) transformed values

Table 163 Bio-efficacy of microbial agents against *Myllocerous subfasciatus* on brinjal (IIHR)

Sl.No.	Treatments	Leaf damage scoring			
		Before spray	After I spray	After II spray	After III spray
T1	*M.anisopliae* oil @ 1ml/l	5.37	1.21	3.80	4.65
T2	*M.anispoliae*AAU @ 5g/l	5.71	0.97	3.17	3.83
T3	*B.bassiana* AAU @ 5g/l	5.90	1.15	3.33	4.23
T4	*M.anisopliae*NBAIR@ 5g/l	5.35	1.23	2.96	4.09
T5	*B. bassiana*NBAIR @ 5g/l	5.44	1.56	3.03	3.24
T6	*Heterorhabditisindica*@ 2.5 10^9 IJs ha^{-1}	5.41	1.17	3.45	4.09
T7	Imidacloprid @ 0.5 ml /l	5.97	1.45	3.03	3.04
T8	Control	5.52	1.29	4.21	5.59
	CD at 0.05%	NS	0.46	1.90	1.47

18. TOMATO

19.1 Bio-intensive pest management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato

18.1.1 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 2019. There were three treatments with six replications each.

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/litre water.
- *Lecanicillium lecanii* (NBAIR) 1x 10^8 conidia/ml @ 5g/litre for sucking pests

T2: Chemical control -Indoxacarb 14.5 SC @ 500ml/ha

T3: Untreated Control

The pooled per cent fruit damage in BIPM (13.24%) was significantly lower than untreated control (17.93%). However, chemical control recorded minimum per cent fruit damage (10.86%). The per cent reduction in fruit damage over control was 49.47 and 26.15 per cent in chemical control and BIPM plot, respectively. The fruit yield in BIPM (27.16 q/ha) was at par with chemical control (30.94 q/ha), However, both the treatments were significantly better than untreated control (21.27q/ha) (Table 164).

Table 164 BIPM module for management of tomato insect pests

Treatment	Per cent fruit damage	Yield (q/ha)
BIPM	13.24 [b] (21.28)	27.16 [a]
Chemical control (Indoxacarb 14.5 SC @ 500 ml/ha)	9.06 [a] (18.12)	30.94 [a]
Untreated control	17.93 [c] (24.98)	21.27 [b]
CD (p=0.05)	(0.84)	4.49
CV (%)	17.43	13.73

18.1.2 AAU-Anand

Year of commencement: 2017-18 *Rabi* season

Location: Farmer's field, Runaj, Sojitra taluka, Anand district

Methodology and treatments:

Crop/Variety : Tomato - Alankar (Hybrid -F1)
Spacing : 60x30 cm
Plot size : Gross: 7.8x 4.8 m
Net: 7.2 x 3.6 m
Layout : Randomized Block Design (RBD)

Treatments : **T1 = BIPM package**

1. Seed bio-priming with *Trichoderma harzianum*@ 10 g/ kg of seeds
2. Raising marigold as trap crop
3. Use of NBAIR pheromone traps @ 1 trap per plot
4. *Trichogramma achaeae / Trichogramma chilonis* @ 50,000/ ha per release (6 releases)
5. Azadirachtin 1500 ppm @ 4 ml/lit
6. *Bacillus thuringiensis* (PDBC BTG-1) 1%WP ($1x10^8$) @ 5g/ lit
7. *Lecanicillium lecanii* (Vl-8) 1%WP ($1x10^8$) @ 5g/ lit for sucking pests

T2 = Chemical control

1. Chlorantraniliprole 18.5 SC @ 0.006% for *Tuta absoluta*
2. Indoxacarb 14.5 SC @ 0.015% for other pests

T3 = Untreated Control

Replications : Seven

Methodology and observations : The treatment application was started at initial occurrence of pests. Six releases of parasitoids at weekly interval and three sprays of bio-pesticides 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 mines / sucking pests.
- 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 (kg/plot)

Table 165 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	1.23 (1.01)	20.26 (11.99)	16.05
Chemical Control	1.19 (0.92)	20.13 (11.84)	16.87
Untreated Control	1.74 (2.53)	29.18 (23.77)	10.64
S. Em. ± T P T x P	0.04 - -	0.69 - -	0.55 - -
C. D. at 5 % T P T x P	0.13 - -	2.09 - -	1.68 - -
C. V. %	13.82	8.39	13.16

Mean of five observations
* $\sqrt{x + 0.5}$ transformed values,
** Arc sin transformed values, Figures in parentheses are retransformed values

Results:

Demonstration experiment was conducted in *Rabi* 2019-20. During the experimental period, incidence of *H. armigera* 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 (16.87 t/ha) which was at par with the yield recorded in BIPM package (16.05 t/ha). However, lowest yield was recorded in untreated control (10.64 t/ha). It can be concluded that BIPM package is promising in minimizing the pest damage with higher yield.

18.1.3 MPKV, Pune

Bio-intensive pest management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato (MPKV, Pune)

Trial during 2019-20:

The experiment is laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune and planting of Tomato var. 'Namdhari 501' is done on 22.01.2020 with 4.5 x 4.5 m plot size and, 90 x 45 cm spacing in Randomized Block Design replicated thrice with eight treatments**(Trial is in progress)**

Trial during 2018-19:

The experiment was laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune.The planting of Tomato var. 'Namdhari 501' was done on 28/02/2019 with 4.5 x 4.5m plot size and90 x 45 cm spacing in Randomized Block Design replicated thrice with eight treatments.The treatment details are as follows:

T_1:BIPM
i) Seed treatment with *Trichoderma harzianum* @ 10g/kg of seed.
ii) Raising marigold as trap crop.
iii)Use of NBAIR pheromone traps @ 1 trap per plot.
iv) *Trichogramma achaeae/ Trichogramma pretiosum* @ 50000 per release (6 releases)
v) Azadirachtin 1500 ppm @ 2 ml/lit.
vi)*Lecanicillum lecanii* (NBAIR)1X10^8 spores/ g @ 5 g/lit for sucking pests.
T_2: Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests
T_3: Untreated control

The observations of larval population of *H. armigera* and per cent fruit infestation were recorded on ten randomly selected plants per plot. The observations of sucking pests, thrips and whitefly were recorded at 30, 45 and 60 days after transplanting (DAT). The yield of healthy marketable fruits per plotwas registered at each picking. The fruit damage caused by *H.armigera* was recorded at weekly interval.

For BIPM module, seed treatment with *Trichoderma harzianum,* installation of pheromonetrap, planting of marigold as trap crop, six releases of *Trichogramma achaeae*@ 50,000 per release, two sprays of Azadirachtin 1500 ppm @ 2 ml/lit, one sprays of *Lecanicillum lecanii* (@ 5 g/lit was given. Two sprays of indoxacarb 14.5 SC was given in farmers practice treatment.

Results: The data given in the below table indicated that BIPM treatment recorded minimum larval population of *H. armigera* (0.66 larvae/10 plants) which was at par withchemical treatment (0.74 larvae/10 plants). In BIPM treatment, fruit damage on number basis (14.89%) and on weight basis (13.33 %) was significantly lowto rest of the treatments. Regarding sucking pest population, the BIPM treatment recorded minimum number of thrips (3.86 thrips/plant) and whiteflies (1.15 flies/plant). The highest marketable fruit yield (21.63 t/ha) was recorded in BIPM treated plots, whereas untreated control plot recorded lowest yield (15.84 t/ha). The incidence of American pinworm, *Tuta absoluta* on tomato was not observed throughout the season. Therefore, the data of American pinworm, *Tuta absoluta* isnot included in the report.

Treatment	Larval population/10 plants		Fruit infestation (%)		Yield (t/ha)
	Pre-count*	Post count*	No. basis**	Wt. basis**	
T1: BIPM	3.60 [a] (2.03)	0.66 [a] (1.08)	14.89 [a] (15.55)	13.30 [a] (21.39)	21.63 [a]
T2: Indoxacarb 14.5 SC	3.33 [a] (1.96)	0.74 [a] (1.12)	21.97 [b] (20.25)	16.90 [b] (24.27)	21.17 [a]
T3: Untreated control	3.38 [a] (1.97)	5.14 [b] (2.37)	31.76 [c] (31.90)	29.87[c] (33.13)	15.84 [b]
S.E. ±	**0.16**	**0.11**	**0.56**	**0.86**	**1.44**
CD at 5%	**NS**	**0.33**	**1.71**	**2.63**	**4.42**
CV	**12.60**	**8.66**	**11.17**	**4.93**	**10.92**

(*Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values)
(Figures in parenthesis are arc sin transformed values).**

Trial during 2019-20:

The experiment is laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune and planting of Tomato var. 'Namdhari 501' is done on 22.01.2020 with 4.5 x 4.5 m plot size and, 90 x 45 cm spacing in Randomized Block Design replicated thrice with eight treatments.

(**Trial is conducted and intial treatments are given. Hence, this trial is in progress.)**

The BIPM of data of *Helicoverpa armigera* and sucking pests of tomato for the years 2018-19 (Table 43 and 44), 2017-18 (Table 157 and 158) and pooled data for the year 2017-18 and2018-19are given in Table 47 and the data on cost of spraying and economics of treatments are given in Tables 166 and 167.

Table 166 Effect of BIPM and insecticides against sucking pests on tomato (Year, 2018-19)

Treatment	**Thrips/plant**				**whitefly/ plant**			
	30 DAT	**45 DAT**	**60 DAT**	**AV**	**30 DAT**	**45 DAT**	**60 DAT**	**AV**
T1**: BIPM**	4.60 [a] (2.26)	4.03 [a] (2.13)	2.96 [a] (1.86)	3.86 [a] (2.09)	-	1.49 [a] (1.41)	0.82 [a] (1.15)	1.15 [a] (1.29)
T2: Indoxacarb 14.5 SC	5.79 [a] (2.51)	5.04 [a] (2.35)	3.70 [a] (2.05)	4.84 [a] (2.31)	-	1.42 [a] (1.38)	0.75 [a] (1.12)	1.04 [a] (1.24)
T3: Untreated control	8.67 [a] (3.03)	9.53 [b] (3.17)	12.08 [b] (3.55)	10.09 [b] (3.25)	-	4.69 [b] (2.28)	3.21 [b] (1.93)	4.51 [b] (2.24)
S.E. ±	0.20	0.20	0.13	0.09	-	0.12	0.11	0.10
CD at 5%	0.62	0.60	0.39	0.29	-	0.36	0.34	0.30
CV	11.95	7.38	13.46	9.78	-	10.53	11.52	16.41

(Figure in parenthesis are ($\sqrt{x+0.5}$) transformed values)
DAT: Days After Transplanting

Table 167 Effect of BIPM against sucking pests on tomato (Year 2017-18)

Treatment	**Thrips/plant**				**whitefly/ plant**			
	30 DAT	45 DAT	60 DAT	AV	30 DAT	45 DAT	60 DAT	AV
T1**: BIPM**	4.20[a] **(2.15)**	2.70[a] **(1.78)**	2.00[a] **(1.57)**	2.97[a] **(1.86)**	3.40[a] (1.96)	3.10[a] **(1.89)**	2.30[a] **(1.67)**	2.93[a] **(1.85)**
T2: Indoxacarb 14.5 SC	5.40[a] **(2.42)**	8.00[b] **(2.90)**	9.30[b] **(3.12)**	7.57[b] **(2.83)**	4.20[b] (2.16)	4.80[b] **(2.28)**	6.20[b] **(2.57)**	5.07[b] **(2.35)**
T3: Untreated Control	7.60[b] **(2.84)**	10.10[c] **(3.23)**	13.50[c] **(3.73)**	10.40[c] **(3.29)**	5.60[c] (2.47)	6.30[c] **(2.60)**	8.20[c] **(2.94)**	6.70[c] **(2.68)**
S.E. ±	0.11	0.13	0.08	0.10	0.06	0.06	0.09	0.08
CD at 5%	**0.33**	**0.39**	**0.25**	**0.3**	**0.19**	**0.18**	**0.28**	**0.23**
CV	12.20	13.69	8.26	**10.54**	**8.18**	7.94	**10.92**	9.32

(*Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values)

(Figures in parenthesis are arc sin transformed values).**

Table 168 Effect of BIPM against *H.armigera* on tomato (Year 2017-18)

Treatment	**Larval population/10 plants**		**Fruit infestation (%)**		**Yield (q/ha)**
	Pre-count*	**Post count***	**No. basis****	**Wt. basis****	
T1**: BIPM**	10.60a (3.32)	2.20[a] (1.64)	16.60[a] (24.01)	14.80[a] (22.58)	21.82[a]
T2: Indoxacarb 14.5 SC	10.80[a] (3.36)	5.40[b] (2.41)	19.20[b] (25.96)	17.40[b] (24.64)	18.77[b]
T3: Untreated control	10.60[a] (3.32)	17.60[c] (4.23)	35.80[c] (36.75)	33.40[c] (35.29)	15.64[c]
S.E. ±	**0.08**	0.11	**0.38**	0.57	**0.75**
CD at 5%	**NS**	**0.35**	**1.17**	**1.74**	**2.29**
CV	**7.19**	**11.64**	**3.75**	**5.84**	**11.40**

Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values)

DAT: Days After Transplanting

Table 169 Effect of BIPM and insecticides against *Helicoverpa armigera* on tomato (Pooled mean data forYear 2017-18 and 2018-19)

Treatment	**Larval population/10 plants**		**Fruit infestation (%)**		**Yield (t/ha)**	**B: C ratio**
	Pre-count*	**Post count***	**No. basis****	**Wt. basis****		
T1**:** BIPM	7.10 [a] (2.68)	1.43[a] (1.36)	15.75[a] (23.37)	14.05[a] (22.01)	21.72[a]	1.60
T2: Indoxacarb 14.5 SC	7.06[a] (2.66)	3.07[a] (1.77)	20.58 [a] (26.97)	17.15 [a] (24.46)	20.24[a]	1.53
T3: Untreated Control	6.99[a] (2.65)	11.37[b] (3.31)	33.78[c] (35.53)	31.64[c] (34.22)	15.74[b]	1.98
S.E. $\pm$	0.18	0.21	1.27	1.32	1.51	
CD at 5%	NS	0.61	3.67	3.82	4.40	
CV	9.79	13.75	6.25	6.94	11.04	

(*Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values)
(Figures in parenthesis are arc sin transformed values).**

Table 170. Effect of BIPM and insecticides against sucking pests on tomato (Year 2017-18 and 2018-19)

Treatment	**Thrips/plant**				**whitefly/ plant**			
	30 DAT	**45 DAT**	**60 DAT**	**AV**	**30 DAT**	**45 DAT**	**60 DAT**	**AV**
T1**: BIPM**	4.40[a] (2.21)	3.37[a] (1.96)	2.48[a] (1.72)	3.42 [a] (1.98)	1.70[a] (1.34)	2.30[a] (1.65)	1.56[a] (1.41)	2.04[a] (1.57)
T2: Indoxacarb 14.5 SC	5.60[a] (2.47)	6.52[a] (2.63)	6.50[b] (2.59)	6.20 [b] (2.57)	2.10[a] (1.44.)	3.11[a] (1.84)	3.48[a] (1.85)	3.05[a] (1.80)
T3: Untreated Control	8.14[a] (2.94)	9.81[b] (3.21)	12.79[c] (3.64)	10.24 [c] (3.28)	2.80[a] (1.59)	5.50[b] (2.44)	5.71[b] (2.44)	5.61[b] (2.46)
S.E. $\pm$	0.29	0.30	0.19	0.18	0.09	0.17	0.17	0.16
CD at 5%	NS	0.87	0.56	0.53	NS	0.49	0.48	0.46
CV	16.10	16.29	10.27	9.83	8.53	11.96	12.32	11.65

(Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values)
DAT: Days After Transplanting

Results: It is seen from Table 160 that the BIPM treatment recorded minimum larval population of *H. armigera* (1.43 larvae/10 plants) which was at par withchemical treatment (3.07larvae/10 plants). In BIPM treatment, fruit damage on number basis (15.75%) and on weight basis (14.05 %) was at par withchemical treatment (20.58 %) and (17.15%), respectively. The highest marketable fruit yield (21.72 t/ha) was recorded in BIPM treated plots with B:C ratio (1.60) as against yield in chemical treatment (20.24 t/ha) with B:C ratio (1.53), whereas untreated control plot recorded lowest yield (15.74 t/ha) with B:C ratio (1.98). Regarding sucking pest population, the BIPM treatment recorded minimum number of thrips (3.42 thrips/plant) and whiteflies (2.04 flies/plant) and was at par with chemical treatment (2.10) and (3.05) (Table 48). The data on cost of spraying and economics of treatments are given in Tables 171 and 172.

The incidence of American pinworm, *Tuta absoluta* on tomato was not observed throughout the season. Therefore, the data of American pinworm, *Tuta absoluta* is not included in the report.

Table 171 Cost of Spraying

Tr. No.	Treatment	Total cost of Input
T_1	BIPM Seed treatment with Phule tichoderma, Installation of Pheromone trap, Marigold seedling as trap crop, 2 Sprays of Azadirachtin 1500 ppm, 1 Spray *L. lecanii*	12000/
T_2	Indoxacarb 14.5 SC (1ml/l) 2 sprays	4860
T_3	Untreated control	-

Table 172 Economics of biopesticide treatments

Tr. No.	Treatment	Cost of Cultivat-ion/ha	Cost of Spraying Rs	Total cost Rs.	Yield (t/ha)	Rate/ Mt (Rs)	Gross returns (Rs. /ha)	Net return (Rs. /ha)	B: C ratio
T_1	**BIPM**	259259	12000/-	271259/-	21.72	20000/-	434400/-	163461	1.60
T_2	Indoxacarb 14.5 SC	259259	4860/-	264119/-	20.24	20000/-	404800/-	140681	1.53
T_3	Untreated control	159259	-	159259/-	15.74	20000/-	314800/-	155541	1.98

18.1.4 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 *Helicoverpa armigera, Tuta 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 where no treatment was given were also maintained for comparison. The treatment applications were started from the June end with the initiation of the attack of *Tuta absoluta*. *Trichogramma achaeae* was released six times at weekly intervals and azadirachtin was applied twice at 15 days interval, while, only one spray of *Lecanicillium 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 *Tuta absoluta* and *Helicoverpa 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, which were extrapolated to get yield per hectare. The data were subjected to analysis of variance using RBD and the results of the experiment are presented in tables 3and 4 and described as under.

Incidence of *T. absoluta* on leaves:

The number of mines by *Tuta absoluta* as recorded on 12th of July were statistically on par in all the plots and varied from 0.80 to 0.87 mines/leaf. The incidence of *T. absoluta* decreased both in BIPM and chemical plots, while, in untreated plot it increased and on 27th July it was 0.67 mines/leaf in BIPM plot, 0.40 mines/leaf in chemical plot and 0.83 mines/leaf in untreated plot (Table 173). On 12th of August the pest incidence was 0.70, 0.63 and 2.13 mines per leaf in BIPM, chemical and untreated plots, respectively. On 28th of August the incidence was 0.67, 0.80 and 2.23 mines, respectively. Both the BIPM module and the chemical insecticides were statistically equally effective in managing the pest.

Table 173 *Tuta infestation* on tomato leaves

Treatment	Mines/leaf on indicated dates			
	July 12	July 27	August 12	August 28
BIPM	0.83 ± 0.31	0.67 ± 0.15	0.70 ± 0.33	0.67 ± 0.24
Chemical control	0.87 ± 0.24	0.40 ± 0.13	0.63 ± 0.24	0.80 ± 0.33
Untreated control	0.80 ± 0.38	0.83 ± 0.26	2.13 ± 0.68	2.23 ± 0.41
CD (0.05)	NS	0.18	0.57	0.48
CV (%)	16.4	18.7	22.1	32.3

Incidence of *T. absoluta* on fruits:

The average fruit infestation recorded on 12th of July was statistically same in all the plots and varied from 0.47 per cent in chemical control to 0.51 per cent in BIPM plots. With time the incidence increased in all the plots and was 0.93, 0.81 and 1.29 per cent in BIPM, chemical and untreated plots, respectively on 27th of July (Table 174). Thereafter, the percentage of infested fruits decreased in the BIPM plot, whereas, it went on to increase gradually in chemical and untreated control plots and was 0.81, 1.21 and 3.78 per cent on 12th September in BIPM, chemical and untreated plots, respectively. Both the BIPM and chemical insecticides were statistically equally effective in reducing the fruit infestation by *T. absoluta* in tomato. The yield was maximum (26.1t/ha) in BIPM plots, but, statistically on par (24.9t/ha) with that recorded in chemical treated plots. In untreated plots the yield was, however, significantly lower (18.2t/ha) than recorded in the BIPM or the chemically treated plots.

Table 174 *Tuta absoluta* infestation on fruits

Treatment	**Infested fruits (%) on indicated date**					**Yield (t/ha)**
	July 12	**July 27**	**August 12**	**August 28**	**Sept 12**	
BIPM	0.51 ± 0.18 (4.09 ± 0.47)	0.93 ± 0.30 (5.53 ± 0.72)	0.86 ± 0.13 (5.32 ± 0.71)	0.94 ± 0.21 (5.56 ± 0.63)	0.81 ± 0.09 (5.16 ± 0.43)	26.1 ± 5.2
Chemical control	0.47 ± 0.11 (3.93 ± 0.62)	0.81 ± 0.18 (5.16 ± 0.87)	0.93 ± 0.17 (5.53 ± 0.68)	1.17 ± 0.32 (6.21 ± 0.79)	1.21 ± 0.51 (6.32 ± 0.89)	24.9 ± 4.7
Untreated control	0.50 ± 0.17 (4.05 ± 0.66)	1.29 ± 0.37 (6.52 ± 0.82)	2.79 ± 0.88 (9.62 ± 1.13)	3.27 ± 0.91 (10.42 ± 1.01)	3.78 ± 0.97 (11.2 ± 1.03)	18.2 ± 6.1
CD (0.05)	NS	(0.48)	(0.86)	(1.05)	(1.31)	4.7
CV (%)	7.1	14.8	21.2	28.4	29.9	34.8

Incidence of *H. armigera* and aphids:

The incidence of *Helicoverpa armigera* was very low throughout the cropping season varied from 0.33 to 0.67 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 12th September was lowest (6.8) on chemically treated plants, followed by on par population (8.3) in BIPM plots. In untreated control plots the aphid population was 22.3.

18.2 Large Scale Field Trials for the Management of *Helicoverpa armigera* (Hubner) on Tomato (MPUAT– 2 ha)

MPUAT, Udaipur

Variety: Location specific popular variety
Plot Size: 2.0 ha
Location: Farmer's field atPilader and Veerpura (Jaisamand)
Year: 2019-20
Treatments: 3
Treatment details:

T1 = BIPM

- Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds.
- Azadirachtin 1500 ppm @ 2 ml/lit.
- *Beauveria bassiana* @ 1x10^8 conidia /gm, @ 5g/lt – 2 sprays at 15 days interval
- Spray of HaNPV (1.5x10^{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 45 SC @ 0.25 ml/***l***

T3 = Untreated Control

Observations:

1. The treatment applications were started at initial occurrence of *H. armigera* infestation and biopesticides wereapplied during evening hours at fortnightly interval.
2. Randomly select 10 plants/ 40m^2 crop area were observed for presence of holes/ damage caused by the larva.
3. Observations were recorded at fortnightly interval from fruit formation to last harvest.
4. Fruit damage percentage and yield were recorded.

Table 175: Effect of different modules on incidence of *H. armigera* and yield of tomato during *Rabi*, 2019-20

Treatments	Modules/Treatments	*H. armigera* larvae /plant*	Fruit damage* (%)	Fruit yield (t/ha)
T1	BIPM Package	2.65	24.88	14.35
T2	Chemical Control	2.43	22.45	15.10
T3	Untreated Control	3.35	35.68	9.05

Results:

Demonstration experiment was conducted in *Rabi*, 2019-20. 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 (15.10 t/ha) which was at par with the yield recorded in BIPM package (14.35 t/ha). Significantly, low yield was recorded in untreated control (9.05 t/ha). It could be concluded that BIPM package had promising results in minimizing the pest damage with higher yield.

19. OKRA

19.1 Efficacy of biocontrol agents for the management of fruit borer *Earias vittella* on okra

AAU, Anand

Objective: To evaluate the efficacy of different biocontrol agents on fruit borer *Earias vittella* infesting okra.
Year of commencement: 2017-18 – *Kharif*
Location: Agronomy farm, AAU, Anand

Variety	:	GAO 5
Spacing	:	60 x 30 cm
Plot size	:	Gross - 7.8 x 4.8 m
	:	Net - 6.6 x 4.2 m
Treatments	:	Eight
Replications	:	Three
Layout	:	Randomized Block Design (RBD)

Treatments		Concentration	Quantity (ml or g)/ 10 L
T_1	*Lecanicillium lecanii* 1% WP	$2x10^8$ cfu/g	50 g
T_2	*Metarhizium anisopliae* 1% WP	$2x10^8$ cfu/g	50 g
T_3	*Beauveria bassiana* 1% WP	$2x10^8$ cfu/g	50 g
T_4	*Trichogramma chilonis*	50,000 parasitoids*	6 releases*
T_5	*Bacillus thuringiensis* 1% WP	$2x10^8$ cfu/g	50 g
T_6	NSKE	5%	500 g
T_7	Emamectin benzoate 5 SG(12.5 ga.i./ha)	0.0025%	5 g
T_8	Untreated control	-	-

* Egg parasitoid *T. chilonis* 50,000/ ha – Total 6 releases at weekly interval

Methodology &Observations:

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.The observations were recorded on five randomly selected plants/ plot.

1. **Pre and post- treatment counts of fruit infestation.**

The observation on larval population of *E. vittella* was recorded from five randomly selected plants per treatment before spray and at 5^{th}, 10^{th} and 15^{th} 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.

2. **Yield of healthy marketable fruits (kg/plot).**

Results:

First year (2018-2019):

Larval population: Among different biocontrol agents evaluated for their bio efficacy against *E. vittella* on okra, the data on larval population after first spray depicted that T_5 - *Bacillus thuringiensis* @ 5 g/ litre recorded the lowest larval population (0.60 larva / plant) which was significantly different from other biocontrol treatments tested. Next best treatment was T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (0.85 larva/ plant) followed by the treatment T_6- NSKE 5% (0.87 larva/ plant).

The data on larval population after second spray indicated that the lowest larval population was recorded in treatment T_5-*Bacillus thuringiensis* @ 5 g/ litre (0.54 larva/ plant) followed by T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (0.67 larva/ plant) and T_6-NSKE 5% (0.73 larva/ plant). The treatment T_5 - *Bacillus thuringiensis* @ 5 g/ litre, T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha and T_6- NSKE 5% were found to be at par with each other.

After third spray, significantly the lowest larval population was reported in T_5 - *Bacillus thuringiensis* @ 5 g/litre (0.31 larva/ plant) which was superior to all the biocontrol treatments tested on *E. vittella.* Next best effective treatment was T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (0.40 larva/ plant) followed by T_6- NSKE 5% (0.48 larva/ plant) and they were also at par with T_5 - *Bacillus thuringiensis* @ 5 g/ litre.

The data on larval population pooled over periods over sprays depicted that among different biocontrol treatments evaluated, T_5 - *Bacillus thuringiensis* @ 5 g/ litre (0.48 larva/ plant) was first effective treatment with the lowest larval population followed by T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (0.64 larva/ plant) and they were statistically at par with each other. The third effective treatment was T_6- NSKE 5% (0.69 larva/ plant).

Fruit damage and yield: With regard to the efficacy of biocontrol treatments in reducing the fruit damage, the lowest fruit damage (%) was recorded in the treatment T_5 - *Bacillus thuringiensis* @ 5 g/litre (7.29% - number basis, 8.53% - weight basis).The next best treatment was T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ha (8.27% - number basis, 10.27% - weight basis) which was at par with T_6- NSKE 5% (8.81% - number basis, 10.12% - weight basis) in reducing the fruit damage as compared to untreated control treatment T_8-

(29.54% - number basis, 31.90% - weight basis). Similar trend was observed in fruit yield. Among biocontrol treatments evaluated, T_5 - *Bacillus thuringiensis* @ 5 g/litre recorded the highest fruit yield (109.10 q/ha) which was at par with the treatments T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (104.55 q/ha) and T_6- NSKE 5% (104.14 q/ha).

Second year (2019-2020):

Larval population: Among different biocontrol treatments evaluated for their bio efficacy against *E. vittella* on okra in 2019, the data on larval population after first spray depicted that T_5 - *Bacillus thuringiensis* @ 5 g/ litre (0.71 larva/plant) recorded the lowest larval population. Next best treatment was T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ha (0.87 larva/ plant) followed by treatment T_6- NSKE 5% (0.96 larva/ plant). The treatment T_5 - *Bacillus thuringiensis* @ 5 g/ litre was found to be at par with T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ha and T_6- NSKE 5%.

The data on larval population after second spray depicted that the lowest larval population was recorded in treatment T_5 - *Bacillus thuringiensis* @ 5 g/litre (0.62 larva/ plant) followed by T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (0.78 larva/ plant) and T_6 - NSKE 5% (0.92 larva/ plant). The treatmentT_5 - *Bacillus thuringiensis* @ 5 g/litre was found to be statistically at par with T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha and they were significantly different from T_6- NSKE 5%.

The data on larval population after third spray indicated that the lowest larval population was recorded in treatment T_5 - *Bacillus thuringiensis* @ 5 g/litre (0.33 larva/ plant) followed by T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ha (0.50 larva/plant) and T_6- NSKE 5% (0.56 larva/ plant). All the three effective biocontrol treatments against *E. vittella* were at par in reducing the pest population.

Second year's data on larval population pooled over periods over sprays followed the similar trend like first year. Among different biocontrol treatments tested, T_5 - *Bacillus thuringiensis* @ 5 g/liter (0.54 larva/plant) was first effective treatment with the lowest larval population followed by T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ha (0.71 larva/plant) and they were statistically at par with each other. The third effective treatment was T_6- NSKE 5% (0.80 larva/ plant) and it was at par with T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ha but significantly different from T_5 - *Bacillus thuringiensis* @ 5 g/ liter in reducing the larval population.

Fruit damage and yield: With regard to the efficacy of biocontrol treatments in reducing the fruit damage, the lowest fruit damage (%) was recorded in the treatment T_5 - *Bacillus thuringiensis* @ 5 g/litre (6.72% - number basis, 7.65% - weight basis).The next best treatment was T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (8.11% - number basis, 9.69% - weight basis) which was at par with T_6- NSKE 5% (8.19% - number basis, 9.94%- weight basis) in reducing the fruit damage. Similar trend was observed in fruit yield. T_5 - *Bacillus thuringiensis* @ 5 g/litre recorded the highest fruit yield (112.95 q/ha) which was at par with the treatments T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (105.66 q/ha) and T_6- NSKE 5% (105.14 q/ha).

Pooled over periods and years:

Larval population: Among different biocontrol agents evaluated for their bio efficacy against *E. vittella* on okra in 2018-2019 and 2019-2020, the data on larval population pooled over periods over years depicted that T_5 - *Bacillus thuringiensis* @ 5 g/litre recorded the lowest larval population (0.52 larva/plant) and it was significantly different from other treatments tested. Next best treatment wasT_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (0.67 larva/ plant) followed by treatment T_6- NSKE 5% (0.75 larva/ plant) and T_3- *Beauveria* *bassiana* @ 5 g/ litre (0.75 larva/plant). The second-best biocontrol treatment T_4- *Trichogramma chilonis* @ 50,000 parasitoids/ ha was at par with T_6- NSKE 5% and T_3- *Beauveria bassiana* @ 5 g/litre. Next effective treatment was T_2- *Metarhizium anisopliae* @ 5 g/litre (1.09 larva/plant) followed by the least effective treatment T_1- *Lecanicillium lecanii* @ 5 g/ litre (1.60 larva/ plant).

Fruit damage and yield: The pooled over periods over years data with regard to the efficacy of biocontrol treatments in reducing the fruit damage on number basis and weight basis, the lowest fruit damage (%) was recorded in the treatment T_5 - *Bacillus thuringiensis* @ 5 g/ litre (7.00% - number basis, 8.09% - weight basis).The next best treatment was T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ ha (8.19% - number basis, 9.97% - weight basis) which was at par with T_6- NSKE 5% (8.50% - number basis, 10.04% - weight basis) in reducing the fruit damage as compared to the untreated control T_8- (29.33% - number basis, 32.34% - weight basis). Similar trend was observed in pooled data of fruit yield. Among biocontrol treatments evaluated, T_5 - *Bacillus thuringiensis* @ 5 g/litre recorded the highest fruit yield (111.02 q/ha) which was at par with the treatments T_4-*Trichogramma chilonis* @ 50,000 parasitoids/ha (105.10 q/ha) and T_6- NSKE 5% (104.64 q/ha).

Conclusion:

Application of *Bacillus thuringiensis* (1% WP - $2x10^8$ cfu/g)@ 50g/10 liter waterat fortnightly interval for three times or six releases of *Trichogramma chilonis*@ 50000/ha at weekly interval found effective for the management of fruit borer (*Earias vittella*) on okra.

Table 176 Bio-efficacy of different biocontrol agents against *Earias vittella* on okra (2018-19)

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	*Lecanicillium lecanii* @ 5 g/ litre	1.56a (1.93)*	1.34a (1.30)	1.38c (1.40)	1.44c (1.57)	1.39d (1.43)	1.54d (1.87)	1.40c (1.46)	1.44d (1.57)	1.46d (1.63)	1.54d (1.87)	1.40d (1.46)	1.40d (1.46)	1.44d (1.57)	1.43e (1.54)
T2	*Metarhizium anisopliae* @ 5 g/ litre	1.54a (1.87)	1.35a (1.32)	1.22bc (0.99)	1.13b (0.78)	1.23cd (1.01)	1.38cd (1.40)	1.25bc (1.06)	1.22cd (0.99)	1.28c (1.14)	1.25c (1.06)	1.16c (0.85)	1.14c (0.80)	1.18c (0.89)	1.23d (1.01)
T3	*Beauveria bassiana* @ 5 g/ litre	1.55a (1.90)	1.30a (1.19)	1.17b (0.87)	1.03b (0.56)	1.17bc (0.87)	1.25bc (1.06)	1.11b (0.73)	1.03bc (0.56)	1.13b (0.78)	1.11bc (0.73)	1.01bc (0.52)	0.95bc (0.40)	1.02b (0.54)	1.11c (0.73)
T4	*Trichogramma chilonis* @ 50,000 parasitoids/ha	1.54a (1.87)	1.32a (1.24)	1.16b (0.85)	1.01b (0.52)	1.16bc (0.85)	1.18bc (0.89)	1.08b (0.67)	0.98b (0.46)	1.08b (0.67)	1.00abc (0.50)	0.95bc (0.40)	0.91b (0.33)	0.95b (0.40)	1.07bc (0.64)
T5	*Bacillus thuringiensis* @ 5 g/ litre	1.49a (1.72)	1.20a (0.94)	1.08ab (0.67)	0.87ab (0.26)	1.05ab (0.60)	1.14b (0.80)	1.05b (0.60)	0.87ab (0.26)	1.02b (0.54)	0.98ab (0.46)	0.87ab (0.26)	0.83ab (0.19)	0.90b (0.31)	0.99b (0.48)
T6	NSKE 5%	1.54a (1.87)	1.34a (1.30)	1.17b (0.87)	1.01b (0.52)	1.17bc (0.87)	1.25bc (1.06)	1.11b (0.73)	0.96b (0.42)	1.11b (0.73)	1.02abc (0.54)	1.01bc (0.52)	0.95bc (0.40)	0.99b (0.48)	1.09c (0.69)
T7	Emamectin benzoate 5 SG @ 0.0025%	1.59b (2.03)	1.19a (0.92)	0.98a (0.46)	0.71a (0.00)	0.96a (0.42)	0.90a (0.31)	0.79a (0.12)	0.71a (0.00)	0.80a (0.14)	0.79a (0.12)	0.71a (0.00)	0.71a (0.00)	0.73a (0.03)	0.83a (0.19)
T8	Untreated control	1.56a (1.93)	1.56b (1.93)	1.64d (2.19)	1.78d (2.67)	1.66e (2.26)	1.80e (2.74)	1.85d (2.92)	1.85e (2.92)	1.83e (2.85)	1.82e (2.81)	1.85e (2.92)	1.85e (2.92)	1.84e (2.89)	1.78f (2.67)
S. Em. ±	**Treatment(T)**	0.09	0.09	0.05	0.08	0.05	0.07	0.06	0.07	0.04	0.08	0.07	0.06	0.04	0.03

Period (P)	-	-	-	-	0.03	-	-	-	0.02	-	-	-	0.03	0.02
Spray (S)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
T x P	-	-	-	-	0.08	-	-	-	0.07	-	-	-	0.07	0.04
T x S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
T x S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07
C. D. at 5% T	NS	NS	0.16	0.23	0.13	0.22	0.18	0.22	0.11	0.24	0.21	0.19	0.12	0.07
P	-	-	-	-	0.08	-	-	-	0.07	-	-	-	0.07	0.04
S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
T x P	-	-	-	-	0.22	-	-	-	NS	-	-	-	NS	0.07
T x S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12
S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	NS
T x S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	NS
C. V. (%)	9.91	11.80	7.44	11.69	11.14	9.70	8.69	10.81	9.82	11.53	10.88	10.04	10.84	10.75

Note:* Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values
Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test at 5 % level of significance
NS = Non –significant BS= Before Spray DAS = Days After Spray

Table 177 Influence of different biocontrol agents on fruit damage and yield of okra (2018-19)

Treatments		Fruit damage (%)		Yield (q/ha)
		Number basis	Weight basis	
T1	*Lecanicillium lecanii* @ 5 g/ litre	24.06d (16.62)	24.76d (17.54)	80.50d
T2	*Metarhizium anisopliae* @ 5 g/ litre	21.79cd (13.78)	21.82cd (13.82)	90.93cd
T3	*Beauveria bassiana* @ 5 g/ litre	18.64bc (10.22)	20.44bc (12.20)	101.33bc
T4	*Trichogramma chilonis* @ 50,000 parasitoids/ha	16.71bc (8.27)	18.69bc (10.27)	104.55bc
T5	*Bacillus thuringiensis* @ 5 g/ litre	15.66ab (7.29)	16.98b (8.53)	109.10b
T6	NSKE 5%	17.27bc (8.81)	18.55bc (10.12)	104.14bc
T7	Emamectin benzoate 5 SG @ 0.0025%	11.30a (3.84)	12.02a (4.34)	122.45a
T8	Untreated control	32.92e (29.54)	34.39e (31.90)	59.44e
S. Em ±		1.51	1.13	4.13
C. D. at 5%		4.57	3.44	12.54
CV%		13.17	9.37	7.42

Note: Figures outside the parentheses are arcsine transformed values, those inside are retransformed values. Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test at 5 % level of significance

Table 178 Bio-efficacy of different biocontrol agents against *Earias vittella* on okra (2019-20)

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	*Lecanicillium lecanii* @ 5 g/ litre	1.53a (1.84)*	1.40ab (1.46)	1.48c (1.69)	1.46d (1.63)	1.45c (1.60)	1.54c (1.87)	1.47c (1.66)	1.49d (1.72)	1.50e (1.75)	1.59d (2.03)	1.46d (1.63)	1.44c (1.57)	1.50e (1.75)	1.48e (1.69)
T2	*Metarhizium anisopliae* @ 5 g/ litre	1.56a (1.93)	1.56b (1.93)	1.26bc (1.09)	1.26cd (1.09)	1.36c (1.35)	1.36bc (1.35)	1.27bc (1.11)	1.23c (1.01)	1.29d (1.16)	1.26c (1.09)	1.25cd (1.06)	1.11b (0.73)	1.21d (0.96)	1.29d (1.16)
T3	*Beauveria bassiana* @ 5 g/ litre	1.53a (1.84)	1.34ab (1.30)	1.13d (0.78)	1.07bc (0.64)	1.18b (0.89)	1.22b (0.99)	1.14b (0.80)	1.08bc (0.67)	1.15bc (0.82)	1.17bc (0.87)	1.03bc (0.56)	0.99b (0.48)	1.06c (0.62)	1.13c (0.78)
T4	*Trichogramma chilonis* @ 50,000 parasitoids/ha	1.49a (1.72)	1.36ab (1.35)	1.14d (0.80)	1.01b (0.52)	1.17b (0.87)	1.19b (0.92)	1.14b (0.80)	1.07bc (0.64)	1.13bc (0.78)	1.01abc (0.52)	1.00bc (0.50)	0.98b (0.46)	1.00bc (0.50)	1.10bc (0.71)
T5	*Bacillus thuringiensis* @ 5 g/ litre	1.56a (1.93)	1.29ab (1.16)	1.11ba (0.73)	0.91ab (0.33)	1.10b (0.71)	1.14b (0.80)	1.05b (0.60)	0.98ab (0.46)	1.06b (0.62)	0.95ab (0.40)	0.89ab (0.29)	0.91ab (0.33)	0.91b (0.33)	1.02b (0.54)
T6	NSKE 5%	1.64b (2.19)	1.40ab (1.46)	1.20b (0.94)	1.05bc (0.60)	1.21b (0.96)	1.25b (1.06)	1.27bc (1.11)	1.05bc (0.60)	1.19cd (0.92)	1.04abc (0.58)	1.02bc (0.54)	1.02b (0.54)	1.03bc (0.56)	1.14c (0.80)
T7	Emamectin benzoate 5 SG @ 0.0025%	1.53a (1.84)	1.21a (0.96)	0.90a (0.31)	0.71a (0.00)	0.94a (0.38)	0.86a (0.24)	0.79a (0.12)	0.79a (0.12)	0.82a (0.17)	0.90a (0.31)	0.73a (0.03)	0.75a (0.06)	0.79a (0.12)	0.85a (0.22)
T8	Untreated control	1.60a (2.06)	1.60c (2.06)	1.72d (2.46)	1.80e (2.74)	1.71d (2.42)	1.76d (2.60)	1.71d (2.42)	1.85e (2.92)	1.77f (2.63)	1.87e (3.00)	1.86e (2.96)	1.87d (3.00)	1.87f (3.00)	1.78f (2.67)
S. Em. ± Treatment(T)		0.09	0.08	0.07	0.07	0.04	0.07	0.07	0.07	0.04	0.08	0.08	0.07	0.04	0.03
Period (P)		-	-	-	-	0.03	-	-	-	0.02	-	-	-	0.03	0.02
Spray (S)		-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
T x P		-	-	-	-	0.07	-	-	-	0.07	-	-	-	0.08	0.04

T x S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
T x S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08
C. D. at 5% T	NS	NS	0.22	0.22	0.12	0.21	0.20	0.23	0.11	0.25	0.23	0.21	0.13	0.07
P	-	-	-	-	0.08	-	-	-	0.07	-	-	-	NS	0.04
S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
T x P	-	-	-	-	0.21	-	-	-	NS	-	-	-	NS	0.07
T x S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12
S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07
T x S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	NS
C. V. (%)	9.76	10.49	9.99	11.07	10.16	9.22	9.31	10.80	9.67	11.86	11.48	10.48	11.32	10.58

Note: * Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values

Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test at 5 % level of significance NS = Non – significant BS= Before Spray DAS = Days After Spray

Table 179 Influence of different biocontrol agents on fruit damage and yield of okra (2019-20)

Treatments		Fruit damage (%)		Yield (q/ha)
		Number basis	Weight basis	
T1	*Lecanicillium lecanii* @ 5 g/litre	24.63d (17.37)	23.77d (16.25)	81.48d
T2	*Metarhizium anisopliae* @ 5 g/litre	21.38cd (13.29)	20.67cd (12.46)	92.45cd
T3	*Beauveria bassiana* @ 5 g/litre	18.65bc (10.23)	19.28bc (10.90)	101.12bc
T4	*Trichogramma chilonis* @ 50,000 parasitoids/ha	16.55b (8.11)	18.14bc (9.69)	105.66bc
T5	*Bacillus thuringiensis* @ 5 g/ litre	15.02ab (6.72)	16.06b (7.65)	112.95b
T6	NSKE 5%	16.63b (8.19)	18.38bc (9.94)	105.14bc
T7	Emamectin benzoate 5 SG @ 0.0025%	11.31a (3.85)	12.23a (4.46)	126.20a
T8	Untreated control	32.65e (29.11)	34.93e (32.78)	58.81e
S. Em. ±		1.26	1.16	4.09
C. D. at 5%		3.81	3.53	12.41
C. V. (%)		11.10	9.87	7.23

Note: Figures outside the parentheses are arcsine transformed values, those inside are retransformed values. Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test at 5 % level of significance

Table 180 Bio-efficacy of different biocontrol agents against fruit borer *Earias vittella* on okra (Pooled over years)

Treatments		No. of larvae / plant									Pooled
		1st spray			2nd spray			3rd spray			
		2018*	2019*	Pooled**	2018*	2019*	Pooled**	2018*	2019*	Pooled**	
T1	*Lecanicillium lecanii* @ 5 g/ litre	1.39d (1.43)	1.45c (1.60)	1.42g (1.52)	1.46d (1.63)	1.50e (1.75)	1.48e (1.69)	1.44d (1.57)	1.50e (1.75)	1.47e (1.66)	1.45e (1.60)
T2	*Metarhizium anisopliae* @ 5 g/ litre	1.23cd (1.01)	1.36c (1.35)	1.30f (1.19)	1.28c (1.14)	1.29d (1.16)	1.29d (1.16)	1.18c (0.89)	1.21d (0.96)	1.19d (0.92)	1.26d (1.09)
T3	*Beauveria bassiana* @ 5 g/ litre	1.16bc (0.85)	1.18b (0.89)	1.17cde (0.87)	1.13b (0.78)	1.15bc (0.82)	1.14c (0.80)	1.02b (0.54)	1.06c (0.62)	1.04c (0.58)	1.12c (0.75)
T4	*Trichogramma chilonis* @ 50,000 parasitoids/ha	1.16bc (0.85)	1.17b (0.87)	1.17cde (0.87)	1.08b (0.67)	1.13bc (0.78)	1.11bc (0.73)	0.95b (0.40)	1.00bc (0.50)	0.97bc (0.44)	1.08c (0.67)
T5	*Bacillus thuringiensis* @ 5 g/ litre	1.05ab (0.60)	1.10b (0.71)	1.08b (0.67)	1.02b (0.54)	1.06b (0.62)	1.04b (0.58)	0.90b (0.31)	0.91b (0.33)	0.90b (0.31)	1.01b (0.52)
T6	NSKE 5%	1.17bc (0.87)	1.21b (0.96)	1.19e (0.92)	1.11b (0.73)	1.19cd (0.92)	1.15c (0.82)	0.99b (0.48)	1.03bc (0.56)	1.01c (0.52)	1.12c (0.75)
T7	Emamectin benzoate 5 SG @ 0.0025%	0.96a (0.42)	0.94a (0.38)	0.95a (0.40)	0.80a (0.14)	0.82a (0.17)	0.81a (0.16)	0.73a (0.03)	0.79a (0.12)	0.76a (0.08)	0.84a (0.21)
T8	Untreated control	1.66e (2.26)	1.71d (2.42)	1.68h (2.32)	1.83e (2.85)	1.77f (2.63)	1.80f (2.74)	1.84e (2.89)	1.87f (3.00)	1.85f (2.92)	1.78f (2.67)
S. Em. ±Treatment(T)		0.05	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.03	0.02
Period (P)		0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.01
Spray (S)		-	-	-	-	-	-	-	-	-	0.01
Year(Y)		-	-	0.02	-	-	0.01	-	-	0.02	0.01
T x P		0.08	0.07	0.05	0.07	0.07	0.05	0.07	0.08	0.05	0.03
T x S		-	-	-	-	-	-	-	-	-	0.03
T x Y		-	-	0.04	-	-	0.04	-	-	0.04	0.03
P x Y		-	-	0.03	-	-	0.02	-	-	0.03	0.02
S x P		-	-	-	-	-	-	-	-	-	0.02
Y x S		-	-	-	-	-	-	-	-	-	0.02
T x S x P		-	-	-	-	-	-	-	-	-	0.05

Y x P x S	-	-	-	-	-	-	-	-	-	0.03
Y x T x P	-	-	0.08	-	-	0.07	-	-	0.07	0.04
Y x T x S	-	-	-	-	-	-	-	-	-	0.04
Y x T x P x S	-	-	-	-	-	-	-	-	-	0.07
C. D. at 5% T	0.13	0.12	0.09	0.11	0.11	0.08	0.12	0.13	0.09	0.05
S	-	-	-	-	-	-	-	-	-	0.03
P	0.08	0.08	0.05	0.07	0.07	0.05	0.07	NS	0.05	0.03
Y	-	-	NS	-	-	NS	-	-	NS	0.03
T x P	0.22	0.21	0.15	NS	NS	NS	NS	NS	NS	0.09
T x S	-	-	-	-	-	-	-	-	-	0.09
T x Y	-	-	NS	-	-	NS	-	-	NS	NS
P x Y	-	-	NS	-	-	NS	-	-	NS	NS
S x P	-	-	-	-	-	-	-	-	-	0.05
Y x S	-	-	-	-	-	-	-	-	-	NS
T x S x P	-	-	-	-	-	-	-	-	-	NS
Y x P x S	-	-	-	-	-	-	-	-	-	NS
Y x T x P	-	-	NS	-	-	NS	-	-	NS	NS
Y x T x S	-	-	-	-	-	-	-	-	-	NS
Y x T x P x S	-	-	-	-	-	-	-	-	-	NS
C. V. (%)	11.14	10.16	10.65	9.82	9.67	9.74	10.84	11.32	11.09	10.66

Note: * Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values

Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test at 5 % level of significance

NS = Non –significant *Pooled over periods, ** Pooled over periods and years

Table 181 Influence of different biocontrol agents on fruit damage of okra (pooled over years)

Treatments		Fruit damage (%)					
		Number basis		Pooled	Weight basis		Pooled
		2018	2019		2018	2019	
T1	*Lecanicillium lecanii* @ 5 g/ litre	24.06d (16.62)	24.63d (17.37)	24.35d (17.00)	24.76d (17.54)	23.77d (16.25)	24.26e (16.88)
T2	*Metarhizium anisopliae* @ 5 g/ litre	21.79cd (13.78)	21.38cd (13.29)	21.58d (13.53)	21.82cd (13.82)	20.67cd (12.46)	21.25d (13.14)
T3	*Beauveria bassiana* @ 5 g/ litre	18.64bc (10.22)	18.65bc (10.23)	18.64c (10.22)	20.44bc (12.20)	19.28bc (10.90)	19.86cd (11.54)
T4	*Trichogramma chilonis* @ 50,000 parasitoids/ha	16.71bc (8.27)	16.55b (8.11)	16.63bc (8.19)	18.69bc (10.27)	18.14bc (9.69)	18.41bc (9.97)
T5	*Bacillus thuringiensis* @ 5 g/ litre	15.66ba (7.29)	15.02ba (6.72)	15.34b (7.00)	16.98b (8.53)	16.06b (7.65)	16.52b (8.09)
T6	NSKE 5%	17.27bc (8.81)	16.63b (8.19)	16.95bc (8.50)	18.55bc (10.12)	18.38bc (9.94)	18.47bc (10.04)
T7	Emamectin benzoate 5 SG @ 0.0025%	11.30a (3.84)	11.31a (3.85)	11.30a (3.84)	12.02a (4.34)	12.23a (4.46)	12.12a (4.41)
T8	Untreated control	32.92e (29.54)	32.65e (29.11)	32.79e (29.33)	34.39e (31.90)	34.93e (32.78)	34.66f (32.34)
S. Em. ± T		1.51	1.26	0.88	1.13	1.16	0.74
Y		-	-	0.49	-	-	0.41
Y x T		-	-	1.39	-	-	1.15
C. D. at 5%- T		4.57	3.81	2.53	3.44	3.53	2.13
Y		-	-	-	-	-	-
Y x T		-	-	NS	-	-	NS
C. V. (%)		13.17	11.10	12.19	9.37	9.87	9.62

Note: Figures outside the parentheses are arcsine transformed values, those inside are retransformed values
Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test at 5 % level of significance

Table 182. Influence of different biocontrol agents on yield of okra

Treatments		Yield (q/ha)		
		2018	2019	Pooled
T1	*Lecanicillium lecanii* @ 5 g/ litre	80.50d	81.48d	80.99e
T2	*Metarhizium anisopliae* @ 5 g/ litre	90.93cd	92.45cd	91.69d
T3	*Beauveria bassiana* @ 5 g/ litre	101.33bc	101.12bc	101.23c
T4	*Trichogramma chilonis* @ 50,000 parasitoids/ha	104.55bc	105.66bc	105.10bc
T5	*Bacillus thuringiensis* @ 5 g/ litre	109.10b	112.95b	111.02b
T6	NSKE 5%	104.14bc	105.14bc	104.64bc
T7	Emamectin benzoate 5 SG @ 0.0025%	122.45a	126.20a	124.32a
T8	Untreated control	59.44e	58.81e	59.12f
S. Em. ±T		4.13	4.09	2.63
Y		-	-	1.45
Y x T		-	-	4.11
C. D. at 5% T		12.54	12.41	7.54
Y		-	-	-
Y x T		-	-	NS
C. V. (%)		7.42	7.23	7.32

Note:
Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test at 5 % level of significance

20. CABBAGE

20.1 Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Lipaphis erysimi* and diamond back moth, *Plutella xyllostella*

20.1.1 AAU-Jorhat

Experimental details:

Location	:	Horticultural Orchard, AAU, Jorhat
Target pests	:	Cabage aphid and DBM
Plot Size	:	6mX 5m
Design	:	4RBD
Variety	:	Asha F1
Treatments	:	6
Fertilizer dose	:	N: P: K=80:60:60
Date of Planting	:	15.01.2019

Treatment details:

T1= Bb-5a, isolate of *Beauveria bassiana* @ ($1x10^8$ spores/ml)
T2= Bb-45, isolate of *Beauveria bassiana* @ ($1x10^8$ spores/ml)
T3= Ma-4, isolate of *Metarhizium anisopliae*@ ($1x10^8$ spores/ml)
T4= Vi-8, isolate of *Lecanicillium lecanii*
T5= Alternate spray of Malathion 50EC @ 1.5 ml/litre / Imidacloprid 17.8 SL @ 0.3 ml/litre
T6= Untreated control

The field experiment was carried out to evaluate the efficacy of different entomopathogenic fungi against cabbage aphid and DBM during *rabi*, 2019-20. Four rounds sprays of entomopathogenic fungi (@ 5ml/litre) and alternate spray of chemical insecticides as standard insecticide check were made at 15 days interval starting from appearance of aphid and DBM in the experimental field. Observations were recorded as pre and post count before and after imposing of each treatment. For pre and post treatment count, five plants were randomly selected from each plot to assess the number of aphids, DBM and natural enemy complex. Yield of marketable heads were also recorded at the time of harvesting taken from each plots and records of all pickings were pooled together to get average yield.

Table 183 Bioefficacy of different EPF against DBM and aphid on cabbage

Treatments	Aphid/plant			DBM/plant			Yield (q/ha)
	Before spray	After spray	Reduction over control (%)	Before spray	After spray	Reduction over control (%)	
T_1	6.92	3.40[a]	58.07	8.67	5.29[ab]	39.26	185.3[abc]
T_2	7.09	3.38[a]	58.19	7.93	6.09[b]	30.08	174.33[c]
T_3	7.17	3.69[a]	54.50	8.53	5.51[ab]	36.73	179.43[abc]
T_4	6.75	3.15[a]	61.15	8.20	5.09[ab]	41.56	196.0[ab]
T_5	7.67	2.71[a]	66.58	8.00	4.64[a]	46.72	202.0[a]
T_6	7.44	8.11[b]	-----	8.26	8.71[c]	------	145.47[d]
CD= 0.05	NS	1.12		NS	1.41		19.62
CV%		15.12			13.12		5.98

Results:

The result (Table 183) indicated that, four alternate spraying of chemical insecticide at 15 days interval could significantly reduce the mean population of *B.brassicae* (2.71/plant) and *P. xyllostella* (4.64/plant) in cabbage in comparison to different biopesticides and gave a maximum yield of 202.0 q/ha. Among the different EPF, V1-8 isolate of *L. lecanii* @ 5 ml/litre was the next best treatment in reducing the mean population of aphid (3.15/plant) and DBM(5.09/plant), with next higher yield of 196.0q/ha. The mean reduction of aphid and DBM infestation over control in *L. lecanii* treated plot was 61.15 and 41.56 percent, respectively. However, it was observed that all the EPF of ICAR- NBAIR strains (Bb-5a, Bb-45, Ma-4) in reducing the cabbage aphids and DBM was equally effective with each other and found to be statistically different only from untreated control. Maximum number of aphid (8.11/plant) and DBM (98.71/plant) was recorded in untreated control plot with minimum yield of 145.47q/ha. In case of natural enemy complex, higher number of coccinellids of 1.77/plant was recorded in entomopathogen treated plot compared to insecticidal treated plot with only 0.06/plant.

Fig 57: View of Experimental plot of Cabbage

20.1.2 ICAR-IIVR, Varanasi

Plot size 8x5m=40 m^2; Replication = 04; Design: RBD; Variety = Golden Acre

Treatments

1. Bb-5a isolate of *Beauveria bassiana* @ 5 g/lit
2. Bb-45 isolate of *Beauveria bassiana* @ 5 g/lit
3. Ma-4 isolate of *Metarhizium anisopliae* @ 5 g/lit
4. Vl-8 isolate of *Lecanicillium lecanii* @ 5 g/lit
5. Recommended Insecticide application (Indoxacarb 14.5 SC @ 0.75 ml/lit)
6. Control (Untreated)

Table 184 Bio-efficacy of different EPF against DBM and Aphids infesting cabbage

Treatments	DBM / plant			Aphid/plant			Spider / plant	Ladybird beetle / plant
	Before spray	After spray	PROC#	Before spray	After spray	PROC#		
T1	10.56	5.80[b]	42.17	24.09	19.27[bc]	17.40	0.18	0.39
T2	10.47	5.10[b]	49.15	24.36	17.63[b]	24.43	0.30	0.42
T3	10.08	4.30[a]	57.13	23.89	18.80[b]	19.41	0.22	0.54
T4	10.32	4.77[ab]	52.44	25.17	14.70[a]	36.99	0.18	0.48
T5	9.84	3.97[a]	60.42	24.36	13.73[a]	41.15	0.11	0.27
T6	11.06	10.03[c]	--	24.01	23.33[d]	--	0.38	0.54
SEm(±)	--	0.59	--	--	0.71	--	--	--
LSD (5%)	--	1.32	--	--	1.66	--	--	--

#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 of 2019-20 at the experimental farm of ICAR-IIVR, Varanasi. From the table it is evident that among the biopesticides tested, *Metarhizium anisopliae* (Ma-4 strain) was most promising with 57.13 per cent reduction over control (PROC) against diamond back moth (*Plutella xylostella*) followed by *Lecanicillium lecanii* (Vl-8 strain). In case of aphid (*Myzus persicae*), maximum reduction (36.99 PROC) was recorded with *Lecanicillium lecanii* (Vl-8 strain) which is statistically superior over the other biopesticides followed by *Beauveria bassiana* (Bb-45 strain) with 24.43 PROC. However, amongst the all treatments, Indoxacarb 14.5 SC at its recommended dose @ 0.75 ml/lit was the best both in reducing DBM and Aphids in cabbage. IN case of two polyphagous predators *viz*., spider and lady bird beetle (*Menochilus sexmaculatus*) populations were lowest in Indoxacarb treated plots (0.11 and 0.27 per plant, respectively), and were relatively higher in untreated control and entomopathogens treated plots.

20.2 Biological control of lepidopteran pest complex and aphid on cabbage

Crop/Variety	:	Rare ball F1
Area	:	30x20 m
Layout	:	Randomized Block Design
Treatments	:	T1: Raising of mustard as intercrop, Release of MITS of *Trichogrammachilonis*@ 100,000/release against *Plutella xylostella*, 6 releases to be made at 30 days after transplanting, release of *Chrysoperla zastrowi sillemi* @ 2000/ release, 2 releases to be made at 15 days interval against cabbage aphid, *L. lecani*-1x10^8 spore/ ml @ 5ml/lt and *Bt* (NBAIR) three sprays and *Bacillus thuringiensis* NBAII BtG4 2%. T2 : Farmers practices (to be specified by each centre)
Replications	:	Divide block into 5 equal sized units, each unit should serve as replication.
Observations	:	• Pre- release observation – No. of holes on the leaves,

		No. of larvae, such 5 spot to be selected for observation including 10 plants each spot, observation will be taken 4 times at 15 days interval • Collection of eggs, about 100 eggs to be collected to check parasitisation, observation will be recorded 4 times. • Aphid – observation to be recorded in 5 random spots including 10 plant each spot for aphid infestation and total number of infested plant to be counted. Five observation to be taken on the aphid colony infesting leaves by using the 1cm window, • Yield data

The experiment was carried out during *Rabi*, 2019-20 in college of horticulture and forestry. CAU, Pasighat. The research field was divided into 5 blocks. In the first location, IPM module was followed for management of insect pests.

Results: Incidence of *Plutella xylostella* in Biocontrol based IPM and Farmer's practice in Pasighat during *Rabi*, 2019-20 is presented in table 4.Incidence of *Plutella xylostella* recorded as 4.25, 7.8, 8.2 and 9.3 larvae/plant was recorded in untreated plot at 45, 60, 75 and 90 DAT respectively. Farmer's practice with three round sprays of profenophos 0.05% gave good protection with average infestation of 1.91,1.25,1.05,0.88 larvae/plant at 45, 60, 75 and 90 DAT respectively. Biocontrol based IPM recorded significantly lower incidence 1.6,0.9,0.4,0.22 larvae/ leaf at 45, 60, 75 and 90 DAT respectively. Highest yield 42370kg/ha was recorded in Biocontrol based IPM.

Table 185 Incidence of *Plutella xylostella* in Biocontrol based IPM and Farmer's practice in Pasighat during *Rabi*, 2019-20.

Treatments	Pre treatment	45 DAT-15 days after 1 release/spray	60 DAT-15 days after II release/spray		75 DAT-15 days after III release/spray		90 DAT-15 days after IV release/spray		Yield Kg/ha	BC ratio
	Number of larve/ plant	Number of larve/ plant	Number of larve/ plant	Parasitoid emergence/5 larvae	Number of larve/ plant	Parasitoid emergence/5 larvae	Number of larve/ plant	Parasitoid emergence/5 larvae		
Biocontrol -based IPM	0.95 (0.97)	1.60(1.26)	0.90(0.95)	3.5(1.87)	0.40(0.63)	7.8(2.79)	0.22(0.47)	11.50(3.39)	42370(205.84)	2.1
Farmer's Practice profenophos 0.05%	0.91(0.95)	1.91(1.38)	1.25(1.12)	00.00	1.05(1.02)	00.00	0.88(0.94)	00.00	40290(200.72)	2.0
Untreated control	0.97(0.98)	4.25(2.06)	7.80(2.79)	0.5(0.71)	8.20(2.86)	2.5(1.58)	9.3(3.05)	3.99(2.00)	37200(192.87)	1.84
$CD_{0.05}$		0.043	0.097	0.035	0.045	0.024	0.033	0.044	0.277	
SE(m)±		0.013	0.029	0.011	0.013	0.007	0.01	0.013	0.084	
SE (d)		0.018	0.041	0.015	0.019	0.01	0.014	0.019	0.118	
CV%		1.57	2.01	1.671	1.589	0.839	1.173	1.313	0.094	

Figures in the parenthesis are transformed value
DAT= days after transplanting
Figure in the parentheses are transformed values.

Result: of Incidence of cabbage aphid in Biocontrol based IPM in Pasighat during *Rabi*, 2019-20 is presented in table 186. From the table it is learned that biocontrol based IPM significantly reduce the aphid population 3.5, 2.14, 1.8 colony/ per plant after 1st, 2nd, 3rd spray respectively. Farmers are sprayed dimethoate 0.05%, and recorded the aphid of 4.5, 2.85, 2.5 colony per plant after 1st, 2nd, 3rd spray respectively. Highest yield was recorded in biocontrol based IPM compare to chemical control.

Table 186 Incidence of cabbage aphid in Biocontrol based IPM and Farmer's practice in Pasighat during *Rabi*, 2019-20.

Treatments	Aphid colony/plant 1st Spray		Aphid colony/plant IInd spray		Aphid colony/plant IIIrd spray		Yield (Kg/ha)
	Before spray	After spray	Before spray	After spray	Before spray	After spray	
Biocontrol -based IPM	5	3.5	3.0	2.14	2.01	1.8	43560
Farmer's Practice Dimethoate 0.05%	5.2	4.5	4.35	2.85	2.75	2.5	41110
Untreated control	5.5	6.5	7.1	7.6	7.9	8.0	38479
SE(m)±	-	0.026	-	0.018	-	0.034	9.142
$CD_{0.05}$	-	0.086	-	0.061	-	0.111	30.277
CV%	-	1.206	-	0.853	-	1.836	0.050

Fig 58. Light traps fitted in the field to monitor the insects, right side cabbage trail field

21. CHILLI

21.1 Screening of promising isolates of entomopathogenic fungi for management of mites in chilli

RARS, Kumarakom

Variety	:	Ujjwala (KAU variety)
Layout	:	Randomized Block Design.
Plot size		8×5 M
Treatments	:	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
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 mites ➢ Yield

Since there was no incidence of whitefly, experiment was conducted against chilli mite. The population of chilli yellow mite, *Polyphagotarsonemus latus*, was recorded from upper, middle and lower leaves of plants. Four foliar sprays were carried out and infestation was recorded at 1^{st}, 3^{rd}, 5^{th}, 7^{th} and 9^{th} day after each spray and expressed as mites per leaf and is presented in the Table 187-188. Treatment with Vl-8 isolate of *Lecanicillium lecanii* recorded a per cent reduction of 40.29 over control as against the chemical check which could bring about 95.68 % reduction at 9^{th} day after second spray. None of the bioagents could cause significant reduction in mite population after first and third sprays. However, Vl-8 isolate of *L. lecanii* showed significant reduction in mite infestation at 1^{st}, 3^{rd}, 5^{th} and 9^{th} days after fourth spray, where it was on par with the chemical check at 5^{th}day after spray. *L. lecanii* produced notable reduction of 79.91 per cent over controlat 3^{rd} day after fourth spray, which was followed byBb-5a isolate of *Beauveria bassiana* andMa – 6 isolate of *Metarhizium anisopliae.*Bb-5a isolate of *B. bassiana* could cause significant reduction in 9^{th} day after fourth spray also. There was no significant difference in the yield data recorded.

Table 187 Efficacy of isolates of entomopathogenic fungi for management of mites in chillies (RARS, Kumarakom, 2019-2020) contd………

Treatment	Mean number of mites*											
	First spray						Second spray					
	Precount	1st day	3rd day	5th day	7th day	9th day	Precount	1st day	3rd day	5th day	7th day	9th day
T1	1.78 (1.66)	1.41 (1.55)	0.73 (1.31)	1.33 (1.45)	0.43 (1.19)	0.50 (1.22)	0.75 (1.32)	0.41 (1.18)	2.68 (1.84)	1.12 (1.44)	1.72 (1.63)	0.99 (1.41)
T2	1.29 (1.50)	2.33 (1.81)	1.52 (1.56)	2.02 (1.70)	0.64 (1.25)	0.54 (1.22)	0.95 (1.36)	0.66 (1.24)	2.81 (1.88)	1.21 (1.45)	2.27 (1.78)	1.04 (1.42)
T3	1.56 (1.56)	1.66 (1.61)	0.75 (1.31)	3.62 (2.12)	1.06 (1.38)	0.58 (1.24)	0.96 (1.38)	0.94 (1.36)	3.04 (1.95)	1.71 (1.62)	1.41 (1.54)	1.31 (1.51)
T4	1.16 (1.43)	0.87 (1.32)	0.62 (1.25)	1.31 (1.50)	0.52 (1.22)	0.50 (1.22)	0.81 (1.33)	0.39 (1.17)	1.46 (1.53)	0.77 (1.30)	0.77 (1.31)	0.83 (1.35)
T5	1.08 (1.42)	0.81 (1.30)	0.58 (1.22)	0.04 (1.02)	0.21 (1.09)	0.00 (1.00)	0.58 (1.25)	0.00 (1.00)	0.08 (1.04)	0.02 (1.01)	0.29 (1.13)	0.06 (1.03)
T6	1.70 (1.63)	2.52 (1.87)	1.62 (1.61)	3.35 (2.04)	1.12 (1.45)	0.81 (1.34)	0.99 (1.40)	0.98 (1.38)	3.09 (1.95)	1.41 (1.55)	0.96 (1.39)	1.39 (1.54)
CD (0.05)	NS	NS	NS	0.60	NS	NS	NS	NS	0.61	0.37	0.32	0.17
CV	19.31	20.86	20.70	24.32	19.80	14.80	15.81	18.67	23.51	17.48	14.29	7.93

Values in parantheses are square root transformed

Table 188. Efficacy of isolates of entomopathogenic fungi for the management of mites in chillies 2019-20 Contd.,

	Mean number of mites*												Yield (kg/plot)
	Third spray						Fourth spray						
	Precount	1st day	3rd day	5th day	7th day	9th day	Precount	1st day	3rd day	5th day	7th day	9th day	
T1	1.14 (1.45)	0.96 (1.38)	0.67 (1.28)	1.13 (1.44)	0.89 (1.34)	0.64 (1.27)	1.04 (1.42)	0.625 (1.26)	1.33 (1.47)	1.35 (1.52)	1.06 (1.43)	1.12 (1.44)	43.53
T2	1.25 (1.48)	1.25 (1.48)	0.81 (1.32)	1.39 (1.52)	1.33 (1.46)	0.83 (1.31)	1.42 (1.55)	1.18 (1.45)	2.08 (1.73)	1.85 (1.65)	0.91 (1.38)	1.96 (1.68)	48.12
T3	1.10 (1.44)	0.83 (1.34)	0.75 (1.30)	1.21 (1.46)	1.23 (1.47)	0.77 (1.31)	1.08 (1.44)	0.54 (1.24)	0.98 (1.39)	1.77 (1.65)	0.99 (1.40)	1.92 (1.69)	52.87
T4	1.27 (1.50)	0.77 (1.33)	0.58 (1.25)	0.91 (1.36)	0.75 (1.30)	0.52 (1.22)	0.91 (1.38)	0.42 (1.18)	0.46 (1.21)	0.89 (1.37)	0.81 (1.34)	0.5 (1.22)	48.95
T5	1.16 (1.47)	0.00 (1.00)	0.00 (1.00)	0.04 (1.02)	0.04 (1.02)	0.21 (1.09)	0.77 (1.32)	0.12 (1.06)	0.12 (1.06)	0.10 (1.05)	0.14 (1.07)	0.04 (1.02)	70.56
T6	1.27 (1.51)	1.41 (1.55)	0.92 (1.38)	1.50 (1.57)	1.62 (1.59)	1.12 (1.44)	1.49 (1.56)	1.35 (1.53)	2.29 (1.80)	2.12 (1.75)	1.25 (1.5)	2.21 (1.8)	63.52
CD (0.05)	NS	0.25	NS	0.29	NS	NS	NS	0.29	0.32	0.32	0.18	0.26	NS
CV	11.33	11.99	13.45	13.62	19.43	12.49	12.16	14.95	14.82	14.06	8.97	11.58	25.02

22. CUCUMBER

22.1 Bio-efficacy of some bio-pesticides against white fly, *Bemisia tabaci* in cucumber.

UBKV, Pundibari

Location: Instructional Farm, UBKV, Pundibari
Agro-climatic zone: Terai zone
Plot size: 6x5 m
Variety: Malini
Layout: RBD
Replication: 4
Date of transplanting: 01.09.2019
Fertilizer dose: as per State recommendation
Treatment details:

T1-*Lecanicillium lecanii* (NBAIR strain) @ 6gm/lit. (10^8 spores/ml)
T2- *Beauveria bassiana* (NBAIR strain) @ 6gm/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: 05.10.2019
Second: 16.10.2019

Results:

It is evident from the table-3 that all the treatments performed statistically better than the control treatment for management of white fly in cucumber. Among the tested fungal biopesticides, *Lecanicillium lecani*(NBAIR strain) significantly reduced the white fly population as compared to the other culture. The treatment *Lecanicillium lecani*(NBAIR strain) was almost at par with the effect of Azadirachtin 10000 ppm. However, the chemical treatment with Buprofezin 25SC ranked best in controlling the white fly followed by Azadirachtin 10000 ppm and *Lecanicillium lecani*(NBAIR strain) in both the spray. Significantly highest yield of cucumber was obtained in the treatment Buprofezin 25SC (194.75 qt/ha) followed by Azadirachtin 10000 ppm (106.75 qt/ha)and *Lecanicillium lecanii*(103 qt/ha).

Table 189. Bio-efficacy of some bio-pesticides against white fly, *Bemisia tabaci* in cucumber.

Treatment	**Population of white fly/ leaf**						**Yield (qt./ ha)**	**Percent increase over Control (%)**
	First spray			**Second spray**				
	Pre-treatment	**3DAS**	**7DAS**	**Pre-treatment**	**3DAS**	**7DAS**		
T1-*Lecanicillium lecanii* (NBAIR strain) @ 6 gm/lit.	11.00 (3.31)*	7.50 (2.73)	3.00 (1.72)	7.25 (2.69)	4.00 (1.94)	1.50 (1.21)	103.00 (4.63)**	95.26
T2-*Beauveria bassiana* (NBAIR strain) @ 6 gm/lit.	11.75 (3.42)	8.50 (2.89)	6.50 (2.54)	8.50 (2.91)	7.50 (2.73)	3.50 (1.85)	90.25 (4.50)	71.09
T3- Azadirachtin 10000 ppm @ 1ml/lit.	10.00 (3.13)	6.50 (2.54)	2.75 (1.64)	7.00 (2.62)	3.50 (1.85)	1.25 (1.10)	106.75 (4.67)	102.36
T4- Buprofezin 25 SC @ 1.5 ml/lit.	12.00 (3.44)	4.50 (2.04)	0.63 (0.78)	4.50 (2.10)	1.13 (1.03)	0.50 (0.71)	194.75 (5.27)	269.19
T5- Control	11.25 (3.35)	12.50 (3.52)	13.25 (3.69)	14.00 (3.74)	13.50 (3.67)	14.00 (3.74)	52.75 (3.96)	
SEm (±)	0.20	0.21	0.10	0.14	0.12	0.09	0.03	
CD (at 5%)	0.64	0.65	0.33	0.45	0.37	0.30	0.08	
(%)	12.56	15.26	10.27	10.32	10.80	11.26	1.16	

DAS- Days after spray * Figures in the parenthesis are square root transformed values.
18** Figures in the parenthesis are log transformed values.

23. POLYHOUSE PESTS

23.1 Management of sucking pests on cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition

23.1.1 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.

Design: CRD Variety: KPCH 1
Plot size: 2x2 m^2 Replications: 5
Treatments:
T1: *Blaptostethus pallescens*@ 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

Salad cucumber variety KPCH 1 was raised in a polyhouse of size 450 m^2. Ten day old seedlings with three leaves were transplanted into soilless medium, comprising of coir pith and vermicompost, at a spacing of 2.2m x 0.4 m. Cucumber plants were trailed vertically on floriculture nets. Fertilizers were applied at the rate of 150: 45: 220 kg N P K, 100 kg Ca and 40 kg Mg per ha in seven split doses at three days interval from seedling to flowering stage of crop. No lateral branches were allowed up to a height of 1m. Crop was irrigated daily using a drip irrigation system. A fertilizer regime of 200: 50: 300 kg NPK, 40 kg Ca and 50 kg Mg per ha in twelve split doses at three days interval was followed during reproductive stage of the crop. Harvesting of fruits was done twice a week.

Mixed stages of *T. truncatus* were released by stapling mulberry leaf discs containing mites onto the under surface of lower leaves of cucumber plants, twenty days after transplantation and were allowed to establish. Plots receiving different treatments were separated from each other by using garden nets to prevent movement of predator from one treatment to another.

Treatments were applied after establishment of spider mites on cucumber plants. Mite population was recorded before as well as 3, 6 and 9 days after each round of treatment application from three plants were randomly selected from each replication. Mite counts were taken from three infested leaves at the top, middle and bottom of each tagged plant. Number of mites per cm^2 leaf area was recorded *in situ* from three loci/leaf. The results are presented in Table 190.

Plate 12. View of experiment on management of spider mites in cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse conditions

Table 190. Field efficacy of *Blaptostethus pallescens*against *Tetranychus truncatus* on cucumber

Treatment	Number of mites per cm²								Yield per plant (kg)	Number of plants survived** (50DAT)
	First release				Second release					
	Precount	3DAR*	6DAR	9DAR	Precount	3DAR	6DAR	9DAR		
B. pallescens @ 10/m row	3.57	3.51[b]	3.28[b]	3.19	3.02	2.6[a]	1.97[a]	1.53[a]	2.46[b]	35
B. pallescens @ 20/m row	3.72	2.89[bc]	2.62[bc]	2.41	2.35	1.86[ab]	1.59[a]	0.70[b]	2.96[a]	73
Spiromesifen @ 100g.ai ha^{-1}	3.89	1.55[c]	1.26[c]	1.11	1.07	0.15[b]	0.06[b]	0.08[b]	3.25[a]	103
Untreated control	4.98	5.88[a]	6.84[a]	-	-	-	-	-	1.52[c]	0
CD (0.01)	NS	1.954	1.945	NS	NS	1.887	1.339	0.678	0.548	

*DAR – Days after release

Three days after the first release, lowest number of 1.55 mites/ cm^2 was recorded in plots treated with spiromesifen at the rate of 100g.ai ha^{-1}, which was on par with mite counts of 2.89/ cm^2in plots that received bugs at the rate of 20/m row. This was followed by plots where *B. pallescens* were released at the rate10 bugs /m row, with a mite population of 3.51/ cm^2. All the above treatments were significantly superior to untreated control (5.88mites/cm^2).

A similar trend was observed six days after treatment as well, with the lowest incidence of 1.26mites/ cm^2 in plots treated with spiromesifen. Plots in which *B. pallescens* were released @ 20/m row had 2.62 mites/ $cm^2$and was on par with acaricide treated plots. Both the above treatments were significantly superior to *B. pallescens* released @ 10/ m row, which recorded 3.29 mites/ cm^2.All the three treatments were significantly superior to untreated check, with the highest incidence of 6.84 mites/ cm^2.

Nine days after the first release, plots treated with the acaricide recorded 1.11mites/ cm^2. Mite population, at 3.19 mites/ $cm^2$was the highest in plots where bugs were released @ 10/ m row, while plots in which the bugs were released @ 20/ m row had 2.41 mites/ cm^2.There was no significant difference among the treatments.All the plants in control plot had dried up completely due to severe mite infestation.

A similar trend was observed after second round of treatment application as well. Three days after release, lowest mite population was recorded in plots treated with acaricide (0.15 mites/cm^2). This was followed by 1.86 and 2.6 mites/cm^2 in treatments involving release of *B. pallescens*@ 20 and 10/ m row respectively, with the former being on par with the value registered in spiromesifen treated plots.

All the treatments except control registered consistent reduction in the mite population throughout the study period. Among these, spiromesifen at the rate of 100 g a.i ha^{-1} was the most effective treatment, with reduction in mean mite population from 3.89/ cm^2 to 0.08/cm^2. Plots where the predator was released also had significantly fewer mites compared to untreated control. The mite population in plots where *B. pallescens* were released at 20/m row was comparable to that of acaricide treated plots, indicating the potential of the predator to be a safer alternative to synthetic acaricides in managing spider mites in cucumber under polyhouse conditions. There was, however, considerable difference among the treatments with respect to the number of plants surviving at fifty days after transplanting. While 93.6 per cent of plants survived infestation in plots treated with spiromesifen, the corresponding figures were 66.4 per cent and 31.8 per cent for release rates of 20 and 10 bugs/m row respectively. None of the plants survived mite infestation beyond 20 days after release of mites in control plots.

***Blaptostethus pallescens* @ 10/ m row**

***Blaptostethus pallescens* @ 20/ m row**

Spiromesifen @ 100 g a. I ha $^{-1}$

Untreated control

View of the experimental plot three days after first round application of treatments

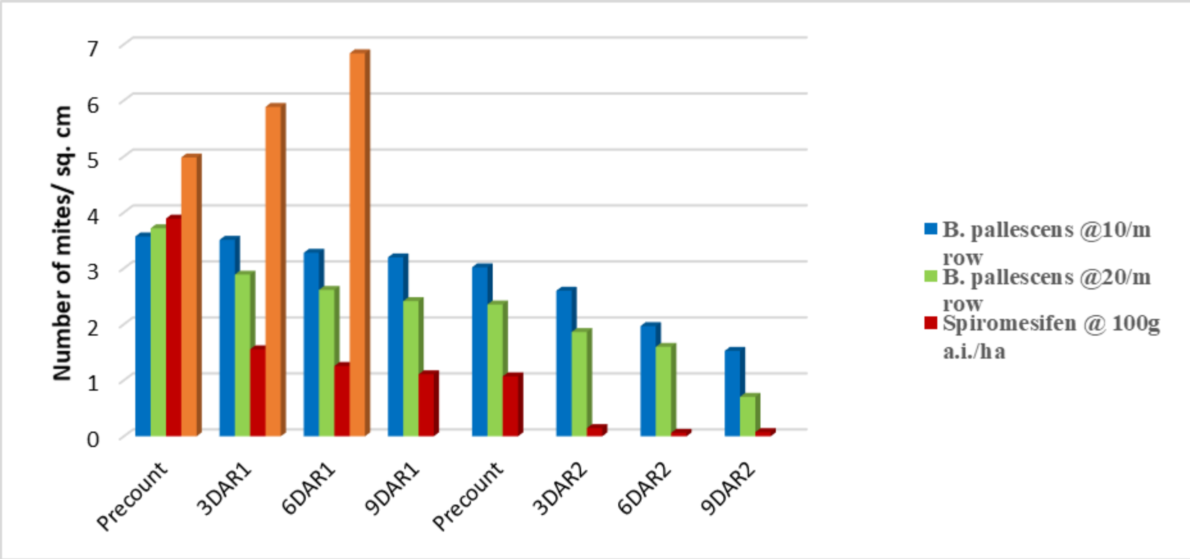


Fig.59. Field efficacy of *Blaptostethus pallescens* against *Tetranychus truncatus* on cucumber

23.2. Management of red spider mite, *Tetranychus urticae* infesting rose in polyhouse conditions

23.2.1 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 x 2 m, 90 x 60 cm in RBD with 6 treatments and 4 replications. Entomopathogenic fungi formulations and predatory mite were obtained from the National Bureau of Agriculturally Important Resources (NBAIR), Bangalore. 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 *Neocelus* sp @ 20 per plant
T5: Abamectin 1.9 EC @ 1 ml/lit. of water
T6: Untreated control

Year 2018-19

Observations: The mite population was recorded on 3 leaves per plant and post count was recorded 7 days after each spray. The first release of predatory mite (total six releases) and spray of entomopathogenic fungi formulation was done on 04.04.2019, 19.4.2019 and 4.5.2019.

Results: It is seen from Table 191 that three sprays of Abamectin 1.9 % EC at 15 days interval found effective in reducing the mite population on rose (16.94 mites/ 3 leaves /plant) and it was significantly superior over rest of the treatments. The treatment with six releases of predatory mites @ 20 per plant showed average of 22.49 mites/3 leaves /plant and it was the next best treatment. However, *Lecanicillium lecanii* and *Beauveria bassiana* were at par with each other in suppressing mite population on rose.

Table 191. Bioefficacy of bioagents against red spider mite *Tetranychus urticae* infesting rose in polyhouse conditions (Year 2018-19)

Tr. No.	Treatment	Mites population/3 leaves/plant				Average
		Pre count	I Spray	II Spray	III Spray	
T1	*Lecanicillium lecanii (NBAIR)* 10^8 cfu/ml @ 5 g/lit	70.23 [a] (8.41)	47.65 [c] (6.94)	37.98 [b] (6.20)	18.35 [b] (4.34)	33.00 [c] (5.79)
T2	*Beauveria bassiana (NBAIR)* 10^8 cfu/ml @ 5 g/lit.	67.03 [a] (8.22)	54.75 [a] (7.43)	42.23 [b] (6.54)	18.13 [b] (4.32)	33.50 [c] (5.83)
T3	*Metarhizium anisopliae (NBAIR)* 10^8 cfu/ml @ 5 g/lit.	65.10 [a] (8.10)	48.88 [d] (7.03)	41.78 [b] (6.50)	24.03 [b] (4.95)	39.39 [d] (6.32)
T4	Predatory mites @ 20 per plant *Neocelus* sp @ 20 per plant	66.00 [a] (8.15)	35.85 [b] (6.03)	28.43 [b] (5.38)	9.13 [a] (3.10)	22.49 [b] (4.79)
T5	Abamectin 1.9 EC @ 1 ml/lit. of water	67.93 [a] (8.27)	25.95 [a] (5.14)	10.30 [a] (3.29)	7.93 [a] (2.90)	16.94 [a] (4.18)
T6	Untreated control	67.00 [a] (8.22)	87.03 [e] (9.36)	92.78 [c] (9.66)	109.85 [c] (10.50)	98.44 [e] (9.95)
SE±		0.07	0.20	0.30	0.25	0.13
CD at 5%		N.S.	0.59	0.90	0.76	0.41
CV		1.82	5.59	9.57	10.13	4.38

Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values

Year 2019 -20

Observations : The mite population was recorded on 3 leaves per plant and post count was recorded 7 days after each spray. The first release of predatory mite (total six releases) and spray of entomopathogenic fungi formulation was done on 07.01.2020, 22.01.2020 and on 06.02.2020.

Results : It is seen from Table 192 that three sprays of Abamectin 1.9 % EC at 15 days interval found effective in reducing the mite population on rose (17.74 mites/ 3 leaves /plant) and it was significantly superior over rest of the treatments. Rest of the bioagent treatments were at par with each other. *Metarhizium anisopliae* @ 5 g/lit was next best treatment and recorded average 23.88 mites/ 3 leaves /plant, followed by six releases of predatory mites @ 20 per plant showing average of 24.20 mites/ 3 leaves /plant.

Table 192 Bioefficacy of bioagents against red spider mite *Tetranychus urticae* infesting rose in polyhouse conditions (Year 2019-20).

Tr. No.	Treatment	Mites population/3 leaves/plant				Average
		Pre count	I Spray	II Spray	III Spray	
T1	*Lecanicillium lecanii (NBAIR)* 10^8 cfu/ml @ 5 g/lit	35.78 [a] (6.01)	32.23 [b] (5.71)	25.20 [b] (5.05)	18.11 [b] (4.30)	25.18 [b] (5.05)
T2:	*Beauveria bassiana (NBAIR)* 10^8 cfu/ml @ 5 g/lit.	35.98 [a] (6.04)	31.71 [b] (5.67)	28.19 [b] (5.35)	19.15 [b] (4.42)	26.35 [b] (5.17)
T3:	*Metarhizium anisopliae (NBAIR)* 10^8	30.70 [a]	29.23 [b]	23.74 [a]	18.68 [b]	23.88 [b]

	cfu/ml @ 5 g/lit.	(5.58)	(5.44)	(4.92)	(4.35)	(4.93)
T4:	Predatory mites @ 20 per plant *Neocelus* sp @ 20 per plant	34.53 a (5.91)	29.66 b (5.48)	26.74 b (5.20)	16.19 b (4.06)	24.20 b (4.96)
T5:	Abamectin 1.9 EC @ 1 ml/lit. of water	33.83 a (5.84)	23.76 a (4.92)	19.58 a (4.42)	9.88 a (3.21)	17.74 a (4.26)
T6:	Untreated control	36.45 a (6.07)	48.01 c (6.96)	62.35 c (7.92)	72.95 c (8.54)	61.10 c (7.84)
SE±		0.16	0.17	0.20	0.23	0.16
CD at 5%		N.S.	0.50	0.61	0.69	0.48
CV		5.26	5.84	7.38	9.58	5.95

(Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values)

Results: It is seen from pooled data presented in Table 193 that three sprays of Abamectin 1.9 % EC at 15 days interval found effective in suppressing the mite population on rose (16.23 mites/ 3 leaves /plant) and it was significantly superior over rest of the treatments. Rest of the bioagent treatments were at par with each other. Six releases of predatory mites @ 20 per plant showed average of 24.33 mites/ 3 leaves /plant followed by *Lecanicillium lecanii*@ 5 g/lit (29.92 mites/ 3 leaves /plant), *Beauveria bassiana* @ 5 g/lit (31.38 mites/ 3 leaves /plant) and *Metarhizium anisopliae*@ 5 g/lit (32.03 mites/ 3 leaves /plant).

Table 193. Bio-efficacy of bioagents against red spider mite *Tetranychus urticae* infesting rose in polyhouse conditions (Pooled mean data for 2018-19 and 2019-20)

Tr. No.	Treatment	Pre count	Mites population/3 leaves/plant			Average
			I Spray	II Spray	III Spray	
T1	*Lecanicillium lecanii (NBAIR)* 10^8 cfu/ml @ 5 g/lit	53.00a (7.25)	39.94 b (6.37)	31.59 b (5.68)	18.23 b (4.39)	29.92 b (5.47)
T2:	*Beauveria bassiana (NBAIR)* 10^8 cfu/ml @ 5 g/lit.	48.86 a (6.94)	40.29 b (6.39)	35.21 b (5.99)	18.64 b (4.43)	31.38 b (5.59)
T3:	*Metarhizium anisopliae (NBAIR)* 10^8 cfu/ml @ 5 g/lit.	50.54 a (7.11)	41.99 b (6.48)	32.76 b (5.76)	21.35 b (4.72)	32.03 b (5.64)
T4:	Predatory mites @ 20 per plant *Neocelus* sp @ 20 per plant	50.26 a (7.07)	32.76 a (5.80)	27.58 b (5.35)	12.66 a (3.66)	24.33 b (4.92)
T5:	Abamectin 1.9 EC @ 1 ml/lit. of water	50.88 a (7.10)	24.86 a (5.08)	14.94 (3.95) b	8.90 a (3.14)	16.23 a (4.04)
T6:	Untreated control	51.73 a (7.18)	67.52 c (8.19)	77.56 c (8.82)	91.40 c (9.56)	78.83 c (8.85)
SE±		0.17	0.25	0.36	0.26	0.27
CD at 5%		NS	0.74	1.03	0.75	0.76
CV		3.45	5.64	8.36	5.40	6.98

23.3 Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse (YSPUHF, PAU, IIHR)

23.3.1 YSPUHF, Solan

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 were evaluated for the control of sucking pests in capsicum (cv. Callifornia Wonder) under polyhouse conditions. During the experimental period only green peach aphid, *Myzus persicae* was recorded as pest on the capsicum, hence the evaluation of bioagents was done only against *M. persicae.* Results reveal that imidacloprid (0.5ml/L) was the best treatment resulting in 90.3 to 97 per cent reduction in the aphid population at different time intervals after the first and the second spray. Among biocontrol agents, *Chrysoperla zastrowi sillemi* (4 larvae/ plant) resulted in the maximum reduction (58%) in aphid population over control 10 days after the first spray/ release, which was, however, on par with that resulted by azadirachtin (55%) and *Lecanicillium lecanii* (54.6%). Other bioagents resulted in 36.3 to 44.3 per cent pest reduction over control. Ten days after the second spray/ release, among biocontrol agents, *Chrysoperla zastrowi sillemi* (4 larvae / plant) resulted in the highest (80.6%) reduction in the aphid population which was on par with that resulted by imidacloprid (0.5ml/L) (90.3%). Bioagents like *Lecanicillium lecanii* (5g/l of 10^8 conidia/ g) (73%) and azadirachtin (2ml/L of 1500ppm) (68%) were also on par with *Chrysoperla zastrowi sillemi* (4 larvae / plant), but could not match imidacloprid (0.5ml/L) in their efficacy against the pest. Other biocontrol agents resulted in 54.3 to 58 per cent reduction in the aphid population over control 10 days after the second spray/ release.

24.3.2 PAU, Ludhiana

The capsicum seedlings (variety Indra) were transplanted under protected conditions according to agronomic practice norms on November 20, 2019. The crop was transplanted with plant to plant spacing of 30 cm and row to row spacing of 90 cm. The crop is being monitored for the incidence of sucking pests (aphids, whitefly, mites and thrips). As the incidence of pests is noticed, the treatments will be started as per the technical program. Therefore, experiment is **in progress** and the report will be submitted after the completion of the experiment.

24.3.2 IIHR, Bengaluru

Variety: Arka Mohini

No. of treatments: 9; No. of replications: Three

Design: RBD

The results reveal that there was significant reduction in the aphid population, all the entomolopathogenic tretaments were showing lower mean number of aphids per plant compared to control. But there was no signifcant differnece obsevred among the treatments except chemical control.Among all the treatment *Beauveria bassiana* (NBAIR Bb5a) @ 5g/L followed by*Lecanicilium lecanii* (NBAIR Vl8) @ 5g/L was significant efficacy against aphids on capsicum under polyhouse conditions(Table 194). Thrips infestation was negligible during this period.

Table 194 Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse

Sl. No.	Treatments	Mean number of aphids per plant				
		Before spray	After I spray	After II spray	After III spray	Pooled
T1	*Metarhizium anisopliae* (NBAIRMa4) @g/L	116.50 (10.81)	78.88 (8.90)	75.00 (8.68)	70.00 (8.39)	74.62 (8.66)
T2	*Metarhizium anisopliae* IIHR oil @ 1ml/L	150.00 (12.26)	79.99 (8.97)	70.00 (8.39)	66.00 (8.15)	71.99 (8.51)
T3	*Lecanicilium lecanii* (NBAIR Vl8) @ 5g/lt	100.00	65.00 (8.09)	62.66 (8.41)	60.00 (7.77)	62.55 (7.96)
T4	*Beauveria bassiana* (NBAIR Bb5a) @ 5g/lt	99.67	60.00 (7.77)	57.43 (8.07)	56.57 (8.02)	58.00 (7.64)
T5	*Chrysoperla zastrowii*	120.00	100.00 (10.02)	122.00 (11.06)	120.00 (11.45)	114.00 (10.70)
T6	*Blaptostethuspallescens*	112.00	88.89 (9.45)	89.56 (9.96)	85.00 (9.24)	87.81 (9.39)
T7	Azadirachtin @ 2ml/L	120.50	56.00 (8.15)	57.00 (7.58)	50.65 (7.61)	54.51 (7.41)
T8	Fipronil @1ml/L	112.00	22.67 (4.81)	19.00 (4.41)	15.00 (3.93)	18.89 (4.40)
T9	Control	132.44	140.00 (11.85)	134.00 (12.07)	125.00 (11.20)	133.00 (11.55)
	CD at 0.05%	NS	5.10	5.40	5.34	5.10

Figures in paranthesis are Sqrt (x+o.5) transformed values

24. TRIBAL SUB PLAN

24.1. RARS, Anakapalle

- Two trainings with tribal farmers at Kollaput, Dumbriguda mandal, Araku valley on 23.07.2019 and Aratichetlaveedhi, GK Veedhi mandal, Chinthapalli on 01.08.2019.
- Initiated Demonstrations on Organic farming in paddy, ginger, turmeric and vegetables during Kharif season, 2019 benefitting 143 tribal farmers in area of 80 acres in 11 hamlet villages.
- Front line Demonstrations conducted at eleven villages in 80 acres on organic farming paddy, ginger, turmeric and vegetables benefitting 143 tribal farmers of Champaguda,Dumbriguda, Gollarivalasa,Gunjariguda, Kollaput, Jakaravalasa, Kothavalasa, Dumbriguda mandal; Aratichetlaveeddhi, Marripalem, Korrapalli,Godikintha, Gkveedhi mandal,Chinthapalli division, Visakhapatnam district, Andhra Pradesh .
- Distribution of inputs viz., Biopesticides: *Pseudomonas fluorescens*;*Trichoderma viridae*; Botanical pesticide:Neem oil; Neem cake;Biofertilizers; Solar sprayers for FLD farmers.
- Conducted two method demonstrations on mixing liquid biofertilizers with FYM for application in paddy immediately after transplanting at Kollaput on 23.07.2019 and Trichocard clipping in paddy at 30 days after transplanting at Aratichetlaveedhi on 1.08.2019.
- Conducted drenching of *Trichoderma* and spraying Pseudomonas in Turmeric, Ginger against rhizome rot and leaf spot .
- Organised Exposure visit to 48 tribal farmers of Araku valley division and gave raining programme on organic farming in paddy, turmeric, ginger on 23.11.2019 at RARS, Anakapalle during exposure visit .
- Tribal farmers of Araku valley division participated in Kisan mela at RARS,Anakapalle on 23.11.2019, displayed organic rice, rajmah, ginger and ragi and won two first prizes for displaying organic products.

Trainings:


Farmers feedback:

Method demonstrations:

Input distribution

Method demonstration:


Exposure visit:


24.2. AAU, Jorhat Centre, Assam

Materials distributed to the farmers under TSP

Phase-I: A total of 120 farmers from Baralipar and Sontala area of Baska district, Assam in association with KVK, Baska, AAU, Jorhatwere selected and accordingly training and distribution of inputs had been carried out on 29th and 30th November2019.

Sl. No.	**Name of the item**	**Specification**	**Quantity**
1	Rain Coat	Duck Back	120 Nos.
2	Neem Pesticide	Pestoneem	120 liters
3	Water cane	15 litr.	120 Nos.
4	Garden Rack	FRWH 12	120 Nos.
5	Biopesticides	*Beauveria*(Biosona)	120kg

Phase-II: A total of 200 farmers from four villages (Amarabati, Barama, Tamulpur and Baganpara) of Baska district have been selected under the programme. The programme was finalized to be performed during February'2020.All the inputs to be distributed among the farmers have already been purchasedHowever, the programme could not be carried out due to internal problem of the state (CAA agitation, BTAD election and presently lock down situation). Therefore, it will be decided later on when normalcy will come.

Sl. N.o.	**Name of the item**	**Specification**	**Quantity**
1	Neem Pesticide	Pestoneem	200 liters
2	Water cane	15 litr.	200 Nos.
3	Garden Rack	FRWH 12	200 Nos.
4	Biopesticides	*Beauveria* (Biosona)	200kgs
5	Biopesticides	*Metarhizium* (Biometa)	200kgs

Detailed financial expenditure for execution of the project (2019-20)

Particulars	**Cost** (Rs.)
A.Materials to be supplied (crop)	7,12,000.00
B.Training / Awareness and Exposure visit	88,000.00
C.Leaf let/ bulletin	-
Total (A+B+C)=	**8,00,000.00**




Training and material distribution at Boralipar of Baksa district on 29th November, 2019


24.3 KAU, Thrissur

Background: Activities under tribal sub plan (TSP) for the year 2019-20 of AICRP on BCCP, College of Horticulture, Kerala Agricultural University, Vellanikkara were carried out at Wayanad District, which has a large tribal population, accounting for 18.5 per cent of the population in the district and 36 per cent of the State's tribal population. The major agriculture crops include black pepper, ginger, rice, turmeric, banana, coconut, arecanut, vegetables, cardamom, coffee and tea.

Activities: The project activities were undertaken with the support of ATMA (Agriculture Technology Management Agency), Department of Agriculture, Wayanad. A total of 184 farmers in Kottathara, Padinjarethara, Kuppadithara and VengappalliPanchayats in Mananathavadi Taluk and Edavaka and Nallurnad Panchayats in Vythiri Taluk were provided with biopesticides. The tribal farmers were selected with the help of DOA officials. Training programmes were also conducted for the above farmers on the proper use of biopesticides including trichocards. The bioinputs distributed included trichocards, *Trichoderma viride*, *Pseudomonas fluorescens*, *Lecanicillium lecanii*, *Paecilomyces lilacinus* and arbuscular mycorhizal fungi (AMF).

Details of training programmes conducted, number of beneficiaries, bioinputs distributed, *etc.* are given in below.

Sl. No.	**KrishiBhavan**	**Village**	**Taluk**	**No. of beneficiaries**	**Date of supply**	**BC agents supplied**
1	Kottathara	Kottathara	Vythiri	83	28-10-19	Trichocards – 200 cc *Pseudomonas*– 300 kg *Trichoderma*– 100 kg
2	Padinjarethara	Padinjarethara &Kuppadithara	Vythiri	43	24-12-19	*Pseudomonas* – 250 kg AMF – 25 kg
3	Vengappalli	Vengappalli	Vythiri	36	24-12-19	*Pseudomonas* – 100 kg *Lecanicillium* – 50 kg *Paecilomyces*– 25 kg
4	Edavaka	Edavaka& Nallurnad	Mananthavadi	22	24-12-19	*Pseudomonas* – 100 kg *Trichoderma*- 50 kg

Training programme at Kottathara on 28-10-2019

Field demonstration on use of trichocard

കീട നിയന്ത്രണത്തിന് കടന്നൽക്കൂട്ടം

ഇന്ദിരാഗാന്ധിയെ

NewspaperReport on TSP activity (Malayala Manorama dtd 1-11-19)

Training programme at Vengappalli on 24-12-2019

24.4. YSPUHF, Solan

Activities:

- Organised trainings and demonstrations in 19 villages of 3 tribal districts of Himachal Pradesh benefitting covering Apple, almond, peas, beans, cauliflower and cabbage benefitting 982 farmers.
- Technologies like Use of *Metarhizium anisopliae*, *Beauveria bassiana* and azadirachtin for the management of apple root borer and apple stem borer, Use of *Trichoderma* and *Pseudomonas* far the management of diseases in apple vegetable nursery, Use of azadirachtin in cabbage and cauliflower for the management of caterpillars, conservation of parasitoids of apple woolly aphid and other natural enemies and Use/conservation of predatory mites in beans and apple against phytophagous mites were demonstrated to the farmers.
- Inputs like *Metarhizium anisopliae*, *Beauveria bassiana*, Yellow sticky traps, Blue sticky traps, NeemBaan, *Trichoderma viridae*, *Pseudomonas* and Literature (Package of practices for fruits and vegetable crops) were supplied to the farmers.

Outcomes:

- Tribal farmers were exposed to the use of bio-pesticides for pest management for the first time.
- In case of apple, farmers saved about Rs 15000/- per hectare by avoiding chemical treatment for the control of apple root borer.
- In peas, beans, cauliflower and cabbage there was a reduction of 2-3 sprays of chemical pesticides.

Photographs of TSP activities

Farmers taking part in the training programmes and receiving the inputs

Farmers learning about apple root borer and apple crown gall

24.5. SKUAST, Srinagar

Proposed & Approved program of Tribal sub Plan (2018-2019)

1.	Name of the Project Proposal	:	**Integrated Management of Codling moth, *Cydia pomonella*in Ladakh**			
2.	Name of the center	:	Division of Entomology Sher-e- Kashmir University of Agricultural Sciences & Technology, Kashmir (J&K)			
3.	Name of P.I./ Co P.I.	:	Dr. Md. Jamal Ahmad Dr. Sajad Mohi-u-din			
4.	Details of locations of Tribal areas/STs where TSP is going to be executed	:	Kargil (34° 33' 27.54" N and 76° 07' 34.39" E) & Leh (34° 9' 9.3168" N and 77° 34' 37.3764" E).			
5.	a. No of Villages	:	30			
	b. No of Farmers	:	100			
	c. Area under coverage	:	50 ha.			
6.	Crops to be dealt	:	Apple & Apricot			
7.	IPM technologies to be implemented for pest management	:	(a) One spray of Chorpyriphos @1.0 ml/lit (b) Four sequential releases of *Trichogramma cacoeciae* @ 5.0 lakh /ha as bio-agents for the management of codling moth (c) Twice installation of pheromone traps (@ 4 traps/500 m^2) for mass trapping of codling moth (d) Burlapping and killing (e) Collection and disposal of infested fruits *(f)* Two sprays of EPN / *Beauveria bassiana*			
8.	Materials to be supplied to the TSP farmers with clear financial details.	:	Materials (per year)	No.	Rate (Rupees)	Total (Rupee in lakh)
			1.Trichocards	1000	35.00	0.35
			2.Pheromone traps	1500	120	1.80
			3. EPN/*B. bassiana*	50.0 Kg.	200.00	0.1

			4. Chlorpyriphos 20EC	100 lit.	500	0.5
			5. Foot sprayer	50 Nos.	6000	3.0
			6. Spraying containers (Tubs)	50 Nos.	800	0.4
			7. Spraying kits	125	1400.00	1.75
			7. Gunny bags	2,000 meter	20.00	0.4
			Total			**8.3 Lakh**
9.	Training/ Demonstrations to be given to tribal farmers	**:**	Training regarding Management of Codling moth. (a) Training regarding identification of Codling moth. (b) Demonstration regarding release of Tricho-cards, Pheromone traps, trunk banding etc. (c) Timing of management			
10.	Target proposed and expected Achievements	**:**	1. Reduction in fruit infestation 2. Increase in marketable yield			
11.	Anticipated impact of TSP Project on economic improvement of the tribal of the Tribal people and wealth creation in Tribal areas	**:**	The livelihood of people living in tribal areas below poverty line mainly depends on agriculture and allied fields. Main source of income is from horticultural crop. By controlling the key pest, Codling moth, *Cydia pomonella* associated with these fruit crops, the yield can be increased which can help boost the economy of the people living in the tribal areas.			

Detail Report of Tribal Sub Plan (2018-19)

Since Tribal Sub Plan (2018-19) was allotted to the center during March 2019' hence executed during 2019- 20. The same was brought to the notice of Director, NBAIR and permission was sought for submission of its detailed report during 2019-20.

Summarized outline of the project has been tabulated in Table 1. Inputs in kinds (Table 2) were given to seventy seven farmers, in a total of forty villages of subdivision Kargil (34° 33' 27.54" N and 76° 07' 34.39" E) and Leh (34° 9' 9.3168" N and 77° 34' 37.3764" E), which included nineteen villages from Kargil and twenty one from Leh. A list of beneficiaries (Table 3) with complete address and phone numbers was maintained. Receipts of inputs, from beneficiaries were also taken, for record. The farmers were interacted for the know- hows in each village (Plate 1) for the use of distributed inputs (Plates 2 &3) including chemical pesticide, pheromone traps, Tricho cards, foot sprayers, spraying protective kits, tubs, buckets and trunk bands. In big villages like Hardas, Slikchey and Mingy etc. the inputs were distributed on sharing basis. Hon'ble Vice Chancellor, Professor Nazeer Ahmad, SKUAST-K and Professor Mushtaq Ahmad Wani, Assoc. Director from HMAARI, Leh also took active part in distribution of items in Leh and Nobra valley (Plate 4). Prior to distribution of inputs, photo of Adhar card (Plate 5) of the beneficiary was taken and maintained for proof and record. The villages at Kargil were monitored for impact observation. Observations were also made on yield impact, from randomly selected beneficiaries of Kargil (Table 4).

Purchase and distribution of inputs to farmers: Items essentially required for the management of Codling moth, *Cydia pomonella* were purchased after fulfilling the codal formalities and taken to Kargil (202.0 Km) and Leh (425.0 Km.) from SrinagarHQ. Tricho cards were prepared in the laboratory of Bio control unit of the Entomology Division, SKUAST-K and distributed. Because of harsh winter in Srinagar, preceding the execution of TSP, limited number of Tricho cards were distributed during 1st generation of the pest which however was overcompensated during onset of 2nd generation and increased supply of Pheromone traps. In place of *Heterorhabditis pakistanensis*, *Beauveria bassiana* was given to farmers to use against 2nd generation larva as well as overwintering larvae of Codling moth. Twenty meters of trunk bands were given to each farmer to trap and kill overwintering larvae.

The inputs loaded in load carrier were taken from village to village as per scheduled program, pre informed to the farmers and the area Panch/ Sarpanch. Inputs were distributed along with details of printed hand outs and charts. In big villages, the inputs were handed over to the area sarpanch for timely and proper distribution of items. In each village, the farmers were briefed technique and time of using each input. In Leh, distribution of inputs was done in collaboration with KVK, HMAARI (High Mountain Arid Agriculture Research Institute), in presence of Hon'ble Vice Chancellor, Professor Nazeer Ahmad, SKUAST-K and Assoc. Director, Professor Mushtaq Ahmad Wani, HMAARI, Leh.

Impact of Tribal sub plan: The tribal community of Ladakh (Kargil and Leh) views this program of ICAR –NBAIR led by the SKUAST-K with utmost positive gesture and as apple saving mission. With inputs since last three years and on-the-spot awareness programs, the beneficiaries of TSP were observed to adopt and implement IPM of Codling moth. Even the Buddhists accepted pheromone traps, Tricho cards and practiced trunk banding for management of Codling moth, without any religious taboo.With increasing areas, under the coverage of this plan,observed improvement in economy was noticed. A random input from beneficiaries of TSP (2018-19) from different villages of Kargil indicated 20.0- 90.0 per cent increase in marketable yield (Table 4).

Summarized outline of Tribal Sub Plan (2018-19)

S. No.	Particulars	Details
1.	Title of TSP Project	Tribal sub plan on Integrated management of Codling moth, *Cydia pomonella* in Ladakh (Kargil & Leh) (2018-19)
2.	Year of implementation	2019-20
3.	Location	Kargil and Leh
4.	Crop	Apple
5.	Budget	8.27 lakh
6.	Expenditure	8.16 lakh
7.	No. of villages covered	40 (Kargil 19+ Leh 21)
8.	No. of beneficiaries	77
9.	Area covered	Approx. 20- 25 ha.

List of items distributed in Ladakh during 2018-19

S. No.	Name of inputs	No./ Qty
1.	Trichocards	500 Nos.
2.	Pheromone traps	2,415 Nos.
3.	Pheromone lure	2,415 Nos.
4.	Trap liner	2,415 Nos.
5.	*B. bassiana*	40. Kg.
6.	Chlorpyriphos 20 EC	95.0 lit.
7.	Foot sprayer (Maruti)	70.0 Nos.

8.	Tubs (50 lit.)	50.0 Nos.
9.	Bucket (17 lit.)	50.0 Nos.
10.	Spraying kits (Uniform with head gear, boot, gloves, mask and goggle)	75 Nos.
11.	Gunny bags	1600 meter.

Impact of TSP (2018-19) on % increase in marketable yield of apple in Kargil

S. No.	Name & Address of beneficiary	Phone No.	% increase in marketable yield
1.	Asgar Ali, Chani gund, Kargil	9419887469	90.0
2.	Mohmmad hussain, Kirkichoo, Kargil	9419855874	35.0
3.	Gh. Mustafa, Chani gund, Kargil	9419901109	80.0
4.	Mukhtar Husain, Slikchay, Kargil	8491078718	50.0
5.	Feroz Ali, Kirkichoo, Kargil	9622620036	20.0
6.	Khadim Hussain, Hardas, Kargil	6005494722	20.0
7.	Roqaiya Bano, Hardas, Kargil	6005605590	30.0
8.	Syed Hadi, Mirkhoor Baroo, Kargil	9469204044	50.0
9.	Ahmad Raza, Mingy, Kargil	9469181097	50.0
10.	Akbar Ali, Trespone, Kargil	9469477371	60.0

24.6. AAU, Anand

'Biological interventions to enhance the crop production and productivity of tribal farmers of Narmada district in Gujarat'

1. Selection of tribal Farmers.

Tribal farmers (100 No.) were selected from Dediyapada, Sagbara and Tilakwada tehsils of Narmada district. Area covered was ~1 acre/farmer.

2**. Khedut Shibir and training programmes**

In association with Krishi Vigyan Kendra (KVK), Dediyapada, Navsari Agricultural University, khedut shibir and training programmes were organized in the month of July and August 2019 to train the farmers on use of biocontrol inputs and strategies to tackle key pests and diseases to achieve sustainable crop production.

3. Distribution of bio-inputs

The following bio-inputs were distributed to farmers (Microbial based inputs were mass produced at the centre and distributed under TSP programme)

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

4. Field visits to record bio-efficacy and on-farm interactions with the farmers

Field visits were conducted to record the use of bio-inputs by the farmers and bio-efficacy of inputs. Significant reduction (35-40%) in use of chemical pesticides was recorded.

Achievements

- Number of beneficiaries – 200 tribal farmers from 13 different villages of Dedidapada Taluk of Narmada district
- Conducted two training/demonstration programmes on bioagents at KVK, Dedidiapada, Narmada Dist on 19-7-2019 and 19-8-2019
- Distributed bioagents/bio-pesticides
(Tricho card – 10 No., *Beauveria bassiana*, *Bacillus thuringiensis*, *Metarhizium anisopliae* - 2 kg each/farmer, Pheromone trap and lures (*Heliothis* and PBW) – 10 No., Yellow sticky trap – 10 No., *Trichoderma viride*, *Pseudomonas fluorescens,* Mycorrhiza – kg each/farmer)
- Major crops – Bt cotton, vegetables
- Chemical pesticide reduction – 25-30%
- Increase in yield with sustenance – 10-12%

24.7 TNAU, Coimbatore

- Training programme on production of biocontrol agents and biointesive pest management were conducted to benefit the tribal farmers (100Nos.) from Coimbatore, Erode and Tirupur Districts.
- Tribal farmers (35Nos.) from Jambukandy and Senguttai villages in Coimbatore Dt. were exposed to various methods followed in the mass production of parasitoids and predators. Hands on training on production of *Corcyra* eggs and mass multiplication of *Trichogramma* spp., *Chrysoperla zastrowi silemmi, Bracon brevicornis* and *Goniozus nepahnatidis using Corcyra* eggs/larvae was given. Morover, methods for production of *Cryptolaemus montrouzeiri* on pumpkin mealybug and *Acerophagus papayae* on potato mealybug have been demonstrated.

- Training programme on identification of natural enemies (predators and parasitoids) and biointesive pest management to thirty-five farmers from Hosur and Bejeletti villages in Erode Dt. and thirty farmers from Karumutti village in Tirupur Dt. were conducted.
- Parasitoids, Predators, Battery operated sprayers, neem oil, teepol, plastic bucket, plastic mug, plastic trays, cumbu grains, maize grains and vegetable seeds were supplied to the farmers.

Activities	**Villages name**	**District**	**state**	**No. of beneficiaries**
1. Training on awareness on biocontrol agents/ technologies	Jambukandy Senguttai Karamutti Bejeletti	Coimbatore Tirupur Erode	Tamil Nadu	100 100 100
2. Frontline demonstrations of biocontrol technologies	Nivalda,Tilipada,Almavati,Tabda,Soliya,Kanjal,Kelva,Khudadi Nani bedwan, Navagam, Mandala, Pipla, Pansar	Narmada	Gujarat	200
3. Method demonstrations of biocontrol technologies	Kollaput, Kothavalasa, Champaguda, Gollarivalasa,Gunjariguda, Jakaravalasa, Aratichetlaveeddhi, Marripalem, Chinthapalli division, Kothavalasa	Vishakapattinam	Andhra Pradesh	143
4. Method demonstrations of biocontrol technologies	Kinanaur Lauhal Kinnaur Lauhal	Powari Rangrik Kangosh Hurling	Himachal pradesh	200

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

24.8 ICAR-NBAIR, Bengaluru, Karnataka

i) Training on awareness on biocontrol agents/ technologies

S. No	Date	Title of the training	No of beneficiaries	Participants location/ district	State
1	23.07.2019	Organic farming in paddy, ginger, turmeric and vegetables	80 tribal farmers	Kollaput, Dumbrigudamandal, Araku valley	Andhra Pradesh
2	01.08.2019	Organic farming in paddy, ginger, turmeric and vegetables	63 tribal farmers	Aratichetlaveedhi, GK Veedhimandal, Chinthapalli	Andhra Pradesh
3	23.11.2019	Organic farming in paddy, ginger, turmeric and vegetables	48 tribal farmers	Araku valley division	Andhra Pradesh
4	19.7.2019	Awareness on various bio agents	100 tribal farmers	Villages of Dedidapada Taluk of Narmada district	Gujarat
5	19.8.2019	Awareness on various bio agents	100 tribal farmers	Villages of Dedidapada Taluk of Narmada district	Gujarat
6	07.03.19	Production of biocontrol agents and biointesive pest management	100 tribal farmers	Coimbatore, Erode and Tirupur Districts.	Tamil Nadu
7	07.03.19	Mass production of parasitoids and predators	100 tribal farmers	Jambukandy and Senguttai, Coimbatore district	Tamil Nadu
8	21.03.19	Identification of natural enemies (predators and parasitoids)	65 tribal farmers	Hosur and Bejeletti villages in Erode Dt. Karumutti village in Tirupur Dt.	Tamil Nadu
9		Awareness on Biocontrol technologies	982 farmers	19 villages of 3 tribal districts	Himachal Pradesh

		for the management of pests and diseases of Apple, almond, peas, beans, cauliflower and cabbage			
Total no of beneficiaries			**1638**		

ii) Frontline demonstrationsof biocontrol technologies

S. No	**Date**	**Title of the training**	**No of beneficiaries**	**Participants location/ district**	**State**
1	23.07.2019 to 2.11.2019	Organic farming in paddy, ginger, turmeric and vegetables	143 tribal farmers	Champaguda,Dumbriguda Gollarivalasa,Gunjariguda, Kollaput, Jakaravalasa, Kothavalasa, Dumbrigudamandal; Aratichetlaveeddhi, Marripalem, Korrapalli,Godikintha, GKveedhimandal,Chintha palli division, Visakhapatnam district,	Andhra Pradesh
2		Application of Biocontrol technologies for the management of pests and diseases of Apple, almond, peas, beans, cauliflower and	982 tribal farmers	19 villages of 3 tribal districts	Himachal Pradesh
Total no of benefecialries			**1125**		

iii) Method demonstrationsof biocontrol technologies

S. No	**Date**	**Title of the method demonstration**	**No of beneficiaries**	**Participants location/ district**	**State**
1	23.07.2019	Mixing of liquid biofertilizers with FYM for application in paddy	143 tribal farmers	Kollaput	Andhra Pradesh
2	1.08.2019	Trichocard clipping in paddy		Aratichetlaveedhi	Andhra Pradesh

iv. Method demonstrations of biocontrol technologies

1) Parasitoids, Predators (Tricho cards**)**

2) Biopesticides and Boatnicides

Pseudomonas fluorescens, *Trichoderma viride*, *Beauveria bassiana*, *Bacillus thuringiensis*, *Metarhizium anisopliae*, Mycorrhiza, Neem oil,NeemBaan

3) Pheromone trap and lures (*Heliothis* and PBW), Yellow sticky trap,Blue sticky traps,

4) Sprayers and accessories: Solar sprayers, Battery operated sprayers, plastic bucket, plastic mug, plastic trays

Seeds: Vegetable seeds

24.9 IGKV, Raipur, Chhattisgarh

The Tribal sub Plan under IGKV, was allotted on 27/11/2018 vide letter No. F.No.3-3{AICRP-B.C.}/2018-19/7645-46 dated 27/11/2018 with a fund of Rs. 5.0 lacs (Rs. Five lacs). The area selected under TSP was **Jagdalpur. (Bastar)** belonging to the Bastar plateau zone of Chhattisgarh. The Dean, College of Agriculture and Research Centre, Jagdalpur, Dr. S.C. Mukherjee was very cooperative and helped to organize the training programmes along with his staff members. The selection of relevant tribal farmers could be possible only due to his efforts. About 150 farmers were selected all belonging to ST category, their details along with adhaar card number and Bank account number is also attached and also sent earlier.

The first training of TSP under the session 2019-20 was taken up at KVK, Dantewada, of Dantewada district of Bastar on 22ndOct'2019. Large number of tribal farmers gathered, along with the lady Sarpanch who were first given awareness and benefits of biocontrol agents through a presentation in hindi. This was followed by live demonstrations of the various bioagents being reared in the laboratory such as., Trichocards, reduviid bigs, Coccinellid beetles and *Zygogramma* beetles. Application method of Trichocards was also demonstrated on a model plant. Low cost candle based light traps were also displayed. These were also distributed to the tribal farmers. The farmers very interestingly came forward to receive the bioagents to release in their respective fields called (badi) in local language.

(List of farmers and Photographs enclosed)

The second training under TSPwas organized atKVK, Kankeron **25/11/2019.** Under this **50 tribal farmers** wereselected belonging to ST category belonging to Village-Choriya, Block-Narharpur participated. Initially presentation in hindi was given to show the importance of naturally occurring bioagents and their role in insect pest management.Then live display of bio-agents was shown to the farmers. Biocontrol agents like Trichocards, Reduviid bugs, Coccinellid beetles, *Zygogramma* beetles and low cost light traps were distributed to farmers.

(List of farmers and Photographs enclosed)

The third training under TSP will be held at Badechakwa village of Bastar shortly.

I^st^ Training under TSP on Biocontrol, Krishi Vigyan Kendra, Dantewada (C.G.)on 22/10/2019

Demonstration of live bio-agents to tribal farmers of Dantewada


Distribution of bio-agents to the tribal farmer's of Dantewada


II^nd^ Training of tribal farmers under TSP on Biocontrol, Krishi Vigyan Kendra, Kanker (C.G.) on 25/11/2019



Distribution of low cost light trap to the tribal farmers of Kanker


Demonstration of live bioagents and their utility to tribal farmers of Kanker

24.10 UBKV, Pundibari, West Bengal

No of the villages covered and number of tribal farmers benefitted:

Sl. No.	Village, Taluk and Districts	Date of training/ Input distribution	No. of farmers
1.	Dakshin Latabari, Kalchini, Dist. Alipurduar	25.10.2019	30
2.	Nimati Forest Range, Kalchini, Dist. Alipurduar	12.11.2019	30
3.	Ramsai, Maynaguri, Dist. Jalpaiguri	31.12.2019	35
4.	Putimari, Cooch Behar-II, Dist. Cooch Behar	Scheduled on 16.03.2020 but postponed due to the recent outbreak of Novel Corona Virus.	50
5.	Tapsighata, Alipurduar-I, Dist. Alipurduar	Scheduled on 19.03.2020 but postponed due to the recent outbreak of Novel Corona Virus.	50
6.	Dakshin Latabari, Kalchini, Dist. Alipurduar	Scheduled on 20.03.2020 but postponed due to the recent outbreak of Novel Corona Virus.	50

***Inputs decided to besupplied to the tribal farmers**:

Sl. No.	Inputs	Quantity
1	Biocontrol (Microbial) agent for rice/ vegetables/pulses	100 kg (1 kg/farmer and total number of farmers will be100)
2.	Pheromone Trap (Cue lure fruit fly trap) for cucurbits	500 pieces (5 traps/farmer and total number of farmers will be100)
3.	Sprayer machine (5 lit. capacity)	50 sprayers (1 sprayer/ farmer and total number of farmers will be 50)

*Scheduled on 16.03.2020, 19.03.2020 and 20.03.2020 but postponed due to the recent outbreak of Novel Corona Virus.

<u>**Activities Photograph under TSP**</u>

Field day on Beekeeping at Dakshin Latabari, Kalchini, Dist. Alipurduar on 25.10.2020

Field day on Beekeeping at Nimati Forest Range, Kalchini, Dist. Alipurduar on 12.11.2019

Training on biological control of crop pests at Ramsai, Maynaguri, Dist. Jalpaiguri on 31.12.2019

উত্তরবঙ্গের আত্মার আত্মীয়

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রামশাই কৃষিবিজ্ঞান কেন্দ্রে শিবির

ময়নাগুড়ি, ৩১ ডিসেম্বর : মঙ্গলবার জলপাইগুড়ি জেলা কৃষিবিজ্ঞান কেন্দ্রের উদ্যোগে ও উত্তরবঙ্গ কৃষি বিশ্ববিদ্যালয়ের সহযোগিতায় কৃষিবিজ্ঞান কেন্দ্রে একদিবসীয় কৃষি কর্মশালা অনুষ্ঠিত হল। জেলার ৫০ জন তপশিলি উপজাতির কৃষক শিবিরে যোগ দেন। চাষিরা পরিবেশবান্ধব চাষের মধ্য দিয়ে কীভাবে উন্নত মানের চাষ করতে পারবেন, তা নিয়ে শিবিরে আলোচনা করা হয়। উত্তরবঙ্গ কৃষি বিশ্ববিদ্যালয়ের কীটতত্ত্ব বিভাগের অধ্যাপক শ্যামল সাহু, সংকল্প ওঝা, দেবাঞ্জন চক্রবর্তী, ময়নাগুড়ির ব্লক কৃষি অধিকর্তা কৃষ্ণা রায়, জেলা কৃষিবিজ্ঞান কেন্দ্রের প্রোগ্রাম কোঅর্ডিনেটর বিপ্লব দাস, কৃষিবিজ্ঞানী কৌশিক দাস সহ অন্যরা উপস্থিত ছিলেন। অধ্যাপক সাহু জানান, চাষিরা রোগপোকার হাত থেকে কীভাবে তাঁদের ফসলকে রক্ষা করবেন, সেই বিষয়ে এদিন বিস্তারিত আলোচনা করা হয়। বন্ধু পোকার ব্যবহারে শত্রু পোকা দমন করার বিষয়টি নিয়েও আলোচনা হয়।

Training on biological control of crop pests at Ramsai, Maynaguri, Dist. Jalpaiguri on 31.12.2019 published in Bengali News paper

Problems encountered during the year

TNAU, Coimbatore

1. Coconut Rugose whitefly was seen in various districts of Tamil Nadu. The advantages of 'Conservation biological control' were explained to the Department officials and farmers. *Chrysoperla zastrowi silemmi* is being supplied to farmers for the management of this invasive pest.

2. In the maize growing areas in Tamil Nadu, fall army worm damage was observed and IPM measures were recommended to the farmers.

GENERAL AND MISCELLANEOUS INFORMATION

AAU-Anand
Visitors

Dr. Chandish R. Ballal, Director ICAR-NBAIR visited Biological Control Research Laboratory, AAU, Anand on 22 August 2019.

Sr. No.	Visitors	Total
1	Students	469
2	Trainees/farmers	453
	Total	**922**

Awards/Honours/Recognition/Technology developed:

Dr. Raghunandan, B.L. awarded 'Excellence in Research Award' by SSDAT (Society for scientific development in agriculture and technology, Meerut, U.P.) on the occasion of International Conference on Global Initiatives for Sustainable Agriculture and Allied Sciences (GRISAAS-2019) held at ICAR-NAARM, Hyderabad during 20-22 October 2019

Dr. Patel, N. M. awarded Dr. R. C. Patel Award 2019 – 'Best research work done by PhD student in plant protection' during PPAG seminar on 8-11-2019 at Anand Agricultural University, Anand (Major Advisor - Dr. D.M.Mehta, Title of the thesis- 'Biology and seasonal incidence and management of tomato pinworm *Tuta absoluta* Meyrick')

Education, Training and Radio / TV talk

Details of Khedut Shibirs organized during 2019-20

Sr. no	Date	Village & Taluka	No. of farmers attended
1	19/07/2019	KVK, Dediyapada	125
2	19/08/2019	KVK, Dediyapada	100

Lectures and demonstrations conducted to the students/farmers on 'Biological Control of Crop Pests' during their visit to the Laboratory

Sr.	Date	Visitors (No.)	Visitors/Trainee details

No			
1	16/01/19	Students (47)	College of Horticulture, AAU, Anand
2	12/02/19	Students(57) + Faculty (2)	Aspee College of Horticulture and Forestry, NAU, Navsari
3	28/02/19	Students (34)	Agriculture Information Technology College, AAU, Anand
4	06/03/19	Students (49) + Faculty (2)	College of Horticulture, JAU, Junagadh
5	06/03/19	Students (36) + Faculty (2)	College of Horticulture, SDAU, Jagudan
6	25/03/19	Farmers (56)	Farmers from Shinor
7	27/03/19	Farmers (55)	Farmers from KarjanTaluka (GNFC)
8	28/03/19	Farmers (25)	The State Institute of Rural Development, Ahmedabad
9	29/03/19	Farmers (16)	VRTI, Vallabhipur
10	29/03/19	Students (39) + Faculty (1)	Agriculture Information Technology College, AAU, Anand
11	03/04/19	Staff (2) + farmers (30)	The State Institute of Rural Development, Gandhinagar
12	15/05/19	Farmers (30)	The State Institute of Rural Development, Ahmedabad
13	26/06/19	Farmers (30)	The State Institute of Rural Development, NRLM
14	29/06/19	Farmers (33)	Organic Farming Training Agronomy
15	03/07/19	Farmers (22)	Organic Farming Training Agronomy (The State Institute of Rural Development, NRLM)
16	22/07/19	Students (10)	Organic Chemistry, Vadodara
17	29/07/19	Farmers (25)	Ramnek Kothadiya (NGO)
18	30/07/19	Farmers (40)	Jigneshkumar G. Prajapati (NGO)
19	31/07/19	Farmers (22)	GurjanTital (NGO)
20	09/01/19	Students (51)	College of Horticulture, AAU, Anand
21	21/01/20	Farmers (20)	Krishi Vignan Kendra,Vadodara
22	23/01/20	Farmers (49)	ATMA-TAPI
23	11/02/20	Students (49)	College of Horticulture, Jagudan, SDAU
24	11/02/20	Students (58)	Aspee College of Horticulture and Forestry, NAU, Navsari
25	18/02/20	Students (30)	Certificate course of organic farming

Post/under graduate teaching

No.	me of Teacher	urses offered	PG Students Guiding
1.	Dr. D. M. Mehta		1 (M.Sc)
2.	Dr. Raghunandan B.L.	ENT 611 - Molecular Approaches in Entomological Research (1+1)	NIL
		CRO 509 – Plant Microbe Interactions (3+0)	
		CRO 506 – Food and Dairy Microbiology (2+1)	
		CRO 601 – Advances in Fermentation (2+1)	

Participation of Scientists in conference, meetings, seminars, workshops, symposia, training, extension etc. in India and abroad

Dr. Raghunandan, B.L. participated in International Conference on 'Advances in Sustainable Agriculture: Bioresources, Biotechnology and Bioeconomy' and presented paper entitled 'Wide area management of white grub in groundnut through bioagent based IPM module: A success story',29-30November 2019 at Mansarovar Global University, Bhopal, M.P.

Patel, N. M., Raghunandan, B. L. and Mehta, D. M. (2019). Nanotechnology: A potential tool to improve the efficacy of biopesticides. Paper presented in2nd state level convention on "Doubling the farmer's income through Resource management and rural prosperity" held on 12-13th October 2019 at Anand Agricultural University, Anand, Gujarat.

List of publications (Research papers, seminars, symposiums, book, book chapters, pamphlets, technical bulletin, etc.)

Research papers

Raghunandan, B. L,Patel, N. M., Dave, H. J and Mehta, D. M. (2019). Natural occurrence of nucleopolyhedrovirus infecting fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in Gujarat. *Journal of Entomology and Zoology Studies*, 7(2): 1040-1043.

Raghunandan, B.L, Patel, M. V., Patel, N. M. and Mehta, D. M. (2019). Bio-efficacy of different biological control agents for the management of chilli fruit rot/ anthracnose disease. *Journal of Biological Control,* 33(2): 163-168.

Patel, N. M.and Mehta, D. M. (2019). Bio-efficacy of insecticides against tomato pinworm, *Tuta absoluta* (Meyrick). *Journal of Entomology and Zoology Studies*, 7(4): 732-734.

Booklets - Vernacular language

Patel, N. M., Raghunandan, B. L., Bhatiya, Y. A., Patel, P. H. and Mehta, D. M. Jaivik niyantrako. Prakashan shreni, No.: RES 15:6:2019:5000.

Folders - Vernacular language

Patel, N. M., Raghunandan, B. L., Patel, M. V., Patel, G. M., Dave, H. J. and Mehta, D. M. Magfalina pakma bahoda vistarma safed mundane jaivik padhdhti aadhareet sanklit niyantran- ek safad gatha-Prakashan shreni No.: RES 15:5:2019:5000

Patel, N. M., Raghunandan, B. L., Dabhi., R. J., Sindhura., K. A., Patel, P. H. and Mehta, D. M. Punched char tapakavali lashakaree eyal-fall armyworm. Prakashan shreni No.: RES 15:7:2019:5000

Popular articles – Vernacular language

Patel, N. M., Raghunandan, B. L.and Mehta, D. M. Tameteema nuksankarta paankoriyu-v-falvedhaknu (*Tuta absoluta*) sanklit vyavsthapan. (2019). State level Seminar "Krushi ane bagayatee pakoma prvartmaan paak samraxanna prashno ane nirakarn" Plant protection Association of Gujarat, 44-45.

Patel, N. M., Raghunandan, B. L.and Mehta, D. M. (2019). Nanotechnology: Jaivik Jantunashko mateno ek navintam abhigam. *Krushi Govidhya*, 26-27.

Bioagents maintained in the laboratory

- *Trichogramma chilonis*
- *Trichogramma pretiosum*
- *Trichogrammatoidea bactrae*
- *Chrysoperla carnea*

- *Beauveria bassiana* (Bb-5a)
- *Lecanicillium lecanii* (Vl-8)
- *Metarhizium anisopliae* (Ma-4)
- *Bacillus thuringiensis* (PDBC-BT1, NBAII BTG-4)
- *Trichoderma harzianum* (Th-3)
- *Pseudomonas fluorescens* (Pf-1)
- *Paecilomyces lilacinus*
- Entomopathogenic nematode –*Steinernema pakistanens*

ANGRAU, Anakapalle

Awareness programmes organised

AICRP on Biological Control, ANGRAU centre and ICAR-NBAIR, Bangalore organized Awareness programme on management of Coconut rugose spiraling whitefly on 6th January, 2020 at Venkataraopeta, Ranasthalam mandal, Srikakulam district and Farmers awareness programme on management of maize fall armyworm on 7th January, 2020 at Pusapatirega, Vizianagaram district benefitting 220 farmers of Srikakulam and Vizianagaram districts.

Awareness programme on management of Coconut rugose spiralling whitefly at Ranasthalam mandal, Srikakulam district on 06.01.2020:

Organised Awareness programme on management of Coconut rugose spiralling whitefly at Venkataraopeta village, Ranasthalam mandal, Srikakulam district on 06.01.2020 along team of scientists from ICAR- NBAIR, Bangalore. Associate Director of Research, RARS,Anakapalle participated along with Scientists of ARS, Daattcentre, KVK of Srikakulam district . NBAIR Scientists inaugurated entomopathogenic fungi, *Isaria fumosorosea* (NBAIR- pfu 5) production centre for farmer level production by trained farmers by trained farmers at Venkataraopeta village, Ranasthalam mandal, Srikakulam district along with Reddys foundation – Mitra foundation. Assistant Director of Horticulture of two divisions, Horticulture officers and 100 coconut farmers of Srikakulam district participated. Motivated coconut farmers on management of Coconut rugose whitefly with entomopathogenic fungi, *Isaria fumosorosea* (NBAIR- pfu 5); Parasite, *Encarsia guadeloupae and c*onducted method demonstration . Also supplied mother cultures and formulation of *Isaria* fungus to coconut farmers and Department of Horticulture.

Farmers awareness programme on management of maize fall armyworm in Pusapatirega mandal, Vizianagaram district on 07.01.2020:

Organised Awareness programme on management of maize fall armyworm under CABI along with ICAR-NBAIR team of four scientists, at Pusapatirega, Vizianagaram district on 07.01.2020 benefitting 120 maize farmers. Associate Director of Research, RARS, Anakapalle participated along with Joint Director of Agriculture, Two Assistant Director of Agiculture, Two Agricultural Officers and Scientists of Daattcentre, Vizianagaram district. Dr.B,Ramanujam, Principal Scientist , NBAIR gave presentation on management of maize fall armyworm using Biocontrol agents and Biopesticides. Dr.Bakthavatsalam, Principal Scientist , NBAIR Principal Scientist , NBAIR explained about utilization of Pheromone traps against maize FAW ; Dr.Rangeswaran, Principal Scientist , NBAIR explained about the efficacy of *Bacillus thuringiensis* in controlling maize FAW ; Dr. Shylesha described about various parasitoids and predators found effective in managing fall army worm in maize . Dr.P.Jamuna, Associate Director of Research, RARS, Anakapalle motivated maize farmers on importance of biological control in maize fall army worm management. ICAR-NBAIR Scientists distributed biocontrol agents, *Trichogramma pretiosum, Telenomus remus, Tetrastichus, Chelonus* and Biopesticides, *Bacillus thuringiensis, Metarhizium anisopliae* (Ma35), *Beauveria bassiana* (Bb45) to Department of Agriculture and maize farmers.

Training on farmer level production of entomopathogenic fungi, *Isaria fumosorosea* (NBAIR- Pfu 5) for coconut farmers of North castal zone:

Total three training programmes were conducted under AICRP on Biological control at RARS, Anakapalle (Visakhapatnam district), Koyyam village (Etcherla mandal, Srikakulam district) and Venkataraopeta village (Ranasthalam mandal, Srikakulam district) on 5th, 6th and 7th February 2020, respectively. Miss. Poornesha, ICAR-NBAIR, Bangalore imparted hands on training on farm level production techniques of I. fumosorosea for farmers. Total about 200 coconut farmers, official of Dr. Reddys foundation and Department of Horticulture officials of Visakhapatnam, Vizianagaram and Srikakulam districts benefitted from training. This training programme on farm level production of *Isaria fumosorosea* was widely covered in local newspapers (Telugu) for the benefit of large section of farming community and other stakeholders in the Andhra Pradesh. Dr (Mrs.). M. Visalakshi, Principal Scientist (Entomology), RARS, Anakapalle organized and Miss Sumalatha, B.V and Miss Poornesha from ICAR-NBAIR participated as resource person for these demonstration cum training programmes.

Technical guidance to Biocontrol labs at Sugar factories and State Biocontrol labs

- Three Sugar factories i.e., Navabharath Ventures, Samarlakota, East Godavari District and EID Parry sugars Ltd, Sankili, Srikakulam district and KCP Sugars, Vuyyur, Krishna District; State Biocontrol labs at Visakhapatnam and Kakinada; Farmer producing Trichocard centre, Srikakulam district.

Production of Biocontrol agents

- Mass multiplication of *Trichogramma chilonis*, Temparature tolerant *Trichogramma chilonis, Trichogramma japanicum* and *Trichogramma pretiosum* with the protocol of NBAIR, Bangalore for the management of lepidopteran pests in rice, maize, sugarcane, cotton, vegetables.

S.no	Biocontrol agent	Quantity produced (Trichocards No)
1.	*Trichogramma chilonis*	2666
2.	Temparature tolerant *Trichogramma chilonis*	120
3.	*Trichogramma japanicum*	700
4.	*Trichogramma pretiosum*	500

Production of Entomopathogenic fungi (EPF)

- Mass production of Entomopathogenic fungi, *Beauveria bassiana* (NBAIR- Bb 45) and *Metarhizium anisopliae* (NBAIR- Ma35 & NBAIR- Ma4)) as conidiated rice and talc formulation with protocol of NBAIR, Bangalore for the management of whitegrub in sugarcane and fall army worm in maize.
- Initiated production of Entomopathogenic fungi, *Isaria fumosorosea* (Pfu-5) as conidiated rice, as talc formulation and oil formulation with protocol of NBAIR, Bangalore for the management of Coconut rugose spiralling whitefly.

S.no	Biopesticide	Quantity produced (Kg)
1.	*Beauveria bassiana* (NBAIR- Bb 45)	10
2.	*Metarhizium anisopliae* (NBAIR- Ma35)	180
3.	*Metarhizium anisopliae* (NBAIR- Ma4)	20
4.	*Isaria fumosorosea* (Pfu-5)	50

- Mass production of egg parasitoid, *Trichogramma chilonis* and sale of Trichocards to farmers, Daattcentes, sugar factories and department of agriculture and Revenue generated with Trichocards was Rs. 1,42,200.00
- Mass production of Entomopathogenic fungi (EPF), *Metarhizium anisopliae* as conidiated rice - kg produced for sale @ Rs.120/- per kg upto September, 2019 for the management of coconut rhinoceros beetle. Revenue generated with EPF was Rs. 19,200.00
- Total income generation with Biocontrol agents & Biopesticide under revolving fund during the year , 2019-20 : Rs. 1,61,400.00.

Preparation of Reports:

Information on Fall army worm in Andhra Pradesh for the questions raised at Lokshaba:

- Prepared and submitted information on Fall army worm in Andhra Pradesh for the questions raised at Lokshaba as per the letter received from Director of Research, ANGRAU.

Report on NBAIR-Ma 4 Efficacy data for CIBRC registration

- Prepared and submitted report on "Efficacy of entomopathogenic fungi, *Metarhizium anisopliae* (ICAR-NBAIR Ma4) for the management of white grub in sugarcane "during 2015-16 and 2016-17 for CIBRC registration by ICAR-NBAIR,Bangalore.

New Initiation

- AICRP on Biological control imparted skill trainings (15 No.) on farmer level production of entomopathogenic fungi, *Isaria fumosorosea* to 232 No. coconut farmers of Srikakulam, Vizianagram, Visakhapatnam districts for the management of new invasive pest, Rugose spiralling white fly and technical support supplied mother culture for village level production.

Training Programme on mass production of EPF to B.Sc(Ag) students

- Imparted Hands on training for mass production of EPF, *Metarhizium anisopliae* as a part of experiential learning programme for final year B.Sc(Ag) students 215 No at Agricultural College, Naira on 16.11.2019.

Training Programme on mass production of Biocontrol agents and biopesticides

- Associated with Skill training on mass production Biocontrol agents and biopesticides to 15 rural youth at RARS, Anakapalle for one week (13.2.2020 - 20.2 .2020) .

Awareness programme on Biological control

- Conducted awareness programme to Biocontrol demonstration farmers (40 No) from Ranasthalam mandal, Srikakulam district and Denkada mandal, Vizianagaram district on 23.11.2019 at RARS,Anakapalle during 61st Kisan mela .

Training Programme on mass production of EPF to B.Sc (Ag) students

- Imparted Hands on training for mass production of EPF, *Metarhizium anisopliae* as a part of experiential learning programme for final year B.Sc(Ag) students 215 No at Agricultural College, Naira on 16.11.2019.

Exposure visit on Biological control

- Conducted Exposure visit to farmers (100 No) from Chuodavaram and Munagapaka mandals, Visakhapatnam district on 23.11.2019 and created awareness on Biocontrol practices for maize fall army worm and paddy pests at RARS, Anakapalle during 61st Kisan mela .

Parthenium awareness programme

- Conducted Parthenium awareness programme at RARS, Anakapalle on 22.08.2019 as per ICAR- Directorate of Weed Research, Jabalpur under the guidance of Associate Director of Research involving scientists and created awareness among Agricultural polytechnic students about Parthenium hazardsand its management and effectiveness of Biocontrol agent, *Zygogramma bicolorata.*

Kisan mela

- **P**articipated in Kisan mela at ARS, Vizianagaram and arranged exhibition for popularization of Biological control agents 19.10.2019.
- Participated in Kisan mela at RARS, Anakapalle and discharged duties of co-convenor, Exhibition committee on 23.11.2019 and arranged exhibition for popularization of Biological control agents.
- Participated in Kisan mela at RARS, Chinthapalli on 27.02.20 and arranged exhibition for popularization of Biological control agents.

Training programme organized by Department of Agriculture

- Imparted training programme on Ecological engineering to ADA's, Ao's of Department of Agriculture, Visakhapatnam at FTC, Anakapalle on 18.11.2019 for YSR Polambadi programme.
- Imparted training programme on Biological control agents (parasites, predators, fungi, bacteria) in pest management to ADA's, Ao's of Department of Agriculture, Vizianagaram on 03.01.2020 for YSR Polambadi programme.

Training programme on Pink bollworm management organized by DAATTCentre:

- Participated in pink bollworm management in cotton farmers training programme organised by Daattcentre, Vizianagaram on 16.09.2019 at Piridi, Bobbilli mandal, Vizinagaram district, gave lecture on Cotton pink bollworm worm identification, damage and management practices. Conducted demonstration of pink boll worm management with Trichocards in 5 acres area.

Rythu Dinothsavam and Rythubharosa Rythusadassu organized by Department of agriculture:

- Participated in Rythu Dinothsavam orgainsed at Bheemili constituency along team on 08.07.2019, explained about fall army worm management in maize; importance of biologicl control in organic farming of vegetables.
- Participated in Rythubharosa Rythusadassu organized by JDA, Visakhapatnam at Chodavaram, Visakhapatnam district and arranged exhibition on 15.10.2019.

Phone in live programme

- Dr M. Visalakshi participated in Phone in live programme organized at RARS, Anakapalle in coordination with Eenadu and advised answers to the queries raised by farmers in major crops of Visakhapatnam district.

Visitors to Biocontrol lab:

- Explained about Laboratory mass production techniques in multiplication of Biocontrol agents and new invasive pest, fall army worm in maize to IAS Trainees during visit to Biocontrol lab on 18.07.19 .
- Explained about mass production of *Metarhizium anisopliae* to B.Sc (Ag) students for production at Agricultural college, naira under AELP programme on 24.09.2019.
- Explained about Laboratory mass production techniques in multiplication of Biocontrol agents to Commissioner of Agriculture, Government of Andhra Pradesh on 3.11.2019.
- Explained about Laboratory mass production techniques in multiplication of Biocontrol agents to B.Sc (Horticulture) Students of RHWEP programme from Horticulture Research station, T.Venkupalem on 8.11.2019.
- Explained about Laboratory mass production techniques in multiplication of Biocontrol agents to B.Sc (agriculture) Students from College of Agriculture, Naira , Srikakulam district on 29.11.2019.
- Explained about Laboratory mass production techniques in multiplication of Biocontrol agents to NGO farmers from East Godavari district during visit to Biocontrol lab on 19.2.2020.
- Explained about Laboratory mass production techniques in multiplication of Biocontrol agents to farmers under RKVY project "State of art training centre for skill development and empowerment of rural youth on farm mechanization and allied farm engineering technology – network centre" during visit to Biocontrol lab on 22.08.2019.

Articles published

1. Mahanthi Visalakshi, T.R. Ashika, T. Venkatesan, Chandish R. Ballal, K. Laxman, D. Nagarjuna, G. Chittibabu , P. Venkatarao and P. Jamuna 2019 . "Report of the invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) and its natural enemies on maize and other crops from Andhra Pradesh, India" *Journal of Entomology and Zoology Studies, 7(4):1348-1352.*
2. BL Manisha and M Visalakshi 2019. To study and compare the mass rearing and biology of Eri silkworm *Samia cynthia ricini* with Rice meal moth *Corcyra cephalonica* for *Trichogramma chilonis* multiplication " *Journal of Entomology and Zoology Studies,* 7(5): 1045-1049.
3. B L Manisha, M Visalakshi, D V Sairam Kumar and P Kishore Varma 2018. Evaluation of Best Method for Sterilization of Eri Silkworm Eggs Under U.V. Radiation and Refrigerator Storage for Trichocard Production. *The Andhra Agric. J* 65 (2): 378-383.

4. B L Manisha, M Visalakshi, D V Sairam Kumar and P Kishore Varma 2018. Resource efficient and cost reduction technology for *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) production *Journal of Biological Control,* 32(3): 172-178.

Broucher prepared:

- Associated with ICAR- NBAIR in preparing broucher on "Kattera purugu- fall army worm" (telugu language) .
- Prepared broucher on "Kobbarinasinche sarpilakara thelladoma Nivarana- Jeevaniyanthrana paddathulu" (Coconut rugose spiralling whitefly).

COA, Vellayani

Popularisation of biocontrol agents

It was approved as a contingency centre in 2018-19. Four experiments were approved and were completed. Through these experiments we could popularize and demonstrate the efficacy of biocontrol agents in managing the major pests of rice, *L.acuta* and *C. medinalis*. Farmers could be convinced that the biocontrol agents if given a chance could perform well and significantly reduce the pesticide use especially in wet land padasekharams were the chemicals are straight away washed off to water bodies.

Mass production and distribution of biopesticides to farmers: The centre undertakes mass production of biopesticides and pheromone traps to encourage non chemical methods of pest control. The average annual out turn is Rs 2.0 lakhs.

Biopesticides sold from the centre (19-20)

S. No	Item	Quantity
1	*Beauveria bassiana*	415.5 kg
2	*Lecanicillium lecanii*	500 kg
3	*Metarhizium anisopliae*	110 kg
4	Cue lure traps	360 No.
5	ME traps	615 no

New *Trichogramma* production unit: A production unit of *Trichogramma* has been established which will be under function shortly.

Research on biocontrol: The centre focuses on isolation of indigenous biocontrol agents and development of improved forulatos such as chitin enriched oil formulations, capsule formulations etc. Currently 3 Pg and 3 Ph Dprojects are ongoing in the field of biocontrol.

Publications and honors in Biological Control: 6 numbers

1. Nithya P.R and Reji Rani O.P (2019). Enriched bioformulations of *Lecanicillium lecanii* (Zimmermann) Zare and Gams against sucking pests of yard long bean *Vigna unguiculata* L. Walp *sesquipedalis*. Journal of Entomological Research 43(4) 445-450

2. Sreeja P and Reji Rani O.P (2019) Volatile Metabolites of *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and their toxicity to brinjal mealy bug *Coccidohysterix insolita*(G) in the Entomon 44 (3) 183 -190.
3. Reji Rani O.P. and Remya S. (2019). Capsule formulations of *Beauveria bassiana* for the management of pseudostem weevil, Proceedings of the International Conference on Plant Protection in Horticulture: Advance and Challenges,2019, pp 38
4. P. Sreeja and O.P. Reji Rani (2019) Insecticidal metabolites of *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and their toxicity to brinjal mealy bug *Coccidohystrix insolita* (G), Proccedings of the International Conference on Plant Protection in Horticulture: Advance and Challenges,2019, pp 97
5. Remya S. and Reji Rani O.P, (2019). Capsule formulation of *Metarhizium* for the mnagement of banana rhizome weevil. Proceedings National Seminar Promotion of Ecofriendly and Sustainable innovation. Pg. 13
6. Sreeja P and Reji Rani O.P (2019). Insecticidal metabolites from *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and their toxicity to brinjal mealy bug *Coccidohysterix insolita*(G) –Proceedings of the National conference on Phytochemicals and Microbial Bioactive Compounds – Role in Agriculture and Human welfare (PMBC 2019) conducted by Dept. of Microbiology and Biotechnology, Bangalore University, held during 3-4 October 2019, Bengaluru.

Awards

1. **Best Poster Award** for the paper entitled Capsule formulation of *Metarhizium* for the management of banana rhizome weevil by Remya S and Reji Rani, O.P (2019). National Seminar Promotion of Ecofriendly and Sustainable innovation.
2. **Best Paper Award** – for the paper authored by Sreeja P and Reji Rani O.P (2019). Insecticidal metabolites from *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and their toxicity to brinjal mealy bug *Coccidohysterix insolita* (G) –in the National conference on Phytochemicals and Microbial Bioactive Compounds – Role in Agriculture and Human welfare (PMBC 2019) conducted by Dept. of Microbiology and Biotechnology, Bangalore University, held during 3-4 October 2019, Bengaluru.
3. Women Scientist Award 2019 – for contributions in Agricultural Entomology in the field of Biological Control at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology and Toxicology" on 17 November 2019 at Chennai, Tamil Nadu.

Trainings/radio talks and television programmes

S.No	Topic	Beneficiaries	Venue	Date
1	Management of Fruits flies in mango using biopesticides and pheromone traps	Farmer queries	AIR	15.5.1
2	Biocontrol agents for pest and disease managemnt	Live phone in programme in krishi darshan	Doordarshan	24.7.19
3	Hands on training on Fruitfly trap preparation	Staff of Parasite Breeding Station, Parottukonam, Nalanchira, TVM	CoA Vellayani	4.10.19
4	IPM in vegetables and	Farmers, organised by Dept	Eravipuram	5.10.19

	fruit crops of Kerala	of Agriculture	block, Kollam district	
		Live phone in for pest mangement on organic farming		8.11.19
5	Biological control of pests of vegetables	Farmers	Nemom Block	18.2.20

CPCRI, Kasargod

Publications
Research

1) Josephrajkumar, A., Chandrika Mohan, Merin Babu, Arya Krishna, Krishnakumar, V. Vinayaka Hegde and Chowdappa, P. (2019) First record of the invasive Bondar's Nesting Whitefly, *Paraleyrodes bondari* Peracchi on coconut from India. *Phytoparasitica* 47(3): 333-339. DOI 10.1007/s12600-019-00741-2

2) Chandrika Mohan, Josephrajkumar, A., Merin Babu, Arya Krishna, Prathibha, P.S., Krishnakumar, V. and Vinayaka Hegde (2019) First record of the non-native neotropical nesting whitefly, *Paraleyrodes minei* Iaccarino on coconut palms in India and its co-existence with Bondar's nesting whitefly *Paraleyrodes bondari* Peracchi. *Current Science* **117**(3): 515-519.

Seminar Proceedings

1) Josephrajkumar, A., Chandrika Mohan, Regi J. Thomas, Shareefa, M., Anes, K.M. and Krishnakumar, V. (2019) Crop Pluralism in Coconut Plantation for Pest regression.pp 64 In: *Compendium on papers and abstracts -Workshop on organic farming in plantation crops-Present status and future prospects*. (Eds.) Ravi Bhat, Subramanian P. Abdul Haris A, Merin Babu, Josephrajkumar A., Krishnakumar, V. and Anitha Karun, September, 20, 2019, ICAR-CPCRI, Kayamkulam.

2) Josephrajkumar, A., Chandrika Mohan, Jijo Paul, Regi J. Thomas, Vinayaka Hegde and Krishnakumar, V. (2019) Smart Vigilance and stimulo-deterrance in the bio-suppresion of red palm weevil infesting coconut. *Workshop on Outsmarting the Red palm Weevil-A global challenge.* Abstract Book, XIX International Plant Protection Congress, November 10-14, 2019, Hyderabad, p49-50.

3) Prathibha, P.S., Josephrajkumar, A. and Ravindran Patali (2019) Essential oil repellents against red palm weevil *Rhynchophorus ferrugineus* Oliver (Curculionidae: Coleoptera) on coconut. *Workshop on Outsmarting the Red palm Weevil-A global challenge.* Abstract Book. XIX International Plant Protection Congress, November 10-14, 2019, Hyderabad, p 51.

4) Sajan Jilu, V., Maheswarappa, H.P., Srinivasan, T., Alagar, M., G Krishna Rao, G., Chakkani Priya, K., Chandrasekhar, C.S., Wankhede, S.M., and Josephrajkumar, A., (2019) Performance of botanical cake and paste against coconut rhinoceros beetle in juvenile palms. Workshop on the The challenge of coconut rhinoceros beetle (*Oryctes rhinoceros*) to palm production and prospects for control in a changing world, Abstract Book. XIX International Plant Protection Congress, November 10-14, 2019, Hyderabad, p 30.

5) Josephrajkumar, A., Merin Babu, Anes, K.M. and Kalavathi, S. (2019) Smart Agriculture Options for Next Generation Students. Agricultural Education Day, December 03, 2019 ICAR-CPCRI, Regional Station, Kayamkulam. 37p.

6) Josephrajkumar, A., Chandrika Mohan, Merin Babu, Anes, K.M., Regi J. Thomas and Vinayaka Hegde (2020) Strengthening quarantine and Incursion Management of Invasive Pests on Coconut. *In*: *Souvenir cum Abstracts International Seminar on Transboundary Pest Management* pp 137-138, March 04-05, 2020, TNAU, Coimbatore.

7) Merin Babu, Josephrajkumar, A., Anes, K.M., Rajeev, G. and Kalavathi, S. (2020) Science Connect with New Age Students. *Proceedings of workshop on 'Inculcating Spirit of Science and Plant Health Management (ISSPHM)*' ICAR-CPCRI, Regional Station, Kayamkulam 43p.

Popular articles

1) Josephrajkumar, A., Thamban, C. and Shameena Beegum (2019) Barn owl for rodent management in Lakshadweep Islands. *Indian Cocon. J.* April issue **51**(12): 25-26.

2) Abdul Haris, A., Regi J. Thomas, Josephrajkumar, A. and Krishnakumar, V. (2019) *Mazhakala Paricharanam* : Thenginum Thaikalilum Appropriate planting of coconut seedlings in Monsoon (In Malayalam). *Kerala Karshakan* June issue **64**(11): 35-36.

3) Josephrajkumar, A., Chandrika Mohan, Merin Babu and Krishnakumar, V. (2019) Conservation Biological Control and Bio-scavenging: in Rugose Spiralling Whitefly Management in Coconut. *Indian Cocon. J.* **62**(5): 27-29.

4) Chandrika Mohan, Josephrajkumar, A., Anes, K.M. and Krishnakumar, V. (2019) Bio-suppression of coconut scale insects. *Indian Cocon. J.* **62** (8): 13-15.

5) Prathibha, P.S., Chandrika Mohan and Josephrajkumar, A. (2019) Integrated Management of coconut pests. *Indian Cocon. J.* **62** (8): 19-24.

Extension folder

1) Josephrajkumar, A., Chandrika Mohan, Merin Babu, Anes, K.M. and Krishnakumar, V (2019) *Mera Gaon Mera Gaurav-Success Stories of Kayamkulam 2018-2019*, ICAR-CPCRI, Regional Station, Kayamkulam, 2p.

Award

1) The research paper entitled "Strengthening quarantine and Incursion Management of Invasive Pests on Coconut' by Josephrajkumar, A., Chandrika Mohan, Merin Babu, Anes, K.M., Regi J. Thomas and Vinayaka Hegde, presented during the *International Seminar on Transboundary Pest Management*, held at TNAU, Coimbatore during March 4-5, 2020 was conferred the best oral presentation award.

Awareness programmes and field days organized

About 1300 farmers were successfully trained on novel cutting edge technologies in coconut health management through 20 technical sessions. In 11 women and youth empowerment programme, nearly 310 personnel were trained holistically. In all, 20 Farmer Field Schools were conducted empowering 250 farmers in palm health management for doubling income with a knowledge gain of 1.85 folds. About 50 technocrats of State Agricultural Department and Coconut Development Board were trained on scientific coconut farming approaches with inclusive farming strategies through eight technical sessions. In pest management sessions, emphasis was given to conservation biological control of invasive coconut whiteflies and biological control of coconut black headed caterpillar and rhinoceros beetle. Mass production of *Trichoderma* cakes was successfully implemented in Ernakulam and Palakkad district for tackling bud rot disease. Bio-priming of coconut seedlings using *Trichoderma* improved the seedling quality and growth standards. Area-wide implementation of crown cleaning and prophylactic application of neem cake and sand could reduce the incidence of rhinoceros beetle significantly at Thiruvananthapuram. Student community was oriented towards farming instincts and take up career in farm science in Agricultural Education Day and National Science Day programmes organized at the Station.

DSRYHU, Ambajipeta

Research articles/research notes published

S. No.	Title of the paper
1	Chalapathi Rao, N. B. V. Field efficacy of *Pediobius imbrues* (Hymenoptera: Eulophidae) parasitoid on coconut slug caterpillar *Macroplectra nararia* Moore (Limacodidae: Lepidoptera). 2019. Journal of Biological Control.
2	Chalapathi Rao, N. B.V., Rao, G.K., and Ramanandam, G. 2019. A new report on parasitisation of coconut spike moth, *Tirathaba rufivena* Walker by *Goniozus nephantidis* Muesebeck. Pest Management in Horticultural Ecosystems 24(2) 181-184
3	Neeraja, B., Ramanandam, G., Chalapathi Rao, N.B.V. and Padma, E. 2019. Evaluations of fungicides on *Phytophthora palmivora* incidence of bud rot disease in coconut under in vitro. International Journal of Chemical Studies 7(1): 208-210.
4	Chalapathi Rao, N.B.V., Roshan, D. R., Ramanandam, G and Maheswarappa, H. P. 2019. Hot spot areas of coconut slug caterpillar and its integrated management in Andhra Pradesh Indian coconut Journal February issue: 11-14
5	G. Krishna Rao and Chalapathi Rao, N.B.V. 2019. Surveillance N.B.V. 2019. Eco – Friendly management of new invasive alien pest, Rugose spiralling whitefly, *Alerodicus rugioperculatus* Martin: Inherent menace. J. Appl. Zool. Res. 30(2): 148-158.
6	Padma, E., Ramanandam, G., Ravindra Kumar, K., Kalpana, M., Chalapathi Rao, N.B.V. and Maheswarappa, H.P. 2019. Standardization of fertilizer requirement through fertigation for coconut under Krishna Godavari zone of Andhra Pradesh. Indian J. Hort. 76(4): 622-627

GBPUAT, Pantnagar

Student Guided: 02 M.Sc. Plant Pathology

i) Thesis topic- "Management of Root Knot Nematode (*Meloidogyne enterolobii*) in Tomato and Guava using Bio-intensive Approaches". Guided by Dr. Roopali Sharma

ii) Thesis topic- "Isolation, characterization and evaluation of antagonistic potential of *Trichoderma* against *Rhizoctonia Solani* causing aerial blight of soybean", Guided by Dr. Manju Sharma

Number of Publications:
Research papers: 05
Papers presented in conferences: 04
Proceeding Articles: 05
Popular Articles: 05
Folders: 02
Number of Trainings organised

S.No	Topic	Place	No. of Farmers
1	Use of Biocontrol agents in Rice	Dumkabangar	70
2	Setting up of soil solarization	Halduchaur	85
3	Seed treatment with Bioagents	Nathupur	40
4	Seed treatment of Pea with Bioagents	Motahaldu	55
5	Use of Pheromone trap in Rice	Dumkabangar	50
6	Use of Pheromone trap in Rice	Nathapur	30
7	Soil solarization of tomato Nursery	Davlamalla	75
8	Use of Biocontrol agent for seed treatment, soil treatment,seedling treatment in Tomato	Golapar	80
9	Introduction of Bioagents to farmers	Vijayrampura(TSP)	75
10	Implementation of CMP in vegetables	Vijayrampura(TSP)	125
11	Use of Biocontrol agents in Rice	Vijayrampura(TSP)	170
12	Introduction of Bioagents to farmers	Seetpuri (TSP)	120
13	Pea cultavitation under Biological control	Seetpuri (TSP)	200
14	Introduction of vegetable cultivation	Seetpuri (TSP)	165

No. of Bioagents supplied: 17.89 q Pant Bioagent 3: PBAT-3 (*T. asperellum* Th14 + *Pseudomonas fluorescens* Psf 173)

Farmers fair organized: Demonstrated Biocontrol technology and distributed 250 kg Bioagents in Pantnagar Kisan mela organized twice in a year (Oct, 2019 and March 2020) delivered 08 lectures for farmers in these Kisan mela and actively participated in question answer season for farmers during Kisan mela.

IIVR, Varanasi

Research Paper published:

- Jaydeep Halder, Deepak Kushwaha, A B Rai and B Singh. 2019.Interaction effects between entomopathogenic fungi and neonicotinoid insecticides against *Lipaphis erysimi* in vegetable ecosystem. *Indian Journal of Agricultural Sciences*, 89 (8): 1256-1261.

Research abstract published

- Jaydeep Halder and A B Rai. 2020. Impact of bio-intensive pest management module against major insect pests of tomato and its safety to predatory mirid bugs. *In*: “Indian Horticulture Summit-2020 Mitigating climatic change and doubling farmers’ income through diversification” at MGCGV, Chitrakoot, M.P. from 14-16th February, 2020. pp:172.

In-service awards &professional recognitions

- Dr. Jaydeep Halder, Senior Scientist, ICAR-IIVR, Varanasi awarded “***ISHRD Himadri Young Scientist Award 2014***” for outstanding contribution in the field of Horticulture by the Indian Society of Horticultural Research & Development (ISHRD), Uttarakhand, India during December, 2019.
- Dr. Jaydeep Halder awarded ***Third Best Oral paper*** for the research paper “Impact of bio-intensive pest management module against major insect pests of tomato and its safety to predatory mirid bugs” in the session-VI: Plant Health Management. *In*: “Indian Horticulture Summit-2020 Mitigating climatic change and doubling farmers’ income through diversification” at MGCGV, Chitrakoot, Madhya Pradesh during 14-16th February, 2020.

Training imparted

- Dr. Jaydeep Halderdelivered lecture on “*Concept and prospect of Biocontrol agents*” in National Horticulture Board, Gurugramsponsored EDP training programme on "Entrepreneurship Development Programme for Young Vegetable Growers of East Champaran District, Bihar" organized at ICAR-IIVR, Varanasi during December, 2019.
- Dr. Jaydeep Halderdelivered lecture on “Integrated Insect Pest management in Vegetable Crops” to the farmers from Arariya, Bihar under ATMA Areriya sponsored Training programme on “Improved production technologies in vegetable crops” during December, 2019 organized at ICAR-IIVR, Varanasi, Uttar Pradesh.

IGKV, Raipur

Bio-agents supplied from the Biocontrol laboratory, Department of Entomology, IGKV, Raipur (C.G.) during 2019-2020

***Corcyra* eggs supplied from Bio-control laboratory, Department of Entomology to different campus of IGKV**

S. No.	Items	Qty.	Centre	Date
1.	*Corcyra* eggs	2 c.c.	Manoj Chandrakar, Rajnandgaon	07/08/2019
2.	*Corcyra* eggs	2 c.c.	SGCARS, Jagdalpur	23/08/2019
3.	*Corcyra* eggs	10 c.c.	Dean, SGCARS, Jagdalpur	21/11/2019
	Total	**14 c.c.**		

Bracocards and *Bracon* adult supplied from Bio-control laboratory, Department of Entomology to different places.

S. No.	Items	Qty.	Centre	Date
1.	Braco cards	10 No.	Shri Chintamani Sahu	03/04/2019
2.	Braco card	15 No.	Shrikant Chandrakar, Village-Charmudiya, Dhamtari (C.G.)	12/04/2019
3.	Braco card	12 No.	PC, Sr. Scientist & Head, KVK, Kanker (C.G.)	29/11/2019

4.	Braco card	05 No.	Agam Prakash Patel, Urla, Kumhari, Durg (C.G.)	29/01/2020
5.	Braco card	02 No.	Vijendra Yadav, Janjgir-Champa (C.G.)	25/02/2020
6.	Braco card	05 No.	Shushil Sharma, Bemetara (C.G.)	25/02/2020
7.	Braco card	15 No.	Shri Charan Singh Sahu, Village- Todgaon, Arang Raipur	28/02/2020
8.	Braco card	05 No.	Sr. Scientist & Head, KVK, Janjgir-Champa (C.G.)	29/02/2020
	Total	**69 No.**		

***Zygogramma* beetles supplied from Bio-control laboratory, Department of Entomology to different places.**

S. No.	Items	Qty.	Centre	Date
	Zygogramma beetles	100 No.	Rakhi Sharma, Sharma Farms, Murethi, Chandkhuri, Arang Block-P (C.G.)	22/07/2019
1.	*Zygogramma* beetles	800 No.	Vijay Katre, Vimal G. Vaibhav, Village Dewada, Dist. Rajnandgaon (C.G.)	02/08/2019
2.	*Zygogramma* beetles	100 No.	KVK, Rajnandgaon	16/08/2019
3.	*Zygogramma* beetles	500 No.	Vijay Katre, Vimal G. Vaibhav, Village Dewada, Dist. Rajnandgaon (C.G.)	19/08/2019
4.	*Zygogramma* beetles	500 No.	Shri H.R. Sahu, Vill.- Nagadabri, Balod (C.G.)	20/08/2019
	Zygogramma beetles	300 No.	High School, Jora, Raipur (C.G.)	21/08/2019
5.	*Zygogramma* beetles	900 No.	Rakhi Sharma, Sharma Farms, Murethi, Chandkhuri, Arang Block-P (C.G.)	22/08/2019
6.	*Zygogramma* beetles	50 No.	RARS, Anakapalle, Vishakhapatnam, Andhra Pradesh	30/08/2019
7.	*Zygogramma* beetles	100 No.	Nayan Taunk, Farmer, Village-Sonpairi, Block- Abhanpur, Dhamtari (C.G.)	27/09/2019
8.	*Zygogramma* beetles	100 No.	Abhishek Tiwari, Farmer, Ahiwara, Durg (C.G.)	10/10/2019
9.	*Zygogramma* beetles	200 No.	KVK, Dantewada (C.G.)	21/10/2019
10.	*Zygogramma* beetles	100 No.	Manish Choudhary	06/11/2019
11.	*Zygogramma* beetles	200 No.	KVK, Dantewada (C.G.)	06/11/2019
12.	*Zygogramma* beetles	100 No.	Dean, SGCARS, CoA, Jagdalpur (C.G.)	21/11/2019
13.	*Zygogramma* beetles	200 No.	PC, Sr. Scientist & Head, KVK, Kanker (C.G.)	29/11/2019
14.	*Zygogramma* beetles	20 No.	Jitendar Patel, Korba (C.G.)	25/02/2020
15.	*Zygogramma* beetles	30 No.	Shushil Sharma, Bemetara (C.G.)	25/02/2020

16.	*Zygogramma* beetles	100 No.	Sr. Scientist & Head, KVK, Janjgir-Champa (C.G.)	29/02/2020
	Total *Zygogramma* supplied	**4400**		

Reduviid bug supplied from Bio-control laboratory, Department of Entomology to different places.

S. No.	Items	Qty.	Centre	Date
1.	Reduviid bug	10 No.	CIPM, Raipur (C.G.)	31/07/2019
2.	Reduviid bug	15 No.	Vijay Katre, Vimal G. Vaibhav, Village Dewada, Dist. Rajnandgaon (C.G.)	19/08/2019
3.	Reduviid bug	200 No.	Anup Tiwari, Rajnandgaon (C.G.)	30/08/2019
4.	Reduviid bug	40 No.	Manoj Chandrakar, Rajnandgaon	07/08/2019
5.	Reduviid bug	30 No.	Manoj Chandrakar, Rajnandgaon	03/09/2019
6.	Reduviid bug	50 No.	Turesh Janghel, Khiragarh, (C.G.)	17/09/2019
7.	Reduviid bug	200 No.	Nayan Taunk, Farmer, Village- Sonpairi, Block- Abhanpur, Dhamtari (C.G.)	24/09/2019
8.	Reduviid bug	200 No.	KVK, Dantewada (C.G.)	21/10/2019
9.	Reduviid bug	50 No.	Manish Choudhary	06/11/2019
10.	Reduviid bug	100 No.	KVK, Dantewada (C.G.)	06/11/2019
11.	Reduviid bug	100 No.	Dean, SGCARS, CoA, Jagdalpur (C.G.)	21/11/2019
12.	Reduviid bug	150 No.	PC, Sr. Scientist & Head, KVK, Kanker (C.G.)	29/11/2019
	Total Reduviids supplied	**1145**		

Trichocards supplied from Bio-control laboratory, Department of Entomology to different places.

S. No.	Items	Qty.	Centre	Date
1.	Trichocards	10 No.	Shri Chintamani Sahu, Farmer, Mahasamund, (C.G.)	03/04/2019
2.	Trichocard	45 No.	Shrikant Chandrakar, Village- Charmudiya, Dhamtari	12/04/2019
3.	Trichocard (*T. japonicam*)	02 No.	Dean, TCBCARS, Bilaspur	27/07/2019

			(C.G.)	
4.	Trichocard (*T. chilonis*)	15 No.	KVK, Rajnandgaon, (C.G.)	29/07/2019
5.	Trichocard (*T. japonicam*)	01 No.	CIPM, Raipur (C.G.)	31/07/2019
6.	Trichocard	05 No.	Rakesh Kumar Sahu, Karamtara, Khairagarh, Rajnandgaon (C.G.)	08/08/2019
7.	Trichocard	08 No.	Santosh Kumar Sahu, Kaagdehi, Arang Block (C.G.)	14/08/2019
8.	Trichocard	15 No.	KVK, Rajnandgaon (C.G.)	16/08/2019
9.	Trichocard	02 No.	Shri H.R. Sahu, Vill.- Nagadabri, Balod (C.G.)	20/08/2019
10.	Trichocard	06 No.	Pratik Shrivastav, Vill.- Kisna, Balod (C.G.)	21/08/2019
11.	Trichocard	15 No.	Shri Shashi Bhushan Patel, Vill.- Kisna, Balod (C.G.)	22/08/2019
12.	Trichocard	15 No.	Shri Fattelal Sahu, Vill.- Kisna, Balod (C.G.)	22/08/2019
13.	Trichocard	20 No.	KVK, Raipur (C.G.)	22/08/2019
14.	Trichocard	13 No.	Vikas Singh Thakur, IGKV, Raipur (C.G.)	22/08/2019
15.	Trichocard (*T. chilonis*)	20 No.	KVK, Raipur (C.G.)	22/08/2019
16.	Trichocard (*T. chilonis*)	06 No.	Shrikant Chandrakar, Charmudiya, Kurud, Dhamtari (C.G.)	28/08/2019
17.	Trichocard (*T. japonicam*) 25 (*T. chilonis*) 25	25 No.	Incharge, State Biocontrol Laboratory, Bilaspur (C.G.)	28/08/2019
18.	Trichocard (*T. japonicam*) 32 (*T. chilonis*) 16	48 No.	Shri Balram Singh, Vill.- Kunwa, Dist.- Bemetara (C.G.)	09/09/2019
19.	Trichocard (*T. japonicam*)	15 No.	KVK, Rajnandgaon, (C.G.)	09/09/2019
20.	Trichocard (*T. japonicam*) 25 (*T. chilonis*) 05	30 No.	Vijay Soni, Saja College, (C.G.)	11/09/2019
21.	Trichocard (*T. japonicam*) 04 (*T. chilonis*) 03 (*T. Pretiosum*) 03	10 No.	Shrikant Chandrakar, Village- Kurud, Dhamtari (C.G.)	12/09/2019
22.	Trichocard (*T. japonicam*) 06 (*T. chilonis*) 06	12 No.	Leela Ram Sahu, Villag- Dhooma, Kurud, Dhamtari (C.G.)	16/09/2019
23.	Trichocard (*T. japonicam*) 04 (*T. chilonis*) 02	06 No.	Dr. Sanjay Sharma, AICRP Rice, Raipur (C.G.)	16/09/2019
24.	Trichocard (*T. japonicam*)	04 No.	Turesh Janghel, Khiragarh, (C.G.)	17/09/2019
25.	Trichocard (*T. japonicam*)	25 No.	Ghasiya Ram Nishad,	18/09/2019

			Village- Kara, Raipur (C.G.)	
26.	Trichocard (*T. japonicam*) 12 (*T. chilonis*) 11	23 No.	Sr. Scientist & Head, KVK, Pahanda, Durg (C.G.)	19/09/2019
27.	Trichocard (*T. japonicam*) 21 (*T. chilonis*) 13	34 No.	Kirti Ram Nishad, Village- Manohara, Simga (C.G.)	19/09/2019
28.	Trichocard (*T. japonicam*) 35 (*T. pretiosum*) 10	45 No.	Shrikant Chandrakar, Village- Kurud, Dhamtari (C.G.)	23/09/2019
29.	Trichocard (*T. japonicam*)	15 No.	Sr. Scientist & Head, KVK, Rajnandgaon (C.G.)	26/09/2019
30.	Trichocard	06 No.	Shri Kushak Kumar, Farmer, Village- Mohara, Rajnandgaon (C.G.)	28/09/2019
31.	Trichocard (*T. japonicam*) 25 (*T. pretiosum*) 05	30 No.	Dr. Vijay Soni, College of Agriculture, Marra (C.G.)	28/09/2019
32.	Trichocard (*T. japonicam*) 04 (*T. pretiosum*) 04	08 No.	Omprakash Verma, Village- Dumardee khurd, Rajnandgaon (C.G.)	30/09/2019
33.	Trichocard (*T. japonicam*) 10 (*T. pretiosum*) 05	15 No.	KVK, Pahanda, Durg 2 (C.G.)	30/09/2019
34.	Trichocard	15 No.	KVK, Pahanda, Durg 2 (C.G.)	10/10/2019
35.	Trichocard (*T. japonicam*) 04 (*T. pretiosum*) 02	06 No.	Dr. Vikas Singh Thakur, Deptt. of Entomology, IGKV, Raipur (C.G)	11/10/2019
36.	Trichocard (*T. japonicam*)	10 No.	Shrikant Chandrakar, Village- Kurud, Dhamtari (C.G.)	18/10/2019
37.	Trichocard	15 No.	KVK, Pahanda, Durg 2 (C.G.)	19/10/2019
38.	Trichocard	15 No.	KVK, Pahanda, Durg 2 (C.G.)	31/10/2019
39.	Trichocard (*T. japonicam*) 25 (*T. pretiosum*) 30 (T. chilonis) 35	90 No.	KVK, Dantewada (C.G.)	21/10/2019
40.	Trichocard (*T. pretiosum*) 04 (T. chilonis) 04	08 No.	Manish Choudhary	06/11/2019
41.	Trichocard (*T. japonicam*)	15 No.	KVK, Pahanda (A), Durg-I	11/11/2019
42.	Trichocard (*T. pretiosum*)	02 No.	Sr. Scientist & Head, KVK, Rajnandgaon (C.G.)	04/01/2020
43.	Trichocard	60 No.	Sr. Scientist & Head, KVK,	

	(*T. pretiosum*) 30 (T. chilonis) 30		Raipur (C.G.)	
44.	Trichocards	95 No.	PC, Sr. Scientist & Head, KVK, Dantewada (C.G.)	18/11/2019
45.	Trichocards	15 No.	Sr. Scientist & Head, KVK, Pahanda, Durg-2 (C.G.)	11/11/2019
46.	Trichocards	12 No.	Sr. Scientist & Head, Raipur	27/01/2020
47.	Trichocards	20 No.	PC, Sr. Scientist & Head, KVK, Kanker (C.G.)	29/11/2019
48.	Trichocards	05 No.	Dean, TCBCARS, Bilaspur	21/11/2019
49.	Trichocards	04 No.	Kuleshwar Nishad, Balod, Gunderdehi	23/02/2020
50.	Trichocards	04 No.	Parmanand Verma, Devbagh, Raipur	23/02/2020
51.	Trichocards	02 No.	Damandas Sahu, Dongargarh, Rajnandgaon	23/02/2020
52.	Trichocards	02 No.	Yogesh Kumar Chandrakar, Mahasamund	24/02/2020
53.	Trichocards	02 No.	Omprakash Sahu, Balodabazar	25/02/2020
54.	Trichocards	04 No.	Sr. Scientist & Head, KVK, Janjgir-Champa (C.G.)	29/02/2020
55.	Trichocards	04 No.	Sr. Scientist & Head, KVK, Janjgir-Champa (C.G.)	29/02/2020
	Total	**954 No.**		

Coccinellid beetles supplied from Bio-control laboratory, Department of Entomology to different places.

S. No.	Items	Qty.	Centre	Date
1.	Coccinellid beetles (*Menochilus sexmaculata)*	20 No.	Vijay Katre, Vimal G. Vaibhav, Village Dewada, Dist. Rajnandgaon (C.G.)	19/08/2019
2.	Coccinellid beetles (*Menochilus sexmaculata)*	50 No.	Anup Tiwari, Rajnandgaon (C.G.)	30/08/2019
3.	Coccinellid beetles (*Menochilus sexmaculata)*	100 No.	Sanjay Chandrakar, Nepani Village, Balod (C.G.)	07/09/2019
4.	Coccinellid beetles (*Menochilus sexmaculata)*	50 No.	Turesh Janghel, Khiragarh, (C.G.)	17/09/2019
5.	Coccinellid beetles (*Menochilus sexmaculata)*	100 No.	Nayan Taunk, Farmer, Village- Sonpairi, Block- Abhanpur, Dhamtari (C.G.)	27/09/2019
6.	Coccinellid beetles (*Menochilus sexmaculata)*	50 No.	Gopavrindapala Dasa, Sector- 06, Bhilai, Durg (C.G.)	15/10/2019
7.	Coccinellid beetles (*Menochilus sexmaculata)*	200 No.	KVK, Dantewada (C.G.)	21/10/2019
8.	Coccinellid beetles	50 No.	Manish Choudhary	06/11/2019

	(*Menochilus sexmaculata)*			
9.	Coccinellid beetles (*Menochilus sexmaculata)*	100 No.	KVK, Dantewada (C.G.)	06/11/2019
10.	Coccinellid beetles (*Menochilus sexmaculata)*	200 No.	Nayan Taunk, Farmer, Village- Sonpairi, Block- Abhanpur, Dhamtari (C.G.)	10/12/2019
11.	Coccinellid beetles (*Menochilus sexmaculata)*	50 No.	Farmer, Arang (C.G.)	11/12/2019
12.	Coccinellid beetles (*Menochilus sexmaculata*)	50 No.	Shri Rahul Chandrakar, Farmer, Paragaon, Arang, Raipur (C.G.)	11/12/2019
13.	Coccinellid beetle (*Menochilus sexmaculata*)	100 No.	Sr. Scientist & Head, KVK, Rajnandgaon (C.G.)	04/01/2020
14.	Coccinellid beetle (*Menochilus sexmaculata*)	50 No.	Sr. Scientist & Head, KVK, Raipur (C.G.)	
15.	Coccinellid beetle (*Menochilus sexmaculata*)	25 No.	Jitendar Patel, Korba (C.G.)	25/02/2020
16.	Coccinellid beetle (*Menochilus sexmaculata*)	100 No.	Sr. Scientist & Head, KVK, Rajnandgaon (C.G.)	04/01/2020
17.	Coccinellid beetle (*Menochilus sexmaculata*)	100 No.	Sr. Scientist & Head, KVK, Janjgir-Champa (C.G.)	29/02/2020
	Total Coccinellid beetles supplied	**1395**		

KAU, Kumarakoam

The production of bio-inputs at KAU-RARS, Kumarakom for 2019-20 is as follows;
Lecanicilium lecanii -855 kg
Beauveria bassiana -856 kg

MPKV, Pune
Visitors

i. Shri. D.H. Barge, (Former Student, A.C.Pune) Subati flower farm, Naivasha, Nairobi , Kenya visited biological control laboratory on 1.4.2019.

ii Dr. A.L. Nargalkar, Head, Dept.of Agril. Entomology, DRBSKKV, Dapoli visited biological control laboratory and Fall Army worm trial plot of Maize on 2.4.2019

iii. Dr. Parag D. Turkhade, SMS (Plant Protection), KVK, Kaneri, Kolhapur visited biological control laboratory on 01.07.2019.

iv Dr. K.K. Zade, SMS (Agronomy) KVK, Aurangabad, visited biological control laboratory on 6.8.2019.

v Dr. Vishnu Gite, Scientist (Plant breeding), ARS, Badnapur visited biological control laboratory on 6.8.2019.

vi Shri. Amol Shinde, Additional PS, Minister of State, Govt. of India visited biological control laboratory on 17.8.2019.

vii. Dr. S.D. Masalkar, Associate Dean and Principal, College of Horticulture, Pune visited biological control laboratory on 17.8.2019.

viii. Dr. S.D. Masalkar, Associate Dean and Principal, College of Horticulture, Pune visited biological control laboratory on 17.8.2019.
ix. Dr. P.D. Mane , BAU, Sabour, Bhagapur (Bihar) visited biological control laboratory on 21.8.2019.
x. Dr. A.V. Kolhe, Chief Plant Protection officer, DR. PDKV, Akola visited biological control laboratory on 21.8.2019.
xi. Dr. S.S. Jadhav, Ex. Head, Deptt. of Entomology, MPKV, Rahuri visited biological control laboratory on 20.9.2019.
xi. Dr. C. S. Patil, Head, Department of Agril. Entomology, MPKV, Rahuri visited and took review of research, education and allied activities on 04.10.2019.
xii. Dr. S. R. Gadakh, Director of Research and Director of Extension, MPKV, Rahuri visited Biocontrol laboratory and took review of research and allied activities on 10.10.2019.
xiii Dr. V. S. Supe, Associate Director of Research visited Biocontrol laboratory and took review of research and allied activities on 10.10.2019.
xiv. Dr. S. S. Jadhav, Ex. Head, Department of Agril. Entomology, MPKV, Rahuri visited & reviewed research activity on 11.10.2019.
xv. Hon. Chandrkant Kavlekar, Deputy Chief Minister of Goa State visited Biocontrol laboratory on 13.10.2019.
xvi. Dr. D. S. Pokharkar, Ex. Head, Department of Agril. Entomology, MPKV, Rahuri visited and reviewed research activity on 19.10.2019.
xvii. Dr. C. S. Patil, Head, Department of Agril. Entomology, MPKV, Rahuri visited and took reviewed of education and allied activities on 08.1.2020.
xviii. Dr. Chandish Ballal, Director, NBAIR, and Project Coordinator, AICRP on Biocontrol, Bangalore. visited the Biocontrol laboratory and experiment in the field. Monitored the research activity of the AICRP on Biocontrol, Pune on 01.02.2020. Dr. Chandish Ballal, Director, NBAIR, Bangalore, Bangalore interacted with Students of Experiential learning module of on Mass production of bioagent and Biopesticide.

Education and Teaching

i. 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 under Experiential Learning Programme Module (ELPM).
ii. Dr. S.M. Galande conducted the practical examination of Course No. AEL-ENT- 487 during 29 .4.2019 to 2.5.2019 and prepared the results sheet .
iii. Dr. S.A. More conducted Semester End Theory examination at College of Agriculture, Akluj and worked as Junior Supervisor for the examination period during 2.4.2018 to 8.4.2018.
iv. Dr. S. A. More worked as an Internal examiner During 05.10.2019 to 14.10.2019 Semester end Practical Examination of III New and external examiner for II Old Semester end practical examination.
v. Dr. S.A. More conducted the Theory and Practical classes of Course No, ENT 243 : Insect Ecology and IPM under UG programme.
vi. Dr. S. M. Galande worked as Senior Supervisor for final Semester End examination of III and V Semester at ABM, Gunjalwadi during 04-17 Nov., 2019.
vii. Dr. S. A. More worked as Senior Supervisor for final Semester End examination of III and V Semester at ABM, Narayngaon during 04-17 Nov., 2019.
viii. Dr. S.M. Galande, practical classes of Course No. ENT 121: Fundamentals of Entomology under UG programme.

ix. Dr. S.M. Galande conducted the Theory and Practical classes of Course No. ENT 510: Principles of Integrated Pest Management under PG programme.

x. Dr. S.A. More conducted the Theory and Practical classes of Course No. ENT 501: Insect Morphology, under PG programme.

Extension development activities / Training imparted: (MPKV, Pune)

i. Dr. S.M. Galande presented PPT on FAW and answered the question raised by the Agril. officer and the Extension workers in State Level Subcommittee Meeting for Management of Fall Army Worm in Maharashtra for the year 2019-20 at Sakhar Sankul, Shivaji nagar, Pune on 2.4.2019.

ii. Dr. S.M. Galande attended State Level Subcommittee Meeting for Management of Fall Army Worm in Maharashtra for the year 2019-20, presented PPT on FAW ¸ and answered the question raised by the Agril. officer and the Extension workers, participated in finalising FAW strategies for Maharashtra state at Sakhar Sankul, Shivajinagar, Pune on 11.06.2019.

iii. College of Agriculture organized Ago Technology Exhibition on 12.9.2019 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.

iv. Dr. S. M. Galande delivered lecture on on FAW management at Susare Tal. Pathrdi on 27.9.2019

v. Dr. S. M. Galande delivered lecture on on FAW management at Jawali Tal. Phalatan on 10.1.2020.

vi. Six PG student of Agril. Entomology, College of Agriculture, Latur visited biocontrol laboratory on 2.12.2019. Provided the information of Mass production of Bioagent and Biopesticide.

vii. One staff member and 33 M.Sc. students from Prof. RMC, College Akurdi, visited biocontrol laboratory on 31.12.2019

Participation of scientists in conferences, meetings, seminars, workshops, symposia, Training etc. in India:

Research Meetings:

i. Dr. S.M. Galande attended RFRC meeting at Conference hall, Directorate Research Office, MPKV, Rahuri on 01.04.2019 and presented the recommendation on Okra in the meeting.

ii. Dr. S.M. Galande attended State Level Subcommittee Meeting for Management of Fall Army Worm in Maharashtra for the year 2019-20, presented PPT on FAW and Participated in discussion at Sakhar Sankul, Shivaji nagar, Pune on 2.4.2019.

iii. S.M. Galande attended technical session of Plant protection in Joint Agricultural Research and Development Committee Meeting, 2019 held at MPKV, Rahuri on 30.5.2019 and participated in the discussion.

iv. Dr. S.M. Galande and Dr S.A. More attended XXVIII Annual AICRP Biocontrol Workers Group Meeting' at the AAU, Anand held during 6^{th} to 8^{th}June, 2019. Dr. S. M. Galande, presented the research work done in AICRP on Biological Control of Crop Pests and Weeds, MPKV, College of Agriculture, Pune-centre and finalized the technical programme for 2019-20. Dr. S.M. Galande, act as Rapporteur in the meeting.

v. Dr. S.M. Galande attended State Level Subcommittee Meeting for Management of Fall Army Worm in Maharashtra for the year 2019-20, presented PPT on FAW and Participated in discussion at Sakhar Sankul, Shivajinagar, Pune on 11.06.2019.
vi. Dr. S.M. Galande and Dr. S.A. More attended ZREAC Meeting at Kamdhenu Hall, Commsionerate of Animal Husbandary, Gaeshkhind, Pune-67 and Participated in discussion in the meeting. Dr. S.A. More acted as Rapporteur for the meeting.
vii. Dr. S. M. Galande and S. A. More attended Pre RRC on 29.11.2019 at Dept. of Agril. Entomology, MPKV, Rahuri. Dr. Galande presented the report in the meeting.
viii Dr. S. M. Galande and Dr. S. A. More attended RRC on 17.12.2019 at Dept. of Agril. Entomology, MPKV, Rahuri. Dr. Galande presented the report in the meeting.

Publications

a. Scientific Publications

i. Kanitkar Sandippa, V. M. Raut, Medha Kulkarni, **S. A. More**, D. S. Pokharkar and Meghraj Kadam (**2019**): Efficacy of Brigrade BL (*Beauveria bassiana*) and other insecticides against thrips (*Thrips tabaci* Lindamen), fruit borer (*Spodoptera litura* Fab.) and mite (*Polyphagotarsonemus latus* B.) on chilli crop. Pestology: XLIII No.7 (6): 43-52.

ii. Debarmma S. L., Indira Ghonmode, **S. A. More**, C. S. Choudhary and Phadtare Y.B. (**2019**): Safety of various tested insecticides against natural enemies i.e. *Chelonus blackburni* Cameron. *J. of Entomol & Zoology Stud*.: 7(6): 384-387.

iii. Phadtare Y. B., **S. A. More**, C. S. Choudhary, Indira Ghonmode and Debarmma S. L. (**2019**): Studies on major pollinators and foraging activities of Indian honey bee *Apis cerana* Fab. on mango (*Mangifera indica* L.). *J. of Entomol & Zoology Stud*.: 7(6): 544- 549.

iv. Phadtare Y. B.,**S. A. More**, Indira Ghonmode, C. S. Choudhary, and Debarmma S. L. (**2019**): In vivo and in vitro studies of effect of different insecticides against Indian honey bee *Apis cerana* Fab. *J. of Entomol & Zoology Stud*.: 7(6): 550-554.

Popular articles/ Extension bulletin:

i. News entitled, "Guidance to Maize Growers," published in Namaste Phaltan: 11.1.2020
ii. News entitled, "Guidance to Maize Growers in Jawali," published in Sthairya Phaltan: 11.1.2020

MPUAT, Udaipur

Farmers Training: Three farmer's training were conducted at farmers field in different villages and to aware the farmers for biological control of crop pests in *Kharif* and *Rabi* seasons 2019-20.

S. No.	**Locations**	**Date of training**	**No. of Participants**
a.	**Non TSP area**		
1.	Sawaliya Ji, Chittorgarh	28/07/2019	246
	Total		**246**
b.	**TSP area**		

1.	Hyla, Sayra	03/08/2019	61
2.	Dakan Kotra, Girwa	13/02/2020	82
3.	Kavita, Badgaon	29/02/2020	91
	Total		**234**

Research Paper:

S.No.	Title
1.	Biology of fall armyworm, Spodoptera frugiperda (J.E. Smith) on different artificial diets. Lekha, **M.K. Mahla**, H. Swami, A K Vyas and K C Ahir. Journal of Entomology and Zoology Studies. 2020; 8(1): 584-586.

Published Abstract:

S.No.	Title
1.	Parasitism caused by *Trichogramma chilonis and Cotesia flavipes* against *Chilo partellus* Singh B., **Mahla M.K.**, Chhangani G. and Vyas A.K.
2.	Evaluation of different bio-pesticides against *Chilo partellus* infesting maize Chhangani G., **Mahla M.K.** and Vyas A.
3.	Biology of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on maize (*Zea mays*) Ahir K.C., **Mahla M.K.**, Lekha, Chhangani G. and Sharma K.

Departmental Activities:

1. Workshop on Insect Personality - Biodiversity and Behaviour, 28-29 January, 2020

A two-day Workshop on, "Insect Personality - Biodiversity and Behaviour" was organized at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur, during 28-29 January, 2020; aiming towards the professional skill development and competency among the beneficiaries. The workshop was attended by 50 graduate students and 20 faculty members. the workshop was graced by the presence of the distinguished dignitaries including: HVC, Dr. N. S. Rathore, Director Research, Deans of constituent colleges, Head of Departments, ZDR; the invited experts - Dr. S. Ramani, Dr. H.M. Yeshwanth (UAS, Bengaluru); Dr. R. Swaminathan, Emeritus Scientist (ICAR).

Production of Biopesticides and Bioagents in the departmental labs during 2019-20

S. No.	Particular	Production
1.	*Trichoderma viride*	1502.5Kg

2.	*Metarhizium sp.*	45 kg
3.	*Beauveria sp.*	50 kg
4.	*Tricho card*	4214 cards
5.	*SlNPV*	14 bottles (250 LE)
6.	*HaNPV*	12 bottles (250LE)

PJTSAU, Hyderabad

Visitors:

- Dr. Sudha Rani, CEO, AELP Programmes, PJTSAU visited the Centre in 24.4.2019
- Dr. A. K. Yadav, Consultant, APEDA, GOI & former Director, NCOF, Delhi visited the Centre in 10.5.2019
- Dr. Prabhu Raj, Prof & Head, Dept. of Entomology, UAS, Raichur visited the Centre on 24.5.2019
- Dr. Avil Kumar, Associate Director of Research, PJTSAU visited the Centre in 1 July, 2019 and January 2020
- Dr. Madhu Babu, CEO, AELP Programmes, PJTSAU visited the Centre in 7.8.2019
- Dr. Seema, Associate Dean, College of Agriculture, Rajendranagar PJTSAU visited the Centre in 21.8.2019
- Dr. Fabris, Visiting Faculty, Bio Varsity International, visited the Centre on 26.10.2019
- Dr. K.V.S.Meena Kumari, Dean of P. G. Studies, PJTSAU visited the Centre in 7.2.2020

Awards

1. Dr. S. J. Rahman - Received Best Teacher Award by Lions Club International on 8.9.2019
2. Served as member of Apex/Statutory Committees of Central & State Government:
3. Served as 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 (up to August 2019)
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

Technologies Developed

1. 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 *viz*, Adilabad, Nizamabad, Karimnagar, Sadasivpet (Medak), Mahbubnagar, Rajendranagar (Hyderabad), Warangal, Nalgonda and Khammam.

Education:

- B.Sc. (Ag.), M.Sc.(Ag.) and Ph.D. students of College of Agriculture, Rajendranagar, Hyderabad were trained different methodologies in rearing of different natural enemies and culturing & field use of microbial formulations.

Trainings (As Organizer/Resource Person):

- Imparted training on “Prtocols & Methodologies in Mass Production of *Metarhizium anisopliae*” on 20.5.2019 to all the staff of State Bio Agent Production Units/Labs under Govt. Telangana.
- 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”
- 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.
- Imparted training on “Biological Control in IPM” to Trainees under GOI programme organized by CIPMC, Hyderabad on 11.12.2019”
- 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.
- Imparted training on “Urban Pest Management” to Industry participants on 16.12.2019 organized by NIPHM, Hyderabad

TV/Radio Talk:

- Participated in several Radio Talks on Bio Agents & Bio Pesticides at All India Radio, Hyderabad during 2019-20.
- Participated in Doordarshan Phone In Live Programme and answered the queries of farming community on Biological Control at Doordarshan Kendra, Hyerabad during 2019-20.
-

Post/Under graduate teaching:

- Teaching Courses ENTO -507: Biological Control of Crop Pests 2 (1+1) to P.G. students and ELEC – 230: Bio Pesticides and Bio Fertilizers to U.G. students as Course In-charge
- Guiding M.Sc. (Ag) and Ph.D. students for their Research work in the capacity of Major guide & Member of Advisory Committee
- Ninth (9^{th}) Batch of AELP on Biological Control is being trained for entrepreneurship on mass production of Bio agents as part of B.Sc. (Ag) under graduation programme.

Participation of Scientists in Conferences, meetings, seminars, workshops, symposia in India and abroad:

- Participated in ZREAC meetings in Telangana during at Khammam (Central Telangana Zone), Rajendranagar (Sothern Telangana Zone) and Kamareddy (Northern Telangana Zone) during April, 2019.
- Participated in Brain Storming Session on Certificate Course on Plant Health Management in Organic Farming on 10 -11 May, 2019 organized by NIPHM, Hyderabad
- Participated in State Level Annual Workshop (Crop Protection) 2019-20 on 15 -16 May, 2019 organized at University Auditorium, PJTSAU, Hyderabad.
- Participated in State Level Seed Mela 2019 on 24 May, 2019 organized at University Auditorium, PJTSAU, Hyderabad.
- Participated in 28th Annual Bio Control Workers Group Meeting on 6-8 June, 2019 organized at Anand Agricultural University, Gujarat and chaired a session on Industry – Institute Interface.
- Participated in Work shop on Fall Army Worm in Maize on 29 June, 2019 organized by CIPMC, GOI at Commissionerate of Agriculture, Hyderabad.
- Participated in ICAR-NBAIR Industry Interface Meet on 26 June, 2019 organized at NBAIR, Bangalore and delivered a Lecture on Regulatory Requirements in commercialization of Bio Pesticides.
- Participated in Awareness Programme on Pink Boll Worm in Cotton Meet on 23 August, 2019 organized at Gadwal Jointly by PJTSAU and M/S Kaveri Seeds Pvt. Ltd.
- Participated in Stake Holders Meeting on 21 October, 2019 organized at Karimnagar by Bio Varsity International, New Delhi.
- Participated in a Review Meeting on 7.12.2019 mass production of Bio Agents & Bio Pesticides" to all the staff of State Bio Agent Production Units/Labs under Govt. Telangana at Commissionerate of Agriculture, Hyderabad.
- Participated in Farmers' meetings in at Khammam on 31.12.2019 and created awareness on FAW management in maize and PBW management in cotton.
- Participated in meeting organized under Adopted Village Programme by Rice Section, ARI on 19.2.2020 at Sheriguda Bhadrayapally village, Kothur Mandal, Rangareddy District and explained farmers about eco-friendly pest management practices in cotton, rice and maize.
- Participated in meeting organized by Director of Horticulture, Govt. of Telangana on 20.2.2020 in connection with Rugose Spiralling Whitefly (RSW) to formulate effective management strategies for implementation in affected coconut and oil palm belts in Khammam and Bhadradri Kothagudem districts.
- Participated in AGRITEX Exhibition organized from 23.2.2020 to 25.2.2020 by putting up exhibits of AICRP on Biological Control in PJTSAU Stall and explained the dignitaries, farmers and local visitors on management of pests and diseases through eco-friendly management practices
- Participated in Meeting and Exhibition organized on 26.2.2020 by KVK, Wyra in connection with Energy Conservation Day and addressed the farmers on management of Fall Army Worm (FAW) through eco-friendly management practices
- Participated in Awareness programme on RSW organized by Department of Horticulture at Aswaraopet on 29.2.2020 and took part in the demonstration of *Isaria*

fumasorosea entomo fungal bio agent and Azadirachtin (10000 ppm) spaying in the coconut fields at CSG, Aswaraopet.

- Participated in Pre ZREAC (Entomology & Plant Pathology) meeting organized on 12.3.2020 under the chairmanship of Associate Director of Research, Palem and Co-Chaired the session as University Head of Entomology. Presented the Work Done Report for 2019-20 & Proposed Technical Programme 2020-21 pertaining to AICRP on Biological Control, Rajendranagar as Principal Scientist & Head of AICRP on Biological Control.

List of Bioagents being maintained and mass produced

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 brasiliensis*	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

Technologies assessed/transferred

- *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.
- 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.
- Developed Conservation protocols based on Pest Predator Ratios for Sugarcane Woolly Aphid (SWA), *Ceratovacuna lanigerum* and predators, *Dipha aphidivora* & *Micromus igoratus*- These protocols were discussed and passed on to the managements of three leading Sugar mills in Telangana viz., Gayatri Sugar Mills, Kamareddy; Nizam Deccan Sugars, Medak and Ganapathi Sugars, Sangareddy.

- 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 *viz*, Adilabad, Nizamabad, Karimnagar, Sadasivpet (Medak), Mahbubnagar, Rajendranagar (Hyderabad), Warangal, Nalgonda and Khammam.

PAU, Ludhiana

Visitors

1. Students of B.Sc. (Medical) from Government College for Women, Ludhiana and students of B.Sc. (Agriculture) from Khalsa College, Amritsar visited biocontrol laboratory on 02.04.2019.
2. Scientists from University of Georgia, USA - Dr Allen Moore, Dean, College of Agriculture and Environment Science and Dr Glen Rains, Professor, Department of Entomology visited biocontrol laboratory on 09.05.2019.
3. Farmer Trainees under training programme in PAMETI, PAU Ludhiana visited biocontrol laboratory on 14.05.2019 and 25.2.2020.
4. Visit of Professor Dr. Zhihong Li, Department of Plant Quarantine, College of Plant Protection, China Agricultural University, Beijing, P. R. China on 22.08.2019.
5. Participants of Winter school organized by Department of Entomology visited biocontrol laboratory on 05.12.2019.
6. Dr M K Mahla, Professor and Head, Dr Anil Vyas and Dr Hemant Swami from MPUAT, Udaipur visited biocontrol labortatory on 10.02.2020.

Miscellaneous Information

Education, Training and Radio / TV talk

Post/under graduate teaching

Teacher	**No. of courses taught**	
	PG	**UG**
Dr Neelam Joshi	3	2
Dr Parminder Singh Shera	2	2
Dr Rabinder Kaur	1	3
Dr Sudhendu Sharma	1	3
	No. of PG students guiding/guided	
	Ph. D.	**M.Sc.**
Dr Neelam Joshi	2	2
Dr Parminder Singh Shera	1	1
Dr Rabinder Kaur	2	1
Dr Sudhendu Sharma	-	1

Thesis evaluation / Viva-Voce

- Dr P. S. Shera evaluated M.Sc. thesis and conducted viva-voce of student at Division of Entomology, SKAUST Jammu
- Dr P.S. Shera evaluated Ph.D. dissertation of student from CSIR-IHBT, Palampur
- Dr P.S. Shera acted as reviewer of International journals – Phytoparasitica (NAAS rating: 7.02) and Environmental Pollution (NAAS rating: 11.71)

Radio talk

Topic	**Date of recording**	**Date of broadcasting**
Dr Parminder Singh Shera		
Management of insect pests in sugarcane (All India Radio)	23.7.19	26.7.19

Lectures delivered

Title	**Event and Venue**
Dr Neelam Joshi	
Role of micro organisms as biocontrol agent: progress, problem and potential	Winter School on 'Ecological Perspectives in Arthropod Pest Management for Sustainable Crop Production, PAU, Ludhiana on 26.11.2019
Mass rearing of important entomopathogens and their characterization	Winter School on 'Ecological Perspectives in Arthropod Pest Management for Sustainable Crop Production, PAU, Ludhiana on 26.11.2019
Dr Parminder Singh Shera	
Use of tricho-cards for eco-friendly management of insect pests in *kharif* crops	State level training camp for PAU *Kisan* club members organized by Skill Development Center, Directorate of Extension Education at PAU, Ludhiana on 2.5.2019
Biocontrol of insect pests in *Kharif* crops	Refresher course on Plant Protection Measures for major *Kharif* Crops in Punjab at PAU Ludhiana on 30.7. 2019
Insect pest management in organic farming	Training course on 'Integrated Crop Production' organized by Skill Development Center, Directorate of Extension Education, PAU, Ludhiana on 26.8.2019
Strategies to enhance the effectiveness of natural enemies	Winter School on 'Ecological Perspectives in Arthropod Pest Management for Sustainable Crop Production, PAU, Ludhiana on 23.11.2019
Biocontrol strategies for eco-friendly pest management	Workshop on 'Use of Bioproducts for Crop Management in Punjab' organized by Punjab Farmers' Commission at Kalkat Vikas Chamber, Mohali on 18.2. 2020
Dr Rabinder Kaur	
Biocontrol of Insect Pests and Conservation of Natural Enemies	Dealers/ Members of Agricultural Cooperative Society in one year programme of Diploma in Agricultural Extension Services for Input Dealers at PAMETI, PAU Ludhiana on 29.06.2019

Sensitivity of bioagents to pesticide usage – Ecological implications and future prospects	Winter School on "Ecological Perspectives in Arthropod Pest Management for Sustainable Crop Production" held in Department of Entomology, PAU Ludhiana on 23.11.2019
Artificial diets in insect rearing	Winter School on "Ecological Perspectives in Arthropod Pest Management for Sustainable Crop Production" held in Department of Entomology, PAU Ludhiana on 23.11.2019
Dr Sudhendu Sharma	
Bioagents and their importance in organic farming	Training course on 'Organic Grower' organized by Skill Development Center, Directorate of Extension Education at PAU, Ludhiana on 17.4.2019
Bio-pest control in various crops	State level training camp for PAU Kisan club members organized by Skill Development Center, Directorate of Extension Education at PAU, Ludhiana on 6.6.2019
Identification of common insects as friends and foes	Training course on 'Integrated Crop Production' organized by Skill Development Center, Directorate of Extension Education, PAU, Ludhiana on 27.8.2019
BIPM - An ecological approach for sustainable agriculture	Winter School on 'Ecological Perspectives in Arthropod Pest Management for Sustainable Crop Production, PAU, Ludhiana on 23.11.2019
Use of bio-rationals for crop management in Punjab	Workshop on 'Use of Bioproducts for Crop Management in Punjab' organized by Punjab Farmers' Commission at Kalkat Vikas Chamber, Mohali on 18.2. 2020

Trainings/ training camps organized

Programme	**Venue**	**Dates**
Good Agricultural practices in summer moong	KVK Patiala	5.4.2019
Good Agricultural practices in summer moong	KVK Sangrur	8.4.2019
Biological control of insect pests in *kharif* crops	KVK, Hoshiarpur	26.4.2019
Integrated pest management under protected conditions	KVK Sangrur	21.5.2019
Good agricultural practices in *basmati* rice	PAU Ludhiana	30.5.2019
Mass production and utilization of tricho-cards in *kharif* crops for technical staff of biocontrol labs	Morinda Co-operative Sugar mills Ltd, Morinda	17.7.19
Integrated pest management in organic *basmati* rice	Dhira Patra (Ferozepur)	30.7.2019
Biological control of insect pests in organic *basmati* rice	Sarkaudi (Sangrur)	5.8.2019
Utilization of bioagents for management of insect pests in *kharif* crops	Kheri Kalan (Barnala)	14.8.2019
Biological control of insect pests in *kharif* crops	Bhadalwad (Sangrur)	4.9.2019
Biological control of insect pests in sugarcane	Garhshankar (Hoshiarpur)	13.9.2019

Biological control of insect pests in wheat	Village Biradwal (Patiala)	24.12.2019
Insect pest management in wheat	Village Sakraudi (Sangrur)	27.1.2020
Mass production of host insect and bioagents for technical staff of biocontrol lab	PAU, Ludhiana	4.3.2020
Insect pest management in rabi crops	Village Bhujowal (Patiala)	5.3.2020

Exhibitions arranged on bioagents and biocontrol technologies

Event	Date
Training on 'Biological control of insect pests in *kharif* crops' at KVK Hoshiarpur	26.4.2019
Training 'Good agricultural practices in *basmati* rice' at PAU, Ludhiana	30.5.2019
Training on 'Integrated pest management in organic *basmati* rice' at village Dhira Patra (Ferozepur)	17.7.19
Training on 'Biological control of insect pests in organic *basmati* rice' at village Sarkaudi (Sangrur)	30.7.2019
Training on 'Utilization of bioagents for management of insect pests in *kharif* crops' Kheri Kalan (Barnala)	5.8.2019
Research and Extension Specialists Workshop for *Rabi* crops at PAU Ludhiana	21.8.2019
Regional *Kisan mela*, Ballowal Saunkhri	10.9.2019
Regional *Kisan mela*, Amritsar	10.9.2019
Regional *Kisan mela*, Patiala	13.9.2019
Regional *Kisan mela*, Gurdaspur	17.9.2019
Regional *Kisan mela*, Faridkot	17.9.2019
Kisan mela, PAU, Ludhiana	21-22.9.2019
Research and Extension Specialists Workshop for *Rabi* crops at PAU Ludhiana	18.2.2020
Regional *Kisan mela*, Ballowal Saunkhri	6.3.2020
Regional *Kisan mela*, Amritsar	6.3.2020

Participation of scientists in conference, meetings, seminars, workshops, symposia, training extension etc. in India and abroad

- Dr P.S. Shera attended Brainstorming on Improving Sugar Recovery and Sugarcane Productivity in Punjab held at PAU, Ludhiana on April 8, 2019
- Drs Neelam Joshi and P.S. Shera participated in 28th Biocontrol Workers' Group Meeting of All India Coordinated Research Project on Biological Control of Crop Pests at Anand Agricultural University, Anand from June 6-8, 2019
- Drs Neelam Joshi, Sudhendu Sharma and Rabinder Kaur participated in sensitization workshop on impending insects threats in Punjab held at PAU Ludhiana on June 20, 2019

- Drs P.S. Shera and Sudhendu Sharma attended meeting on Promotion of Biocontrol in Sugarcane and *Basmati* rice at PAU regional research Station, Gurdaspur on July 8, 2019

- Drs Neelam Joshi, P.S. Shera, Sudhendu Sharma and Rabinder Kaur participated in Research and Extension Specialists Workshop for *Rabi* crops at PAU Ludhiana on August 21-22, 2019

- Drs P.S. Shera and Sudhendu Sharma participated in 7th Coordination Committee Meeting of Network Project on Conservation of Lac Insect Genetic Resources" at CAU, Imphal (Manipur), February 3-4, 2020

- Drs P.S. Shera, Sudhendu Sharma and Rabinder Kaur participated in Workshop on Use of Bioproducts for Crop Management in Punjab at Kalkat Vikas Chamber Mohali on February 18, 2020

- Dr P.S. Shera participated in Research and Extension Specialists Workshop for *kharif* crops crops at PAU Ludhiana on February 19, 2020

- Dr P.S. Shera attended 16th Research and 15th Extension Council meeting at PAU, Ludhiana on February 27, 2020

Participation in *Kisan melas*

Kisan mela	**Date**	**Name of Scientist(s)**
Regional *Kisan mela*, Ballowal Saunkhri	10.9.2019	Rabinder Kaur
Regional *Kisan mela*, Faridkot	17.9.2019	Sudhendu Sharma
Kisan mela, PAU, Ludhiana	21-22.9.2019	Neelam Joshi, P.S. Shera, Sudhendu Sharma, Rabinder Kaur
Regional *Kisan mela*, Nag Kalan, Amritsar	6.3.2020	Rabinder Kaur

List of publications

A) Research papers published in journals	**:**	**06**
B) Papers presented in symposium/ workshops/ seminars/ trainings, etc.	**:**	**06**
C) Extension publications	**:**	**07**
❖ Extension articles	:	04
❖ Extension folder	:	02
❖ Extension pamphlet	:	01

Research papers in referred journals:

1. Joshi N, Shera P S, Sangha K S and Sharma S (2019). Bioformulations for management of pod borer, *Helicoverpa armigera* (Hübner) in Mungbean (*Vigna radiata* L.). *Journal of Biological Control* 33: 76-79**(NAAS rating: 5.34)**

2. Kaur R, Sharma S, Shera P S and Sangha K S (2019). Biocontrol based IPM module against insect pests of cauliflower. *Indian Journal of Entomology* (Online published November 2019) **(NAAS: 5.89)**

3. Kaur R, Sharma S, Shera P S and Sangha K S (2019). Evaluation of anthocorid predator, *Blaptostethus pallescens* Poppius against spider mite, *Tetranychus urticae* Koch on okra under insect net cage condition. *Journal of Biological Control* 33: 236-241**(NAAS rating: 5.34)**

4. Kaur R, Gupta M, Singh S, Joshi N and Sharma A (2020). Enhancing RNAi efficiency to decipher the functional response of potential genes in *Bemisia tabaci* Asia II-1 (Gennadius) through dsRNA feeding assays. *Frontiers in Physiology* DOI*:10.3389/fphys.2020.00123* **(NAAS rating: 9.39)**

5. Ritika, Joshi N and Sangha KS (2019) Effect of adjuvants on *Lecanicillium lecanii* against nymphs of *Lipaphis erysimi* (Kalt*). Indian Journal of Entomology*, 81(3): 597-602 **(NAAS rating: 5.89)**

6. Sharma S, Shera P S and Sangha K S (2019). Species composition of parasitoids and predators in two rice agro-farming systems – effect of ecological intensification. *International Journal of Tropical Insect Science*. DOI https://doi.org/10.1007/s42690-019-00072-z **(NAAS rating: 6.85)**

Paper presented in conferences, symposia, trainings, workshops etc

1. Joshi N (2019). Role of micro organisms as biocontrol agent: progress, problem and potential. Paper presented at ICAR sponsored Winter School on 'Ecological Perspectives in Arthropod pest management for Sustainable Crop Production, Department of Entomology, Punjab Agricultural University, Ludhiana.

2. Joshi N (2019). Mass rearing of important entomopathogens and their characterization Paper presented at ICAR sponsored Winter School on 'Ecological Perspectives in Arthropod pest management for Sustainable Crop Production, Department of Entomology, Punjab Agricultural University, Ludhiana.

3. Kaur R (2019). *Sensitivity of bioagents to pesticide usage – Ecological implications and future prospects*. Proceedings of Winter School on "Ecological Perspectives in Arthropod Pest Management for Sustainable Crop Production" held in Department of Entomology, PAU Ludhiana

4. Kaur R (2019). *Artificial diets in insect rearing*. Proceedings of Winter School on "Ecological Perspectives in Arthropod Pest Management for Sustainable Crop Production" held in Department of Entomology, PAU Ludhiana

5. Sharma S and Shera P S (2019). *BIPM - an Ecological Approach for Sustainable Agriculture*. Paper presented at ICAR sponsored Winter School on 'Ecological Perspectives in Arthropod pest management for Sustainable Crop Production', Department of Entomology, Punjab Agricultural University, Ludhiana

6. Shera P S and Sharma S (2019). *Strategies to Enhance the Effectiveness of Natural Enemies*. Paper presented at ICAR sponsored Winter School on 'Ecological Perspectives in Arthropod pest management for Sustainable Crop Production, Department of Entomology, Punjab Agricultural University, Ludhiana

Extension publications:

Extension Articles

1. Shera P S, Sharma S and Kaur R (2019). *Mittar keeriyan rahi sauni dian faslan de haneekarak keeriyan dee roktham karo. Changi Kheti* June, 2019. pp 20-21.

2. Sharma S, Shera P S and Kaur R (2019). Biocontrol of insect pests in major *kharif* crops. *Progressive farming*, June, 2019. pp 21-22

3. Singh Sandeep and Shera P S (2020). Differentiate between useful predatory syrphid flies and harmful fruit flies. *Progressive Farming,* February, 2020. p 22, 33

4. Singh Sandeep and Shera P S (2020). *Labhdayak sirphid makhian ate hanikarak phal dian makhian di pehchan kiven kariae*? *Changi Kheti* February, 2020. pp 21-22

Extension booklets

1. Shera P S, Sharma S, Kaur R and Joshi N (2019). *Natural Enemies of Insect Pests in Punjab*. Department of Entomology, Punjab Agricultural University, Ludhiana
2. Shera P S, Sharma S, Kaur R and Joshi N (2019). *Punjab vich milan waale mittar keere.* Department of Entomology, Punjab Agricultural University, Ludhiana.

Extension pamphlet

1. *Mittar Kirian rahi haneekarak kirian dee roktham*, Punjab Agricultural University, Ludhiana (2020)

Bioagents/hosts maintained in the Biocontrol Laboratory

Host insects	**:**	*Corcyra cephalonica*, *Phenacoccus solenopsis*, *Galleria mellonela*, *Plutella xylostella*, *Pieris brassicae*, *Spodoptera litura*, *Spodoptera frugiperda*
Parasitoids	**:**	*Trichogramma chilonis*, *T. japonicum*, *T. pretiosum*, *T. embryophagum*, *Fulgoraecia melanoleuca*, *Bracon hebetor*, *Aenasius arizonensis*, *Cotesia glomerata*
Predators	**:**	*Chrysoperla zastrowi sillemi*, *Blaptostethus pallescens*
Entomopathogen	**:**	*Beauveria bassiana*, *Nomuraea rileyi*, *Metarhizium anisopliae*

- **A total revenue of Rs. 2,20,225/- was generated through sale of *Corcyra* eggs and tricho-cards to biocontrol laboratories and farmers**
- At present, four sugar mills (2 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.
- A linkage has also been developed by PAU with sugar mills which don't have their own biocontrol laboratory as tricho-cards are being supplied to farmers through these sugar mills in their respective mill areas.
- The nucleus culture of *Corcyra* and *Trichogramma* has been provided to Biocontrol labs of CIPM centre, Jalandhar, PAU Regional Stations (Abohar, Bathinda and Gurdaspur) and Sugar mills of Punjab

Technology transferred/demonstrated

- Large scale demonstrations of biocontrol technologies using bioagents, *T. chilonis* and *T. japonicum* for the management of sugarcane borers conducted over an area of 4823 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 179 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 131 ha for the management of leaf folder, *Cnaphalocrocis medinalis* and yellow stem borer *Scirpophaga incertulas* at farmers' fields in organic *basmati* rice.

SKUAST, Jammu

Teaching

- Was associated with UG/ PG teaching as principal course instructor of courses including : ENT- 325, VS- 315, ENT- 501, ENT- 503, ENT- 509, ENT-514, ENT-602, ENT-604

Students guided

- Actingas major guide of M. Sc. & Ph.D. student (one each)
- 04 students as Co guide (M.Sc.)
- 01 student as co guide (Ph.D.) (Delivered her Ph.D. viva)
- Acting as advisory member of 03 students
-

Publications - 06

1. **Ahmad**, M.J., SajadMohiudin& Abu Manzar (2019) Biological Control of cabbage aphid, *Brevicoryne brassicae*, in poly house, in Kashmir. J. Exp. Zool. 22(2): 1189-1195.

2. Ashaq H. Bhat, Tariq, H. Askari, **Ahmad, M.J.**, Suman, Asha and Ashok Kumar Chaubey (2019). Description of *Heterorhabditis bacteriophora* (Nematoda : Heterorhabditidae) isolated from hilly areas of Kashmir valley. *Egyptian Journal of Biological pest control*, 29:96.

3. Prithiv, Raj, V., Abu Manzar., **M. Jamal Ahmad.,** Imtiyaz, T. Nazki., Zahoor Ahmad, Bhat., Imran Khan and Mudasir Magray (2019). Seasonal incidence of major insect pests and mite on carnation under protected conditions in Kashmir, *J Exp Zool*, **22** (2) : 1197-1202.

4. Prithiv, Raj, V., Abu Manzar., **M. Jamal Ahmad.,**Imtiyaz, T. Nazki., Zahoor Ahmad, Bhat., Imran Khan and Mudasir Magray (2019). Management of major sucking pests on carnation under protected conditions in Kashmir, *Journal of Entomology and Zoology studies*, **7**(4): 1079-1084.

5. Fayaz Ahmad, Tali., Abu Manzar.,**M. Jamal Ahmad**., Imran Khan and Qurat-ul Ain (2019). Comparative resistance of mungbean genotypes against pulse beetles, *Callosobruchus maculatus* (F.) (Coleoptera:Bruchidae) under temperate condition of Kashmir valley, *Journal of Entomology and Zoology studies*, **7**(5): 51-58.

6. SajadMohi-ud-din and Naveed Anjum and **M. Jamal Ahmad** (2019). Seasonal incidence and natural enemy complex of aphid, *Aphis punicae* (Hemiptera: Aphididae) infesting pomegranate in Kashmir, *Journal of Biological Control* (Accepted)

No. of trainings organized - 03

Farmers' No. 150

Topic: Integrated management of Codling moth in Ladakh

Place: Kargil and Ladakh

No. of bioagents produced :06

No. of bio agents supplied:

- 10.0 lakh *Trichogramma cacoeciae* in Ladakh
- 2.0 lakh *T. chilonis* to K.D. farm against maize stalk borer
- 2.0 lakh *T. pretiosum* at Budgam against DBM
- 10,000 *B. pallescens* to farmers at Ganderbal and Srinagar for control of *Tetranychus urticae*

Farmers fair organized: KisanMela was organized by the University where farmers were interacted to use bio agents against a number of pests.

TNAU, Coimbatore

Visitors

S. No.	**Date**	**Visitors**	**Purpose**
1	29.05.19 09.11.19 27.01.20	Dr.G.Sivakumar, Principal Scientist, NBAIR, Bengaluru	To review the activities of AICRP- Biological control of crop pests
2.	09.08.19	Dr. S. Sithanantham, Director, Sun Agro Bioteech Research centre, Chennai	To visit the biocontrol laboratory
3.	13.09.19	Dr. N. Bakthavatsalam, Principal Scientist, NBAIR, Bengaluru	To review the activities of AICRP- Biological control of crop pests
4.	26.09.19	Dr. Chandish R Ballal, Director and Project Coordinator, NBAIR, Bengaluru	To review the activities of AICRP- Biological control of crop pests
5	03.03.20	Dr. R. Muniappan, Director, IPM Innovation Lab, Virginia Polytechnic Institute and State University, Blacksburg, USA	To visit the biocontrol laboratory

Awards / Honours / Recognition: Nil
Education and Training
Courses handled:
UG courses:

1. EXP401 – Commercial production of biocontrol agents (0+5) – Dr. S. Jeyarajan Nelson and Dr. R. Vishnupriya

Ph.D courses :

1. ENT 822 – Entomophages (2+1) - Dr. S. Jeyarajan Nelson

Training imparted / lectures delivered during the year

S.No.	Title of the training /lecture	Beneficiary /participants	Date	Sponsor
1.	Mass Production of biocontrol agents	B.Sc. (Asthetic Crop Science) students - 2Nos.	4.7.19 and 5.7.19	Sultan Qaboos Universiy, Muscat
2.	Mass Production of biocontrol agents	Diploma Agri. Students -40 Nos.	4.7.19	Institute of agriculture
3.	Mass Production of biocontrol agents	B.Sc. (Seri) students – 46Nos.	5.7.19	FC&RI, Mettupalayam
4.	Mass Production of biocontrol agents	B.Sc. (Ag.) students - 44Nos.	8.7.19	Sethubaskara Agricultural College, Sivagangai
5.	Mass Production of biocontrol agents	Farmers – 40 Nos.	18.09.19	KVK, Kottayam, Kerala
6.	Mass Production of biocontrol agents	Agricultural Officers - 6Nos.	14.10.19	Govt of Maldives
7.	Mass Production of biocontrol agents	Laboratory assistants	28.11.19	TNAU, Coimbatore
8.	Mass Production of biocontrol agents	Students 64 Nos.	4.12.19	PRIST deemed to be University, Tanjore
9.	Mass Production of biocontrol agents	Farmers – 40Nos.	10.12.19	MYRADA KVK, Gopi
10.	Mass Production of biocontrol agents	Farmers - 35 Nos.	07.01.20	Needamanagalam, Thiruvarur
11.	Mass Production of biocontrol agents	Students - 9 Nos.	20.01.20	SNGS College, Pattambi, Kerala
12.	Mass Production of biocontrol agents	Students - 43 Nos.	24.01.20	SRMV-IARD, PN Palayam
13.	Mass Production of biocontrol agents	Students - 29 Nos.	30.01.20	Govt. Boys Hr.Sec. School, Kavindapadi
14.	Mass Production of biocontrol agents	Farmers, Entrepreneurs - 18 Nos.	12.02.20	Paid training – Venture Capital scheme
15.	Mass Production of biocontrol agents	Farmers - 24 Nos.	12.02.20	ATMA, Wadakeva, Kozhikode
16.	Mass Production of biocontrol agents	Agricultural Officers -26 Nos.	26.02.20	Department of Agriculture, TamilNadu

5. Extension / Out reach programmes participated

Sl. No.	Date	Title of Program	Benificiary/ Participants	Organizers
1.	13.05.19 27.05.19	Doubling of farmers income Rugose spiralling white fly and maize fall army worm- awareness campaign Kinathukadavu	Farmers	JDA, Coimbatore
2.	14.05.19	Monthly Zonal Workshop	Department	JDA, Coimbatore

			Officials	
3.	21.06.19	Diagnostic field visit (Banana) - Salem	Farmers	P&H, Dept. of Agrl. Entomology
4.	06.09.19	Cassava mealy bug – Release of parasitoids - Demonstration	Farmers	ADA, Edapadi
5.	24.09.19	Coconut rugose spiralling whitefly – Field demonstration of IPM packages	Farmers	ATMA training Thippampatty - Pollachi
6.	25.09.19	Awareness campaign on fall army worm – RAWE students	Farmers	ATMA training, Valavadi
7.	11.10.19	Diagnostic field visit (Guava) – Allukuli, Gopi	Farmers	P&H, Dept. of Agrl. Entomology
8.	26.11.19	Coconut rugose spiralling whitefly – Field demonstration of IPM packages	Farmers	ATMA training Kalangal, Sulur
9.	11.12.19	Awareness campaign - Coconut rugose spiralling whitefly – Kosavampalayam, Sengodampalayam, Mulakarai	Farmers	KVK, Tirupur
10.	18.01.20	Awareness campaign - Coconut rugose spiralling whitefly	Farmers	ATMA training Kovilpudur,Madachur, Karapadi JDA, Erode
11.	20.01.20	Coconut rugose spiralling whitefly – Field demonstration of IPM packages	Farmers	ATMA training, Pichandampalayam
12.	23.01.20	Awareness seminar - Coconut rugose spiralling whitefly	Farmers	JDA, Erode
13.	04.03.20 05.03.20	Exhibition – Biocontrol agents of Coconut rugose spiralling whitefly - International seminar on Trans-boundary pest management	Scientists	TNAU, Coimbatore

Publications:

1. Jeyarajan Nelson.S., A.Aravind and A.Thennarasi.2020. Effect of biocontrol agents on maize fall army worm *Spodoptera frugiperda* (J.E. Smith). In: International seminar on Trans-boundary pest management, March 4,5, 2020, TNAU, Coimbatore Abstract P.No.157-158
2. Elango, K., S. Jeyarajan Nelson, S. Sridharan, V. Paranidharan And S. Balakrishnan.2019. Biology, Distribution and Host Range of New Invasive Pest of India Coconut Rugose Spiralling Whitefly *Aleurodicus rugioperculatus* Martin in Tamil Nadu and the Status of its Natural Enemies. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 9, pp.- 8423-8426.
3. Elango, K., S. Jeyarajan Nelson, S. Sridharan, V. Paranidharan And S. Balakrishnan.2019. biology and feeding potential of lady bird beetle *Cryptolaemus montrouzieri* muls. on new invasive pest of india coconut rugose spiralling whitefly *Aleurodicus rugioperculatus* Martin. *IJABR*,.9 (2): 145-148
4. Sangavi. R, Y.S. Johnson Thangaraj Edward, S. Jeyarajan Nelson and C. Meenambigai.2019. Anti-insect activities of solvent extracts of *Andrographis*

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5. Sangavi. R, Y.S. Johnson Thangaraj Edward, S. Jeyarajan Nelson and C. Meenambigai.2019. Anti-insect activities of solvent extracts of *Sesbania grandiflora* on the diamondback moth, *Plutella xylostella* (L.). International Journal of Chemical Studies, 7(6): 1443-1445
6. Dhivya, V., S. Jeyarajan Nelson and M. Paramasivam. 2019. Comparing extraction efficacy of different solvents to extract *Acorus calamus* by using HPLC. Journal of Pharmacognosy and Phytochemistry, 8(3): 3074-3078
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9. Ranjith, M., S. J. Nelson, S. Sithanantham, N. Natarajan and S. Praneetha. 2019. Efficacy of sweet flag formulation against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenée (Crambidae: Lepidoptera) and effect on egg parasitoids, *Trichogramma* spp. Pest Management in Horticultural Ecosystems, 25(2):172-177
10. Ranjith, M., S. J. Nelson, S. Sithanantham, N. Natarajan and S. Praneetha. 2019.Integrated control of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenée. Indian Journal of Entomology, 81(4):779-782
11. Elango, K and S. Jeyarajan Nelson. 2020. Effect of host plants on the behaviour of rugose spiralling whitefly, *Aleurodicus rugioperculatus* and their natural enemies. *Res. Jr. of Agril. Sci.*11(1): 120-123.
12. ***Elango, K., S. Jeyarajan Nelson and P. Dineshkumar.2020.*** Influence of ***colour*** *on* ***oviposition behaviour*** in green lacewing, *Chrysoperla zastrowi sillem*i (Esben - Petersen). *Entomon*, 45(1): 75-80
13. Elango, K, S. Jeyarajan Nelson, S. Sridharan, V. Paranidharan And S. Balakrishnan.2020. Influence of intercrops in coconut on *Encarsia guadeloupae* Viggiani parasitization of coconut invasive pest rugose spiralling whitefly *Aleurodicus rugioperculatus* martin. *Annals of plant protection sciences,* 28(1):1-4

UAS, Raichur

Awards/Recognition

ICAR- AICRP on Biocontrol	Awarded with first prize under ICAR/Hi-tech/International category, Krishi Mela of UAS, Raichur from 14th to 16th December, 2019

Incentive Award	On foundation day of UAS, Raichur during 25th Nonember 2019



After three days of Krishi Mela of UAS, Raichur our Biocontrol Hi- tech stall awarded first prize under ICAR/Hi-tech/International category from 14th to 16th December, 2019.

Publication

S. No	**Authors**	**Title**	**Publication**	**Volume**	**Pages**	**Year**
01	Swapnil Kharat, Ilce G. Medina-Meza, Ryan J. Kowalski, **Arunkumar Hosamani,** Ramachandra C.T., Sharanagouda Hiregoudar, Girish M Ganjyal	Extrusion processing characteristics of whole grain flours of select major millets (Foxtail, Finger, and Pearl)	Food and Bioproducts Processing	114	60-71	2019
02	Ashok1*, Basave Gowda1, S.R. Doddagoudar1, S.N. Vasudevan4, M.G. Patil2 and **Arunkumar Hosamani**[3]	Effect of Foliar Spray of Micronutrients and Growth Regulators on Seed Quality of Onion	International Journal of Current Microbiology and Applied Sciences		337-345	2019

03	Vijaykumar N Ghante, **Arunkumar C Hosamani** and Vikas Kulkarni	Biochemical constituents vis-a-vis Leafhopper, *Amrasca biguttula biguttula* (Ishida) tolerance in Sunflower germplasms	Journal of Entomology and Zoology Studies	7	235-238	2019
04	M. Shridhara*, S.G. Hanchinal, A.G. Sreenivas, **A.C. Hosamani** and J.M. Nidagundi2	Evaluation of Newer Insecticides for the Management of Brinjal Shoot and Fruit Borer *Leucinodes orbonalis* (Guenee) (Lepidoptera: Crambidae)	International Journal of Current Microbiology and Applied Sciences	8	2582-2592	2019
05	Sowmya E **Hosamani, A.** Sreedevi, K., Naveen and Reddy, N	Studies on species composition of root grubs under rainfed situations of Northeastern Karnataka	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		41	2020
06	Pradhan, K. Bheemanna, M. **Hosamani,** A. Hanchinal, S.G. and Saroja, N. Rao	Effect of abiotic factors in termination of diapauses of Pink bollworm, Pectinophora gossypiella (Saunders) (Lepidoptera: Gelechiidae)	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		188	2020
07	Mesta, D., Agadi, S N., Sowmya, E. and **Hosamani, A.**	Ocurrence of brinjal leaf webber *Herpetogramma bipunctalis* (Fabricius) on wild brinjal in Karwar district	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		43	2020
08	**Hosamani**, A. Ramanujam, B. Sowmya, E. and	Biological suppression of invasive pest American pinworm	XVII AZRA International conference on Frontier Research in applied zoology and		71	2020

	Ballal, C. R	*Tuta obsoluta* on tomato	insect pest management strategies: A way forward for food and nutritional security 2020			
09	Sowmya E **Hosamani**, A. Prakash, K. V. Sreedevi, K. and Reddy, N	Distribution and diversity of white grubs species in Northern Karnataka, India	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		91	2020
10	Sowmya E **Hosamani**, A. Ghante, N. V. Reddy, N., Ramya. Doddarayappa, S and Hiremath, R	Seasonal incidence of Guava and Ber fruit fly *Bactrocera* spp. and *Carpomyia vesuviana* costa and its impact on yield	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		92	2020
11	Hiremath, R. **Hosamani**, A. Sowmya, E, Ghante N. V. and Reddy, N	Efficacy of entomopathogenic fungus *Beauveria bassiana* against the chilli mite *Polyphagotarsonemus latus* (Banks) (Acari Tarsonemidae)	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		113	2020
12	Sowmya, E. **Hosamani**, A. Veena, K., Ramya Doddarayappa, S Reddy, N. and Hiremath, R	Studies on the Endophytic properties of Entomopathogenic fungi, *Beauveria bassiana* (Balsamo) against Maize Fall armyworm (*Spodoptera frugiperda* Smith)	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		116	2020
13	Kumar, V. V. **Hosamani, A. C.** Tyagi, K., Hanchinal S. G., Sushila, N. and Kisan, B	Evaluation of newer insecticides for the management of thrips on watermelon	Journal of Farm sciences		439	2020

14	Kiran, S., Prabhuraj A., **Hosamani, A.** Shivaleela and Pampanna	Density and diversity of predaceous coccinellidae in citrus and Guava ecosystem	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		8 - 9	2020
15	Jamuna, B. Bheemanna, M. Timmanna, **Hosamani**, A., and Ghante, V. N	Species diagnosis Occurrence of Thrips and Bud necrosis virus disease in Tomato	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		11	2020
16	Sharanappa, C. H. Katti, P., Hosamani A., Sushila, N. Desai, B. K. and Pampanna, Y	Evaluation of insecticides against thrips (thripidae Thysanoptera) and mites (Tarsonemidae Trombidiformes) of Capsicum	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		82	2020
17	Biradar, R. Bheemanna, M. Hosamani, A., Naik H., Naik, N. and Kandpal, K.	Current scenario of insecticide usage pattern in major Cabbage growing regions of Karnataka	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		87	2020
18	Sunilkumar, N. M. Mallikarjun, N. **HOSAMANI, A** and Ravi, S	Biology of Mango leaf webber, *Orthaga euadrusalis* walker	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		90	2020

19	Ranjith Kumar, E. Guruprasad, G. S. Srinivas, A.G. **Hosamani, A.** and Pramesh, D	Impact assessment of left over crop residues on stem borer damage incidence for subsequent crop	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		96	2020
20	Sudharani., Amaresh Y.S., **Hosamani, A** and Naik, M. K	Management of Pigeonpea sterility mosaic disease through acaricides	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		149	2020
21	**Hosamani,** A. Ramanujam, B. Sowmya, E.A. AND Ballal, C.R.	Biological suppression of Invasive pest American pinworm *Tuta absoluta* on tomato	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		162	2020
22	Nagaraju, M.C. Nadagouda, S. **Hosamani, A**. and Hurali, S.	Seasonal incidence studies on some important insect pests of Bitter gourd (*Momardicha charantia* L.)	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		205	2020
23	Ramya, **Hosamani** A., Vijaykumar N.G., Nadagouda, S and Kenganal, M.	Effect of host egg age on the parasitization ability of egg parasitoid *Trichogrammatoidea bactrae* (Nagaraja) on pink bollworm *Pectinophora gossypiella* (Saunders)	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		105	

24	Hiremath, R. Ghante, V.N. **Hosamani, A.,** . Amaresh,Y. and Shivaleela	Bioefficacy o Beauveria bassiana (Balsamo) and selected chemical insecticides against sunflower sucking pests	XVII AZRA International conference on Frontier Research in applied zoology and insect pest management strategies: A way forward for food and nutritional security 2020		105	2020

Radio talks/ Leaflets and folders/ Youtube

1. Bridge programme of All India Radio (AIR) was broadcasted on 24-07-2019 in which AIR,Dharwad, AIR Vijayapur and AIR Raichur jointly organized discussion on pest management in particular role of biocotrol was discussed (Dr. Arunkumar Hosamani).

2. Role of biocontrol agents in pest management was broadcasted on 06-09-2019 (Dr. Arunkumar Hosamani).

3. To promote biocontrol agents a special sponsored programme was conducted in AIR, Raichur i.e. State hook up programme for 15 minutes which was telecasted on 06-03-2020 all over Karnataka state to which UAS, Raichur paid Rs 20, 000 to AIR, Raichur.

4. Small jingles on various biocontrol agents are prepared and sent AIR, Raicur and those will be broadcasted in ensuing seasons to which UAS, Raichur paid Rs 18, 000.

5. Technical folder in Kannada were prepared and printed on three biocontrol agents

6. On youtube https://www.youtube.com/watch?v=QOHGOYCMd9c mass production is posted

7. On Google map visit biocontrol lab https://goo.gl/maps/FAR5PnyXJRB39KGd7

UBKV, Pundibari

Research Publications:

1. Sreedhar, B.K., Hath, T.K., **Sahoo, S.K., Chakraborty, D.** and Okram, S. (2019). Screening of Indian mustard genotypes against mustard aphid (*Lipaphis erysimi* kalt.) under terai zone of West Bengal. *Journal of Entomology and Zoology Studies*, **7** (5): 1340-1344. NAAS rating **5.53**
2. Patra, B., **Sahoo, S.K.,** and Hath, T.K. (2020). Studies on ovicidal activity of some selected acaricides against *Oligonychus coffeae* Nietner on tea. *Journal of Entomology and Zoology Studies*, **8** (2): 554-556 (NAAS rating **5.53)**
3. Sikdar, S., Hath, T.K., **Chatterjee, M., Chakraborty, D.** and Patra, B. (2019). Diurnal foraging activity of flower visiting insects on some seed spices under terai agroclimatic zone of West Bengal. *Journal of Entomology and Zoology Studies*, **7** (4): 299-303 (NAAS rating **5.53)**
4. **Chatterjee, M.,** Patra, B., **Chakraborty, D.,** Hath, T.K. and Dey, A.N. (2019). A report on severe outbreak of gall inducing psyllid *Pseudophacopteron tuberculatum* Crawford on *Alstonia scholaris* in West Bengal, India. *The Indian Forester*, **145** (12): 1214-1215 (NAAS rating **4.38**)

5. Chakraborty, S., Datta, S.,Debnath, A. Bandopadhya, S. Khalko, S., Jana, J.C. and Saha, B. C. (2019) Variety GCP-49 (Mohini, IC- 0614552). Indian Journal of Genetics and Plant Breeding, 79(2): **516.**

Associated with teaching:

Dr. S.K. Sahoo:

ENT-501 (Insect morphology); ENT- 503(Principle of Taxonomy and classification of insects); ENT-509 (Principles of IPM); ENT-510 (Pests of field, horticultural and plantation crops and storage entomology); ENT-512 (Commercial entomology); ENT- 601 (Immature stages of insects); ENT-608 (Advanced IPM); EXT-151 (Values & Ethics);ENT-151 (Fundamentals of Entomology); ENT-301 (Crop pests and stored grain pests and their management); ENT-302 (Apiculture)

Research projects/ supports:

Dr. S.K. Sahoo:

1. Working as P.I. in the project entitled "Bio-efficacy of coded insecticides IKI3106 80SL against stem borer and leaf folder of Rice" Funded by ISK Biosciences India Pvt. Ltd. from 2018 onwards (Cost of project- Rs.3.99 lakhs).
2. Working as P.I. in the project entitled "Bioefficacy and phytotoxicity evaluation of coded product Fall army worm in maize" Funded by Crystal India Pvt. Ltd. from 2019 onwards (Cost of project- Rs.3.99 lakhs).

Mr. D. Chakraborty:

1. Worked as P.I. of the project entitled "Evaluation of Bio-efficacy of coded insecticide CCP-0415 against *Spodoptera* spp. in Soybean" Funded by Crystal India Pvt. Ltd. from 2019 onwards (Cost of project- Rs.3.99 lakh).
2. Worked as P.I. of the project entitled "Evaluation of Bio-efficacy and Phytotoxicity of Thiodicarb 50% + Imidacloprid 5% WDG against major insect pests of Chilli" Funded by M/s Agro Life Science Corporation from 2019 onwards (Cost of project- Rs.3.36 lakh).

Professional Training:

Dr. S.K. Sahoo

1. Short course on "Molecular identification and DNA Barcoding of insect-pests and natural enemies including invasive pests" held at NBAIR, Bangalore from 18-27th November, 2019 –attended by Dr. S.K. Sahoo

Seminar/ Symposium/ Workshop Attended:

Dr. S.K. Sahoo

1. National Symposium on "Mitigating biotic stresses in agriculture for 21st century: Changing market paradigm" held at UBKV, Pundibari on 5-6th Nov., 2019.
2. Participated in the "Regional Science and Technological Congress" held at Alipurduar College, West Bengal on 18-19 December, 2019.
3. Participated in the 28th Annual Group Meeting of AICRP-Biological held at Anand Agriculture University, Anand, Gujarat during May, 2019.

Mr. D. Chakraborty

1. National Symposium on "Mitigating biotic stresses in agriculture for 21st century: Changing market paradigm" held at UBKV, Pundibari on 5-6th Nov., 2019.

2. Participated in the "Regional Science and Technological Congress" held at Alipurduar College, West Bengal on 18-19 December, 2019.

Dr. Anamika Debnath

1. Attended 30th Annual Workshop of ICAR-AICRP on Spices held during 13- 16th November 2019 at Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu.
2. Attended National Seminar on "cultivation, conservation and sustainable utilization of medicinal plants for livelihood improvement" at UBKV, Pundibari from 20-21st November,2019.
3. Attended 4th Regional Science and Technology and Biotechnology Congress-2019 organized by Alipurduar Collage in collaboration with Department of Science and Technology and Biotechnology Govt of W.B. on 18-19th December, 2019.

Awards obtained

Dr. Anamika Debnath

1. Outstanding paper presentation Award in 4th Regional Science and Technology and Biotechnology Congress-2019 for presenting the paper on "**Evaluation of turmeric germplasms for yield and resistance to foliar diseases in Terai Region of West Bengal**"on 18-19th December, 2019 held at Alipurduar Collage, W.B.

Extension Literature

1. Jaibik Upaye Gaachher Pusti o Rog Niyantran (2019)

Number of students supervising (M.Sc. & Ph.D.) :

Dr. S.K. Sahoo: M.Sc. (Entomology) - 2; Ph. D. (Entomology)- 2
Dr. Anamika Debnath: M.Sc. (Plant Pathology) - 2; Ph. D. (P. Pathology)- 1

YSPUHF, Solan

Functioning of the co-ordinated project

Visitors

- Students (14 no) from Sardar Balabh Bhai Patel University of Agriculture and Technology, Meerut visited the Biocontrol Research Laboratory on 26 March 2019
- Incharge, State Biocontrol Laboratory, Shimla visited Biocontrol Research Laboratory of Dept. of Entomology, UHF, Nauni on 01-05-2019
- Students (28no) from Eternal University Baru Sahib visited the Biocontrol Research Laboratory on 21-11-2019
- Group of extension officers from State Horticulture Department along with experts from New Zealand visited Biocontrol laboratory on 22-11-2019
- Second batch of students (25no) from Eternal University Baru Sahib visited the Biocontrol Research Laboratory on 22-11-2019
- Different stakeholders organized by HFRI, Shimla visited the Biocontrol Research Laboratory on 19-12-2019
- Incharge, State Biocontrol Laboratory, Shimla visited Biocontrol Research Laboratory of Dept. of Entomology, UHF, Nauni on 19-02-2020

Miscellaneous Information

Awards/Honours/Recognition/Technology developed:

Awards: Nil
Honours: Nil

Recognition: PL Sharma received certificate of appreciation from Hon'ble Vice Chancellor, YSP UHF, Solan for outstanding work in biological control

Technology developed/ evaluated:

- Bio-intensive management of *Tuta absoluta* in tomato
- Demonstrated biological control of apple root borer, *Dorysthenus hugelii* by using *Metarhizium anisopliae*

Education, Training and Radio / TV talk

i) Trainings organized:

SN	Title of training	Place	Date	No of participants
1	Eco-friendly management of insect-pests of crops under TSP	Powari, Kinnaur	21.07.2019	50 (27M, 23F)
2	Eco-friendly management of insect-pests of crops under TSP	Kangosh (Nichar), Kinnaur	22.07.2019	50 (36M, 14F)
3	Eco-friendly management of insect-pests of crops under TSP	Rangrik, Lauhal Spiti	21-10-2019	50 (22M, 28F)
4	Eco-friendly management of insect-pests of crops under TSP	Hurling, Lauhal Spiti	22-10-2019	50 (29M, 21F)
	Total			200 (114M,86F)

Lectures delivered in trainings

SN	Title of training	Place	Date	No of farmers
1	Diagnosis and insect-pests management of vegetable crops under Natural farming systems	UHF, Nauni	06.03.2019	30
2	Insect-pests management of vegetable crops under natural farming system	UHF, Nauni	22.08.2019	30
3	Insect-pests management of vegetable crops under natural farming system	UHF, Nauni	06.09.2019	30
4	Demonstration on preparation of decoctions for insect-pests management to farmers and scientists of KVK of UHF , Nauni	UHF, Nauni	21.09.2019	30
5	Winter Management and migratory beekeeping under skill development to the farmers of HP and Sikkim	UHF, Nauni	23.09.2019	45
6	Bee flora in basic Apiculture and queen rearing w.e.f 23.9.2019 22.09.2019 for inservice candidate	UHF, Nauni	27.09.2019	30
7	Migratory Beekeeping w.e.f 7-11 Oct,2019	UHF, Nauni	10.10.2019	25
8	Ecofriendly management of insect-pests temperate fruit and vegetable crops	Rangrik, Kaza	21.10.2019	50
9	Ecofriendly management of insect-pests	Hurling	22.10.2019	50

	temperate fruit and vegetable crops	Kaza		
10	Insect-pest management under natural farming organised by ATMA, Bilaspur	UHF,Nauni	20.10.2019	25
11	Insect-pests management of vegetable crops under natural farming system	KVK, Kandaghat	06.12.2019	30
12	Identification and management of insect-pests of apple and pear in 30 days course Module for certification course on canopy management propagation of fruit plants w.e.f 16 Jan,2019 to 14 Feb,2020	UHF, Nauni	22.01.2020	25
13	Identification and management of insect-pests of apple and pear in 30 days course Module for certification course on canopy management propagation of fruit plants in 5-day training camp	UHF, Nauni	22-01-2020	25
14	Principles of Subhash Palekar Natural Farming	Dept. Ento, UHF, Nauni	6.02.2020	25
15	Insect-pests management of vegetable crops under natural farming system	Dept. Ento, UHF, Nauni	07.02.2019	25
16	Harvesting , processing, storage and use of honey in 7-day training on Commercial Beekeeping	Dept. Ento, UHF, Nauni	10.02.2019	20
17	Principles of Subhash Palekar Natural Farming	Dept of MBA UHF, Nauni	11.02.2020	50
18	Diagnosis and insect-pests management of vegetable crops under Natural farming systems	UHF, Nauni	06.03.2019	30
19	Biocontrol agents of temperate fruits and vegetable crops; identification and mass production	UHF	26.03.2019	14
20	Guest lecture on Biological control of crop pests	LPU, Jalandhar	06-05-2019	200
21	Lecture on Role of biological control in pest management to input dealers	DDA, Solan	11-08-2019	30
22	Lecture on biological control agents in SPNF	UHF	21-09-2019	30
23	Role of biological control in pest management for students of Baru Sahib University- I batch	UHF	21-11-2029	28
24	Identification and role of biocontrol agents in management of apple pests for horticulture officers	UHF	22-11-2019	25
25	Role of biological control in pest management for students of Baru Sahib University – II batch	UHF	22-11-2019	25
26	Lecture on role of biological control in pest	HFRI	18-12-2019	30

	management of forest nurseries	Shimla		
27	Practical demonstration on identification of common natural enemies of crop pests	UHF	19-12-2019	30

ii) Demonstrations:

a) Demonstrations on the management of apple root borer using *Metarhizium anisopliae*:

SN	Location	Number of orchards
1	Rekongpeo, district Kinnaur	3
2	Kaja, District Lauhal & Spiti	2
3	Kotkhai and Rohru, district Shimla	5
4	Rajgarh and Shillai district Sirmaur	3
	Total	11

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	Powari	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	Kangosh	50
3	Demonstrated the use of *Metarhizium anisopliae*, *Beauveria bassiana*, *Trichoderma* and azadirachtin for the management of insect pests and diseases in apple and vegetable crops	Hurling	50
4	Demonstrated the use of *Metarhizium anisopliae*, *Beauveria bassiana*, *Trichoderma* and azadirachtin for the management of insect pests and diseases in apple and vegetable crops	Rangrik	50
	Total		200

iii) Mera Gaon Mera Gaurav:

S. No.	Date	No. of Farmers	Purpose/ activity
i)	14-08-2019	11	Farmers were suggested control measures of different insect pests of tomato and capsicum
ii)	20-08-2019	18	Farmers were suggested control measures of different insect pests of tomato and capsicum

Radio / TV talk: Nil

Post/under graduate teaching
Courses taught:

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:

SN	Student Name	Degree	Title of thesis	Guide
1	Sarawati Negi	Ph D	Bio-ecology and management of invasive leafminer, *Tuta absoluta*(Lepidoptera: gelechidae) on tomato	PL Sharma
2	Anil Jaswal	PhD	Studies on insect pests of cole crops and their natural enemies in Himachal Pradesh	PL Sharma
3	Gaikwad Mahesh Balasahab	PhD	Aphid-natural enemy diversity in horticultural crops of Himachal Pradesh and evaluation of dominant predators against rose aphid, *Macrosiphum rasae* L.	SC Verma
4	Pranshu Guleria	MSc	Biocontrol potential of *Neochrysocharis formosa* (Westwood) against *Tuta absoluta* (Meyrick) in tomato	PL Sharma

5	Pryianka Sharma	MSc	Studies on Spatial Distribution and Parasitization Potential of *Aphelinus asychis* Walker Against Green Peach aphid, *Myzus persicae* (Sulzer) in Bellpepper.	SC Verma
6	Nidhi	PhD	Studies on the effect of host plants and insecticides on the performance of *Neoseiulus longispinosus* (Evans) against *Tetranychus urticae* Koch	PL Sharma
7	Shivani	PhD	Studies on diversity, population dynamics and predatory potential of Syrphid fly against cabbage aphid, *Brevicoryne brassicae* (L.) infesting cruciferous crops in Himachal Pradesh	SC Verma
8	Ritesh Jamwal	MSc	Predatory potential of minute pirate bug, *Blaptostethus pallescens* Poppius against *Tuta absoluta* (Meyrick) in tomato	PL Sharma
9	Anamika Walia	MSc	Studies on parasitisation potential of *Encarsia formosa* Gahan against greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood)	SC Verma
10	Bhisham Dev	MSc	Evaluation of entomopathogenic fungus, *Nomuraea rileyi* Farlow (Samson) against *Helicoverpa armigera* (Hubner)	SC Verma
11	Shikha Katoch	MSc	To be decided	PL Sharma
12	Shagun Thakur	MSc	To be decided	PL Sharma
13	Tanvi Sharma	MSc	To be decided	SC Verma
14	Pryianka Sharma	PhD	To be decided	PL Sharma

Participation in conference, meetings, seminars, workshops, symposia, training extension etc. in India and abroad

- XIX International Plant Protection Congress IPPC 2019 w.e.f. 10-14 November at Hyderabad, Telengana, India.
- Second International Conference on Recent Advances in Agricultural, Environmental & Applied Sciences for Global Development organised by Agro Environmental Developmental Society, Majhra Ghat, Rampur, UP, India and YSP University of Horticulture and Forestry, Nauni, Solan (HP) w.e.f. 27-29, September 2019.
- Attended 28th group meeting of AICRP on Biological Control of Crop Pests and Weeds on 6-8, June 2019 organised by NBAIR at AAU, Anand, Gujarat
- Attended one day workshop on "Eco-innovations for resilient mountain farming'' organised by YSP UHF, Nauni, Solan on 16 March 2019
- Attended meeting with World Bank team regarding review of HPHDP project at Shimla on 10-06-2019
- Attended mid-term review meeting with World Bank team and New Zealand experts regarding POP under HPHDP at Shimla on 13-06-2019
- Meeting with Professor and Head regarding ACRs, exchange of faculty and externally funded projects on 11-09-2019

- Meeting with Professor and Head, Dept. of Plant Pathology regarding organisation of second international conference on 12-09-2019
- Meeting with Professor and Head regarding brain storming session during extension council and research council meetings on 17-09-2019
- Meeting with Director of Research regarding progress under AICRP-BC on 15-10-2019
- Meeting with Registrar regarding celebration of University foundation day on 25-11-2019
- Meeting regarding finalization of planting material to be imported under HPHDP at Directorate of Horticulture on 26-11-2019
- Attended state level Package pf Practices workshop on Vegetable on dated 15.02.2020
- Attended state level Package of Practices Workshop on Floriculture crops on dated 17.02.2020

4.6 List of publications (Research papers, Seminars, symposiums, Book, Book chapters, pamphlets, technical bulletin, etc.)

Research papers:

1. Kumari Deeksha, Verma SC and Sharma PL. 2020.Biology, feeding potential and functional response of *Coccinella septempunctata* L. against *Aphis gossypii* Glover infesting cucumber. *Journal of Entomology and Zoology Studies*, 8(1): 631-636 (**NAAS: 5.53)**
2. Sharma ND, Chandel RS, Sharma ID, Sharma PL and Gurung B. 2020. Pesticides' contamination of lactating mothers' milk in the north-western Himalayan region of India. *Journal of Environmental Biology*, 41 (1): 23-28 (**NAAS: 6.56)**
3. Saini A and Sharma PL. 2019.Interspecific competition between *Cotesia vestalis* (Halliday) and *Diadegma semiclausum* (Hellen), parasitoids of *Plutella xylostella* (L.). *Natl. Acad. Sci. Lett*. https://doi.org/10.1007/s40009-019-00844-8 **(NAAS: 6.52)**
4. Chandel RS, Singh J, Sharma PL, Kumar R and Kumar P. 2019. New insights of processionary moth, *Thaumetopoea cheela* on pistachio nut (*Pistacia vera*): Interaction effect on flowering and nut yield. *The Indian Journal of Agricultural Sciences*, 89 (11):1818–22 **(NAAS: 6.23)**
5. Manohar TN, Sharma PL, Verma SC, Sharma KC and Chandel RS. 2019. Functional response of indigenous *Trichogramma* spp. to invasive tomato leafminer, *Tuta absoluta* (Meyrick) under laboratory conditions. *Int. J. Trop. Insect Sci*.https://doi.org/10.1007/s42690-019-00057-y **(NAAS: 6.66)**
6. Panma Yankit, Rajeshwar S Chandel, P L Sharma and Subhash C Verma. 2019. Zero Budget Natural Farming for Management of Invasive leafminer (*Tuta absoluta*) in tomato. *ICAR News*, 25 (1): 11-12
7. Saini A, Sharma PL and Chandel RS. 2019. Host age influence on the parasitism of the species *Cotesia vestalis* (Haliday) (Hymenoptera: Braconidae). *Egyptian Journal of Biological Pest Control*, 29:48 https://doi.org/10.1186/s41938-019-0151-7 (**NAAS: 6.16)**
8. Verma SC, Sharma Shikha and Sharma PL. 2019.Spatial distribution of cabbage aphid, *Brevicoryne brassicae* (L.) and its parasitoids, *Diaeretiella rapae* (McIntosh) under sub-temperate conditions of Himachal Pradesh, India. *Journal of Biological Control*, 33 (2): 103-108 (**NAAS: 5.34)**

9. Dhirta B, Khanna AS, Sharma PL and Singh M. 2019.Bioassay of *Heterorhabditis bacteriophora* against various insects. *Journal of Entomology and Zoology Studies*, 7(4): 318-323 **(NAAS: 5.53)**
10. Manohar, T.N., Sharma, P.L., Verma, S.C. and Chandel, R.S. 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 (**NAAS: 6.16)**

Papers presented in conferences/symposia:

1. Sharma PL, Choudhary KR, Verma SC, Chandel RS and Negi S. 2019.Sequential sampling plan for *Tuta absoluta* (Meyrick) with and without the effect of predator *Nesidiocoris tenuis* (Reuter) in tomato. Presented in XIX International Plant Protection Congress IPPC 2019 w.e.f. 10-14 November at Hyderabad, Telengana , India. Abstract book PP-209

2. Sharma PL, Chandel RS and Verma SC. 2019. Bio-intensive management of temperate crop pests Presented in XIX International Plant Protection Congress IPPC 2019 w.e.f 10-14 November held at Hyderabad, Telengana, India. Abstract book PP-75

3. Verma SC, Sharma P, Sharma PL, Chandel RS , Negi S and Guleria P. 2019. Biological parameters and functional response of *Aphelinus asychis* Walker on *Myzus persicae*(Sulzer) (Hemiptera: Aphididae) in bellpepper. Presented in XIX International Plant Protection Congress IPPC 2019 w.e.f. 10-14 November at Hyderabad, Telengana, India.Abstract book PP-214.

4. Balaso G M, Yankit P, Nalini C, Verma SC and Sharma PL.2019.Intraguild predation among two aphidophagus coccinellids of cabbage aphid, *Brevicoryne brassicae* Presented in XIX International Plant Protection Congress IPPC 2019 w.e.f. 10-14 November at Hyderabad, Telengana, India. Abstract book PP-246

5. Yankit P, Chandel RS, Sharma PL, Verma SC, Balaso G M and Nalini C. 2019.Spatial distribution and seasonal abundance of invasive leaf miner, Tuta absoluta under different farming systems.Presented in XIX International Plant Protection Congress IPPC 2019 w.e.f. 10-14 November at Hyderabad, Telengana, India. Abstract book PP-273

6. Yankit P, Chandel RS, Sharma PL, Verma SC, Gaikwad MB and Rana A. 2019. Management of invasive lesfminer, Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) on tomato crop by Zero Budget Natural Farming. National Conference on Organic and Natural Farming held at CSKHPKV Palampur w.e.f. 28-29 May 2019.

Book chapters

1. Rana Rajesh K, Singh Rajbir and Sharma PL .2019.Managing apple root borer with self-designed solar light trap, pp 21-24. In Rana Rajesh K, Singh R, Thakur Ashok K, Chahal V P and Singh A K (eds)Contemplating Agricultural Growth through Farmers' Frugal Innovations, ICAR-ATARI-1, Ludhiana, Punjab: 160p.

Compendium chapters:

2.Banshtu T, Verma SC and Sharma PL. 2019. Management of Rodents in Fields and Storage pp 521-522. In Kaith NS, Thakur AK, Kumari N, Bandana, Banshtu T, Kurbah I (eds) Compendium of Lectures: Diploma Course in Agricultural Extension Services for Input Dealers, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Krishi Vigyan Kendra Shimla, Rohru, District Shimla, HP, India 578p.

3.Banshtu T, Verma SC and Sharma PL. 2019. Management of Birds and Wild Animals, pp 523-529. In Kaith NS, Thakur AK, Kumari N, Bandana, Banshtu T, Kurbah I (eds) Compendium of Lectures: Diploma Course in Agricultural Extension Services for Input Dealers, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Krishi Vigyan Kendra Shimla, Rohru, District Shimla, HP, India 578p.

4.Banshtu T, Verma SC and Sharma PL. 2019.Stored Grain Pests and Their Management, pp530-535. In Kaith NS, Thakur AK, Kumari N, Bandana, Banshtu T, Kurbah I (eds) Compendium of Lectures: Diploma Course in Agricultural Extension Services for Input Dealers, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Krishi Vigyan Kendra Shimla, Rohru, District Shimla, HP, India 578p.

5. Banshtu T, Sharma PL and Verma SC. 2019. Phytotoxicity of Pesticides, pp 539-542. In Kaith NS, Thakur AK, Kumari N, Bandana, Banshtu T, Kurbah I (eds) Compendium of Lectures: Diploma Course in Agricultural Extension Services for Input Dealers, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Krishi Vigyan Kendra Shimla, Rohru, District Shimla, HP, India 578p.

Bio-agents maintained in Bio-control Laboratory

- Entomopathogeic fungi: *Metarhizium anisopliae, Beauveria bassiana Lecanicillium lecanii*
- Entomopathogenic nematodes: *Steinernema feltiae*. and *Heterorhabditis* sp (These are maintained by the Nematology section of the Department)
- Parasitoids:*Trichogramma chilonis. T. pretiosum, T. achaeae* and *T. pieridis, T. embryophagum*
- Predators: *Neoseiulus longispinosus, Chrysoperla zastrowi sillemi, Blaptostethes pallescens*

Host/prey insects:

- *Corcyra cephalonica, Tetranychus urticae, Plutella xylostella, Tuta absoluta*

Technology assessed/ transferred:

- Management of apple root borer, *Dorysthenes hugelii* by using *Metarhizium anisopliae*

Foreign visits:

- PL Sharma visited USA as scout team member for import of planting material under HPHDP project w.e.f. 29-10-2019 to 13-11-2019
- PL Sharma visited USA as pre-dispatch team member for import of planting material under HPHDP project w.e.f. 08-02-2020 to 18-02-2020