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

Annual Progress Report 2020-2021

Compiled and Edited
by
G. Sivakumar, T. Venkatesan, Richa Varshney, Amala Udayakumar, M. Sampath Kumar, K. Selvaraj, A. Kandan, Jagadeesh Patil, G. Mahendiran, M. Mohan, K. Subaharan, Omprakash Navik, P. Ram Kumar, Sunil Joshi and N. Bakthavatsalam

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Cover page: *Trichogramma chilonis*

Photo credit: Dr Omprakash Navik

Cover design: G. Mahendiran

Technical Programme for 2020 - 2021

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I.1.2	New distributional records for whiteflies
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PLANTATION CROPS

VEGETABLE CROPS

CONTENTS

EXPERIMENTAL RESULTS

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

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

I.1.1 Diversity and systematics of natural enemies:

Surveys were undertaken to document the fauna of insects, spiders and entomopathogenic nematodesacross India despite the travel restrictions due to COVID-19. The expeditions undertaken yielded several species of natural enemies *viz.*,Chalcididae (66.32%), Eulophidae (19.94%), Pteromalidae (4.14%) and Encyrtidae (3.37%) of Hymenoptera and 14 species of trichogrammatids representing 7 genera. The predominant genera of hymenopteran insect parasitoids were identified as *Dirhinus* Dalman (30.47%) followed by *Brachymeria* Westwood (27.73%), *Hockeria* Walker (22.27%) and *Antrocephalus* Kirby (18.75%). Revisionary studies of the braconid parasitoid, *Apanteles* sp. *ater*-group including subgroup *eublemmae* of the genus (Hymenoptera: Braconidae) of the Oriental region was carried out with an illustrated key, in which a total of 97 species were recorded and illustrated. Three species of tachinid flies, *Peribaea orbata* on larva of *Spodoptera litura, Halidaia luteicornis* on larva of *Parnara* sp., *Sturmiopsis inferens* on larva of *Sesamia inferens* and *Carcelia* sp. from the larvae of *Helicoverpa armigera* (Noctuidae) were identified and described.

The spider fauna of rice ecosystem was documented, where six species of long jawed orb weaver, *Tetragnatha* species have been described of which *T. keyserlingi* was the predominant species across the surveyed locations in Tamil Nadu. The species, *Tetragnathanitens* collected from Tamil Nadu and Telangana was the first report from India. The spitting spider, *Scytodes fusca* Walckenaer of family Scyotidae was redescribed with documentation of variations in the vulval pattern of the female and theory about the introduction of this Pantropical species to India.

I.1.2 New distributional records for whiteflies:

New distributional records were documented for recently invaded whitefly species, rugose spiralling whitefly, *Aleurodicus rugioperculatus,* woolly whitefly, *Aleurothrixus floccosus,* Bondar's nesting whitefly, *Paraleyrodes bondari* and *A. floccosus* for the first time through regular survey and monitoring. Documented around 40 host plants for rugose spiralling whitefly; 21 host plants for nesting whitefly, *Paraleyrodes minei*; 9 host plants Bondar nesting whitefly, *P. bondari*; 13 host plants for solanum whitefly, *Aleurothrixus trachoides* and three host plants for palm infesting whitefly, *A. atratus* for the first time in India.

I.1.3 Molecular characterization:

Molecular characterisation based on *CO1* (*Cytochrome Oxidase 1*) gene was carried out for 75 agriculturally important insects like pests, parasitoids and predators collected from different parts of the country and DNA bar codes were generated. Cytochrome Oxidase b gene was used for the identification of 20 different populations of *S. frugiperda*. Five parasitoids, viz. *Campoletis chlorideae, Chelonus* sp., *Cotesia* sp., *Exorista xanthaspis*, *Telenomus remu s*and *Trichogramma chilonis* collected from the larvae of *S. frugiperda* were identified using mt*CO1* gene and the sequences were deposited in the NCBI database. The tachinid fly, *Exorista xanthaspis* was molecularly characterised for the first time and the accession numbers (MT007801 and MT007802) were obtained.

I.1.4 Biotic potential of natural enemies: Management of cassava mealybug:

A coccinellid predator, *Hyperaspis maindroni* was found in abundant numbers associated with the cassava mealybug infestation on cassava plants in Tamil Nadu contributing to natural control of the mealybug. An hyperparasitoid, *Homalotylus turkmenicus* was reported to parasitize *H. maindroni* grubs to an extent of 80%, which need to be looked in carefully while taking up of the management practices of cassava mealybug.

Management of whiteflies through natural enemies:

The natural enemies of whiteflies *viz., Pseudomallada astur*, *Cybochephalus indicus, Menochilus sexmaculatus, Jauravia pallidula* on rugose spiraling whitefly, *A. rugioperculatus*, *P. astur, C. indicus, C. nigrita* and *J. pallidula*on palm infesting whitefly, *A. atratus* and *Acletoxenus indicus*, *Scymnus utilis, Cryptolaemus montrouzieri* and *P. astur* on wooly whitefly, *A. floccosus* were documented and reported under field conditions. Novel strain of entomopathogenic fungus, *Isaria fumosorosea* (strain ICAR-NBAIR pfu-5) was identified and field validated for the management of *A. rugioperculatus*, *Aleurotrachelus atratus*, *Paraleyrodes bondari* and *Paraleyrodes minei* on coconut and *A. floccosus* on guava at several locations in Karnataka, Andhra Pradesh, Kerala and Tamil Nadu and found that the fungus was effective to the extent of 58-80% under field conditions.

Management of fall armyworm, *Spodoptera frugiperda* with biocontrol agents*:*

Seasonal parasitism of egg parasitoid, *Trichogramma chilonis* against fall armyworm was studied in kharif, rabi and summer seasons and the higher egg parasitism was recorded in kharif (38.91%) followed by rabi (30.23%) and summer (9.12%). Efficacy of indigenous *Trichogramma chilonis* was evaluated along with *T. pretiosum* and *T. mwanzai*a against the fall armyworm under laboratory conditions. Results showed that *T. chilonis* parasitised 89, 79 and 54% host eggs at 12, 24 and 48 hours after exposure while parasitism of *T. pretiosum* was 80, 77 and 44% on different host egg age, whereas, *T. mwanzai* parasitised 68, 79 and 34% host eggs.

Two sprays of liquid formulation of *B. thuringiensis* strain NBAIR-BT25 given at 20 and 35 DAS of maize crop in the field have effectively reduced the FAW incidence by 80 per cent when compared with that of control, and similarly reduced the plant damage to 35 per cent as compared to 89 per cent in untreated control plots. Bacterial biopesticide *Bacillus thuringiensis* strain NBAIR-BT25 which is very effective for the management of FAW. During the field trial (2020-21), two sprays of liquid formulation of *B. thuringiensis* strain NBAIR-BT25 were given at 20 and 35 DAS of maize crop. This *B. thuringiensis* strain NBAIR-BT25 effectively reduced the FAW pest incidence by 80 per cent when compared with control and similarly reduced the plant damage to 35 per cent as compared to 89 per cent in untreated control plots. *B. thuringiensis* strain NBAIR-BT25 treated plots showed 23.25 per cent increase in cob yield.

Studies on penetration and reproduction ability of EPNs, *Heterorhabditis indica, H. bacteriophora, S. carpocapsae, S. abbasi,* and *S. siamkayai* in *S. frugiperda* larvae revealed significant differences in tested fourth instar larva. The greatest penetration rate was observed for *H. indica* (17.2%) followed by *S. carpocapsae*(12.1%), *H. bacteriophora* (10.27%) and *S. abbasi* (6.63%). Multiplication rate of *H. indica* was highest (130 IJs mg $^{-1}$) body weight followed by *S. carpocapsae* (123 IJs IJs mg $^{-1}$) which was statistically at par with *H. indica*. Field evaluation of EPNs, *Heterorhabditis indica* and *Steinernema carpocapsae* and *Spodoptera frugiperda* NPV (SpfrNPV) carried out against *S. frugiperda* in maize crop at Chikkaballapura in Karnataka revealed that the second round of EPNs spraying reduced the larval population to 37.5% at 2.5×10^8 IJs ha^{-1} and 73.33% at 5×10^8 IJs ha^{-1} for *S. carpocapsae* while for *H. indica* the percentage mortality was 54.17% at the rate 2.5×10^8 IJs ha^{-1} and 89% at the rate 5×10^8 IJs ha^{-1}. Similarly, *S. frugiperda* NPV sprayed at three different concentrations ($1.5{\times}10^{12}$ POBs/ha, $1.5{\times}10^8$ POBs/ha, $1.5{\times}10^4$ POBs/ha) ranged from 11.20 to 18.34 per 10 plants. Out of the three concentrations, $1.5{\times} 10^{12}$ POBs/ha was found most effective in reducing the larval numbers from 35.20 to 11.20 per 10 plants followed by the concentration 1×10^8 POBs/ha which reduced from 37.20 to 15.30 per 10 plants.

The trial on IPM of fall armyworm at Kadalaveni, Gouribidanur Taluk, Chikkaballapura district recorded significantly less number of FAW larvae (0.08/plant) in biocontrol plot compared to farmer's practice plot (0.45/plant).

Entomopathogens against thrips:

The entomopathogens, *Pseudomonas fluorescens* strain NBAIR-PFDWD, *Bacillus albus* strain NBAIR-BATP and *Metarhizium anisopliae* strain NBAIR-MaCB were evaluated and found effective against thrips, *Thrips palmi* in watermelon and *S. dorsalis* in chilli crops.

I.1.5 Mobile application on management of pests in coconut, rice and sugarcane:

A mobile application named SHATPADA-BPM-1 (English and Hindi version) and SHATPADA-BPM-2 (English, Hindi, and Kannada version) was developed for the management of important pests on coconut, rice and sugarcane using biological control and other non-chemical methods. The app was installed in around 70 farmers' mobile phones and the same was demonstrated to them during Kisan Divas and the NEH workshop.

Sensors for the detection of *Helicoverpa armigera* nucleopolyhedrovirus

Sensor for detecting the presence of *Helicoverpa armigera* nucleopolyhedrovirus (HearNPV). in the viral formulation. Luminescent, amphiphilic probe has been designed for the first time in optical sensing of a biopesticide HearNPV. The compound showed formation of a pH-sensitive, thermoreversible nanoaggregate in the aqueous medium. The addition of HearNPV resulted in the rapid change in emission color from blue to cyan at pH 7.4. Till date, no optical assay is known which can detect HearNPV in the field detection as low as ~10^3 OBs/mL. Inexpensive reusable paper strips have developed for on-location detection purpose. Moreover, the presence of residual HearNPV can also be traced on leaf-surfaces. Thus, studies will be beneficial for quality verification of HearNPVand making decision onfrequency of sprays for the management of *Helicoverpa armigera* .

I.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

Table 1.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Ghumarwin, Solan, Sarahan, Naina, Tikkar, Kufri, Theog, Kotkhai, Rekongpeo, Pooh, of districts Bilaspur, Solan, Sirmaur, Shimla, and Kinnaur	Aphids, mites, whiteflies and scale insects in 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*, *Platynaspiss aundersii*, *Harmonia eucharis*, *Oenopea sauzetii*, *Oenopia kirbyi*, *Oenopia sexareata*, *Scymnus nubilus*, *scymnus posticalis*, *Coelophora bissellata*, *Harmonia dimidiata*, *Scymnus* sp and *Hyselia sanscrita*
Nauni and Sarahan	Cucumber and stone fruits	*Chrysoperla zastrowisillemi*
Nauni, Solan and Sarahan	Flowering plants	*Episyrphus balteatus*, *Eupeodes frequens*, *Sphaerophoria indiana*, *Melanostoma univitatum*, *Betasyrphus serarius*, *Ischiodon scutellaris*, *Metasyrphus confrator*
Nauni and surroundings	Phytophagous coccinellids such as *Coccinella septempunctata*, *Hippodamyia variegata*on vegetable and fruit crops	*Dinocalpus coccinellae*
Nauni	Cauliflower and cabbage	Parasitoids of diamondback moth, *Diadegma semiclausum*
Nauni and surroundings, Rekongpeo	Peach leaf curl aphid and thrips	Anthacorid predators, *Orius*sp and *Anthocoris* sp.

Nauni, Sarahan	Tomato leafminer	*Nesidiocoris tenuis*, *Neochrysocharis formosa*
Nauni	Vegetable leaf eating beetles	Shield bug, *Zicrona caerulea*
Bilaspur, Mandi, Shimla, Una, Solan and Sirmour	Maize	No natural enemies data reported

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

I.2.2 IGKV, Raipur

Table 2. 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*	

I.2.3 UBKV, Pundibari

Table 3.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Pundibari, Angrakata, Dhormoborer Kuthi Joggo narayoner Kuthi	Rice	*Trichogramma chilonis* and *Trichogramma japonicum* were found to parasitize the yellow stem borer eggs. Twenty three numbers of spiders from three different families (Lycosidae, Oxyopidae and Sparassidae) were recorded. Spiders, damselfly, dragonfly, lady beetle, plant bug, tachinid fly, braconid wasps and earwigs were also found in rice field. Twenty three spiders were collected from rice filed and were preserved and sent for identification to NBAIR. Spiders from three different families (Lycosidae, Oxyopidae and Sparassidae) were found during the experiment and they were active

		throughout the cropping season. Spider population ranged from 0.12-0.76 spiders/square meter.
-	Tea	Spiders, Damselfly, Dragonfly, Lady beetle, Plant bug, Tachinid fly, Braconid wasps and Earwigs
Cooch Behar & Dinhatablocks	Wheat, lentil, ginger and turmeric	*Trichoderma* sp., *Pseudomonas* sp.
Pundibari	Wheat and lentil rhizoshere	*Pseudomonas* sp.

List of Spiders Collected from Rice ecosystem during Kharif 2020

Table 4.

Sl No	Family	Sc name	Activity period
1.	Oxyopidae	*Oxyopes* sp.	Throughout the cropping season
2.	Araneidae	*Larinia* sp.	July to October
3.	Araneidae	*Araneus ellipticus*	July to October
4.	Sparassidae	*Heteropoda* sp.	October-November

I.2.4 TNAU, Coimbatore

Table 5.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Coimbatore, Tirupur, Erode, Theni, Ariyalur, Kanyakumari, Viruthunagar, Thenkasi, Tirunelveli and Dindigul	Natural enemies of rugose spiralling whitefly, *Aleurodicus rugioperculatus*	The parasitisation by *Encarsia guadeloupae* ranged between 15.00 and 70.00 per cent on coconut gardens and a predator *Mallada astur* was seen in all the coconut gardens. *Besides E. guadeloupae* and *M.* astur, many predators *viz.,Cybocephalus* spp., *Cryptolaemus montrouzieri* Muls., *Chilocorus nigrita* (Fabricius),*Cheilomenes sexmaculata* (Fab.), praying mantis and spiders (*Argiopes* sp.) were also recorded as natural enemies of *A. rugioperculatus.* Parasitisation by *Encarsia* sp. was 56 per cent during first fortnight of September, 2020. A maximum of 3 numbers of grubs/leaflet of *Mallada* sp. was observed

Coimbatore district	Natural enemies of *Tutaabsoluta* on tomato	Nil
Coimbatore, Erode, Tiruppur, Salem, and Namakkal districts	Papaya mealybug	*Acerophagus papayae*, *Mallada* sp. and *Cryptolaemus montrouzieri* have been found in all papaya and cassava fields
Different agro-ecological zones of Tamil Nadu	Different crops and pests	*Trichogramma* sp., *Cryptolaemus montrouzieri*, *Chrysoperla zastrowisillemi*, *Mallada astur*, *Argiopes* sp. and *Acerophagus papayae* were recorded. In cassava, *Hyperaspis maindroni* was found to be the predominant coccinellid predator of the new species of mealybug. Besides *H. maindroni*, *Mallada* sp. and *Prochiloneurus aegyptiacus*, *Tetrastichus* sp. were also observed. Among the parasitoid species, *Homalotylus turkmenicus* (7320 Nos.) emerged from the coccinellid predator, *Hyperaspis maindroni* grubs.*Telenomus* sp., *Trichogramma* sp., *Cheilomenes sexmaculata*, Staphylinids and spiders were observed in maize fields.A predator *Mallada astur* was seen in coconut trees infested with RSW and BNW. *Dipha aphidivora* and *Micromus igorotus* were observed on sugarcane woolly aphid.
Thoppampatti and Ambarmpalayamin Coimbatore District	Sugarcane woolly aphid	*Dipha aphidivora*, *Micromus igorotus* and *Encarsia* sp.

I.2.5 OUAT, Bhubaneswar

Table 6.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Puri and Khurda districts	Coconut rugose spiralling whitefly	No biocontrol agents reported

I.2.6 MPKV, Pune

Table 7.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Pune	maize, soybean, sugarcane, tomato and brinjal, bean, jowar, cotton, mango, papaya, Hibiscus	No record of any parasitism of *Trichogramma* spp. However, live individuals of Chrysopid, *Chrysoperla zastrowi sillemi* Esben. were observed in aphid colonies on cotton, maize, bean, jawar, okra and brinjal crops, whereas, *Mallada boninensis* Okam. was observed in aphid, mealy bugs and hopper colonies on cotton, bean, mango, papaya and hibiscus plants from five geographic locations. The eggs, grubs, pupal and adult stages of Coccinellids, *Coccinella septempunctata* L. and *Menochilus sexmaculata* F. were recorded in the aphid colonies on leaf surfaces of crops *viz.*, Cotton, sugarcane, sorghum, maize, cowpea, okra, brinjal, soybean, beans, papaya and pomegranate. The *Cryptolaemus* adults were recovered from the custard apple and papaya orchards and ornamental hibiscus. The specimens of spiders were collected from cotton, sugarcane, maize, soybean, papaya, mango, brinjal, okra, beans and pigeon pea and identified locally. The entomopathogens, *Nomuraea rileyi* diseased cadavers of *S. litura* were collected and isolated from soybean and cabbage crops, while diseased cadavers of *Spodoptera frugiperda* (Smith) infected with *Metarhizium rileyi* were collected from Maize fields. The cadavers ofNPV infected larvae of *S. frugiperda* were also collected from Maize. However, the cadavers of*Sl*NPV and *Ha*NPV infected larvae of *S. litura* and *H. armigera* were collected on soybean, cabbage, pigeon pea,

		capsicum and tomato crops in farmers' fields. *H. armigera* larvae, mango hoppers and white grubs infected with *M. anisopliae* were collected and isolated from pigeon pea crops.
Western Maharashtra	Sugarcane woolly aphid on sugarcane	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*(1.00-3.20 grubs/leaf), syrphid *Eupeodes confrater* (0.60-1.00 larvae/leaf) and spider (0.60-1.00/leaf) during August, 2020 to February, 2021.The parasitoid,*Encarsia flavoscutellum* (1.5 to 2.0/leaf) found distributed and well established in almost all sugarcane fields and suppressed the SWA incidence in Western Maharashtra.
Shahada, Shirpur Chopada	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..

I.2.7 MPUAT, Udaipur

Table 8.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Udaipur, Dungarpur, Banswara, Chittorgarh and Pratapgarh districts of Rajasthan	Maize,gram and tomato	*Cheilomenes sexmaculata*, *Coccinella septempuctata*,*Chrysoperla carnea*, *Brumoides suturalis*, rove beetles, syrphid flies, *Cotesia flavipes*, *Campolites chrloidae*, predatory pentatomid bugs

I.2.8 IIVR, Varanasi

Table 9.

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)

1.2.9 IIRR, Hyderabad

Table 10.

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.

I.2.10 IIMR, Hyderabad

Table 11.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
IIMR, Hyderabad	Millets	*Chilo partellus* incidence was predominant (15-20 %) as compared to *Sesamia inferens* (5 - 10%) in Sorghum. About 10-15 % parasitization by *Cotesia flavipes* was observed on the larvae of*Chilo partellus* during Kharif, 2019.

I.2.11 CISH, Lucknow

Table 12.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Lucknow	Mango	Hoverflies (Syrphidae) are the key amongst non-hymenopterans pollinators recorded. Hoverfly abundance was observed maximum at a daily mean temperature which initiated in the 13th std week

		and reached to its peak by registering as high as 4.90/tree in 15th std week subsequently it was drastically reduced with no further upsurge. The reasonable population of spider was recorded in the month of September at the vegetative stage and peak population was recorded during March –April at flowering and fruiting stage of mango. The maximal population of spider as noted during the first week of April 2020 as high as 6.6 individual/ tree. Weather parameter, primarily max and min temp, encouraged and relative humidity discouraged the spider population. Spider population tolerated temp regime as high as 34˚ C. The peak population of spider was observed at optimum temp between 30-34˚C. As regards Chrysopids, it was initiated in 12th std week, gradually increased and reached to its peak with a maximal population of 3.00 individuals up to 15th std week. Onwards there was no trace of Chrysopids in mango ecosystem The predator coccinellids was noticed during 9th to 14th std weeks during 2020.The predator recorded as high as 5.60 individuals/tree The major 5 species of Coccinellids viz., *Coccinella septempunctata* Linn. *C. transversalis, Menochilus sexmaculata* Fab. *Chilocorus rubidus* Hope and *Scymnus* sp. were observed feeding on mango hoppers; amongst most abundant and spectacular was *Coccinella septempunctata.* Remarkably, the peak population and its activity of lady bird beetles coincided with the peak prevalence in insect pests infesting mango at its reproductive stage namely mango hoppers, mealy bugs, thrips and scale insects. 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.

I.2.12 NCIPM, New Delhi

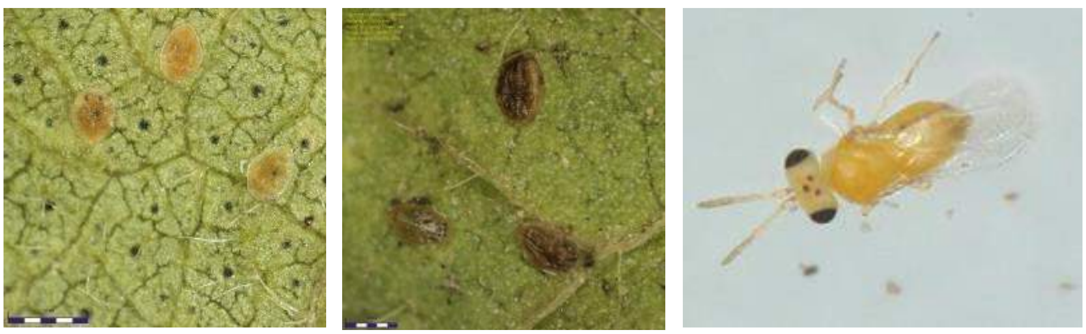
Table 13.

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:1. Parasitization of whitefly nymphs by *Encarsia* spp. in cotton in north zone; *Encarsia* spp. pupae and adult (parasitoids of whitefly)



I.2.13 AAU, Anand

Table 14. : Diversity of *Trichogramma* species in different crop ecosystems in different districts of middle Gujarat

Crop	Location	Date of sentinel card installation	Parasitism in eggs of *C. cephalonica*	Emergence of *Trichogramma* from parasitized eggs	Identified species	ICAR-NBAIR repository voucher No.
Brinjal	Agronomy farm, AAU campus	27/10/2020	Yes	No	--	--
Tomato	Vadod, Anand	26/11/2020	No	No	--	--
Castor	RRS farm, AAU, campus	26/10/2020	Yes	Yes	*T. chilonis*	206
Cotton	Vadod, Anand	27/10/2020	Yes	Yes	*T. chilonis*	207

Geographical population of green lacewing was collected. *Chrysoperla zastrowisillemi* (Esben-Petersen) was found in all the location. Diversity of coccinellids from different crop ecosystems of the region was studied. *Cheilomenes sexmaculatus*Fabricius was found to be the predominant species. Total 33 spider specimens were collected from paddy ecosystem and sent to ICAR-NBAIR for further identification. Fifty soil samples were collected from different locations of Gujarat. Collected samples were analysed for the presence of entomopathogenic nematode (EPN) using *C. cephalonica* larvae (3^{rd} instar). Two soil samples found positive for EPN and specimens were sent to ICAR-NBAIR, Bengaluru for identification.

Table 15.

Table : Diversity of entomopathogenic nematodes (EPN)

Sl. No.	Date of soil sample collection	Location/GPS coordinates	EPN species and strain	Genbank accession No.	Remarks
1	03/07/2020	Talala – Uncultivated land LAT21^{0}13’44’’N LONG70^{0}31’53’’E	*Heterorhabditis indica* AAU-R strain	MW418203	--
2	03/07/2020	Talala – Mango orchard LAT21^{0}4’53’’N LONG70^{0}36’49’’E	*Heterorhabditis indica* AAU-Q strain	--	No recovery from insect during mass multiplication

From the soil samples collected, six isolates of *Metarhizium* sp. have been isolated and identified. Molecular characterization is under progress. During the survey of invasive pest *Spodoptera frugiperda,* NPV infected larvae were collected. NPV occlusion bodies (OBs) were isolated and pathogenicity of the virus was confirmed. In addition, *Metarhizium (Nomuraea) rileyi* infected larvae were also noticed and collected during the survey. From the infected larvae, two strains of *M. rileyi* were isolated and pathogenicity of the fungus was confirmed.

I.2.14 DRYSRHU, Ambajipeta, AP

Table 16.

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

I.2.15 AAU, Jorhat

Table 17.

Site of collection	Crop surveyed with insect host	Biocontrol agents observed	Relative abundance
Allengmora, Borholla, Raraiah, Titabor, Neulgaon, Dergaon, Ahom gaon, Khanikargaon, Teok, Dimow, Sivsagar, Nitaipukhuri	Papaya Mealy bug, *Paracoccus marginatus*	*Spalgiusepius*, *Acerophagous papaya*	++ ++
	Ridgegourd (Fruit fly and red pumpkin beetle)	---	
	Okra (shoot &fruit borer, Jassids)	*Coccinella septempunctata* *C. transversalis* *Cotesia* sp.	++ + +
	Bitter gourd (fruit fly, leaf eating caterpillar)	*C. transversalis*	+
	Cucumber (Fruit fly, aphid)	*C. transversalis*	++
	Cabbage (DBM, aphid, cabbage butter fly)	*C. transversalis* *Cotesia* sp. *Trichogramma* sp. *Chrysoperla* sp.	++ + + ++
	Bhut jalakia (Aphid)	*C. transversalis* *Cotesia* sp.	+++ +
	Brinjal (shoot &fruit borer, leaf roller)	*Trichogramma chilonis*	+++
	Potato (Potato aphid)	*Micraspis croceae* *C. transversalis*	+++ +
	Tomato (aphid, tomato fruit borer)	*Campotetis chloridae*	+++ +
	Paddy (stem borer) Leaf roller	*Cotesia* sp. *Trichogramma chilonis*, *Agrionemis femina* *Ceriagrion cerinorubellum* *Brachythemis contaminate* *Micraspis croceae*	+ + +++ +++ + +++
	Maize (stem borer, FAW)	-	-
	Pumpkin (pumpkin caterpillar, red pumpkin beetle)	*Coccinella septempunctata* *C. transversalis*	+ +
	Sugarcane (Internode borers, wooly aphid)	*Cotesia* sp. (plassey borer)	+++ +

		Strumiopsis inferans (early shoot borer) *Encarsia flavoscutellum* (wooly aphid)	++
Jorhat	Coconut rugose spiralling whitefly	The per cent of parasitization by *Encarsia* sp. was near about in between 22.00 to 27.00 per cent. However, the predator, like spider (unidentified), coccinalids and lacewing were also recoded.	-

I.2.16 CAU, Imphal

Table 18.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
CHF, Phasighat campus	Brinjal, tomato and cabbage, ornamental and medicinal crops	Biocontrol agents with special reference to hymenopteran parasitoids and coccinellid predators were collected by employing yellow pan traps in three different crop-ecosystems
High altitude agroecological zone at Nafra (Aruunachal Pradesh)	Different crop ecologies	Natural enemies samples collected and sent to NBAIR for identification

I.2.17 PAU, Ludhiana

Table 19.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Various agro-ecological zones of Punjab	Maize	Three parasitoids, one egg-larval *Chelonu sformosanus* (Hymenopetra: Braconidae) and two larval parasitoids (Hymenoptera: Ichneumonidae) associated with fall armyworm were collected from maize crop under field conditions. The molecular characterization of two specimens based on mitochondrial cytochrome oxidase 1 (MTCO1) showed a homology of 98-100 % with *Temeleucha* spp. and homology of 88 % with *Chelonus*

		blackburni, respectively. The specimens have been sent to NBAIR for identification at species level.
-	Sugarcane	*Fulgoraecia melanoleuca* was recorded to be key parasitoid infesting *Pyrilla perpusilla* on sugarcane crop. Among different agro-climatic zones, the natural parasitism of pyrilla was more in central plain and sub-mountainous undulating zones as compared to Western zone of Punjab. The parasitoid remained active in overlapping stages during the months of April to November with peak activity in September month at all the locations. It overwintered in cocoon stage from December to March months in sugarcane trash.
-	Rice	A total of 5 spider species from three families, Tetragnathidae, Salticidae and Araneidae were recorded from the rice fields. Among these, *Neoscona theisi* was the predominant species. The key parasitoids collected from rice fields were *Trichogramma chilonis*, *T. japonicum*, *Stenobracon* sp., *Bracon* sp. and *Xanthopimpla* sp.)
-	Cotton	Among predators, coccinellids (*Coccinella septempuntata*, *Cheilomenes sexmaculata*, *Brumus suturalis*, *Serangium* sp.), green lacewing (*Chrysoperla zastrowisillemmi*), *Geocoris* sp., *Zanchius* sp. and spiders were prevalent. The parasitoids namely, *Encarsia* spp. and *Aenasiu sarizonensis* were found to be associated with whitefly and mealybug, respectively
-	Wheat, oilseed and cole crops	Coccinellids (*Coccinella septempuntata* and *Cheilomenes sexmaculata*) and syrphids (*Ischidon scutellaris*, *Episyrphus* sp. and *Metasyrphus* sp.) were collected from wheat, oilseed and cole crops. *Cotesia glomerata* was recorded from *Pieris brassicae* on oilseed and cole crops
-	Gram and Tomato	*Campoletus chlroridae* was found to be parasitizing *Helicoverpa armigera* in gram and tomato crops
Kapurthala, Punjab	Cabbage/ cauliflower	*Spodoptera litura* infected with NPV were recorded

I.2.18 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, *Sasajiscymnus* 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

I.2.19 NIPHM, Hyderabad

Table 20.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Hyderabad	Maize	*Chrysoperla carnea,* Coccinellids (*Cheilomenes sexmaculata* Fabricius., *Coccinella transversalis* Fab.,*Coccinella septempuctata* Linnaeus), Big eyed bug (*Geocoris* sp.), Preying mantis, Dragon fly, Damselfly, Pentotomid bug (*Eocanthecona furcellata*), Reduviid bug (*Rhynocoris fuscipes*), Robber fly, Long legged fly, Carabid beetle, Ear wig, Hover fly, Rove beetle, Long horned grasshopper, Spiders, Wasp. The parasitoids reported are *Cotesia* sp., *Bracon* sp. and *Trichogramma* sp.

I.2.20 UAS, Raichur

During 2020-21 survey was conducted to record the biocontrol agents in major crops of North Eastern Karnataka. In Bidar and Yadgir districts moderate to high incidence of whitefly was noticed in sugarcane and the leaves infested with whitefly were brought to the laboratory and later the natural enemies emerged were collected and stored in 70 % alcohol. During current season unusual incidence of gall midge, *Oreseloia oryaze,* was noticed in paddy ecosystem in both kharif/rabi season in Ballari, Koppal and Raichur districts and the infested shoots were brought to the laboratory and kept for the emergence of natural enemies and stored in 70 % alcohol. Prasitoids collected from pink bollworm were also stored in 70 % alcohol. All the specimens of natural enemies were submitted to ICAR- NBAIR, Bengaluru for identification.

I.2.21 KAU, Thrissur

Table 21.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Thrissur and Palakkad	Rice	243 spiders collected

I.2.22 SKUAST, Srinagar

Survey on maize growing areas of Kashmir including Budgam, Ganderbal and Srinagar indicated stem borers as well as *Mythimna separata.* The larval parasitism by *Cotesia ruficrus* ranged from 33.55 to 63.74 per cent.

Table Maize plant infestation with *Mythimna separata* and its larval parasitism in Ganderbal district during 2020

Table 22.

Location	% plant infestation	% larval parasitism
Zujina	41.33 (39.98)[a]	35.55 (36.58)[a]
Sumbul	42.66 (40.71)[a]	33.27 (35.13)[a]
Kangan	60.0 (50.82)[b]	44.92 (42.04)[b]
Chenwan	62.66 (52.37)[b]	53.36 (46.93)[c]
Thioune	84.0 (66.52)[c]	63.74 (53.11)[d]
CD (0.05)	5.52	4.48

II. SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS

II .1.1. ANGRAU at RARS, 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.

Conducted 18 field visits in paddy, sugarcane, maize, coconut in Visakhapatnam, Vizianagaram and Srikakulam districts of Andhra pradeshduring kharif and rabi, 2020-21

Noticed calotropis grasshopper, *Poekilocerus pictus* on Calotropis in vzianagaram, Srikakulam Districts in May and June, 2020. Coffee grasshopper/ Spotted grasshopper/ Spotted locust/coffee locust, *Aularches miliaris* on *Wrightia tinctonia* and *Aularches miliaris* on cashew in Vizianagaram District in May-June 2020 and *Aularches miliaris* on cashew in Visakhapatnam district, Coffee grasshopper incidence in Vizianagaram and Cheemidivalasa, Pachipentamandal, Vizianagaram district in May2020 and the specimens sent to NBAIR, Bangalore for molecular identification. Rugose spiraling whitefly incidence was low (<5%) in coconut. Monitored moderate to severe incidence of fall army worm (8-22%) in maize. Monitored low to moderate incidence of leaf folder in rice, low to moderate incidence of sheath blight, sheath rot and BLB in rice; moderate incidence of fall army worm in maize ESB incidence was low (<5%)in sugarcane and fall army in maize was severe (> 50 %) in late sown crop . Noticed yellow hairy caterpillar in rice (*Psalis pennatula*) and maize (*Halysidotasps*). Collected infected rice skipper larva and isolated two microbials and kept for sub culturing. Noticed yellow hairy caterpillar in rice (*Psalis pennatula*) and maize (*Halysidotasps*). Collected infestedrice skipper larva and isolated two microbials and kept for sub culturing. ESB incidence was low (<5%) in sugarcane and fall army in maize was low (2-5%). Monitored low to moderated incidence of FAW (5 to 22 %) in maize, low intensity of Rugose spiraling whitefly in coconut. Noticed parasitization of fall army worm eggs with *Telenomus remus* and *Trichiogramma chilonis* in maize. Noticed parasitize emergence of *Encarsia guadeloupae* from coconut rugose whitefly (Table 23).

Table 23. Crop pest outbreak during 2020-21:

S.No	Month	Date	Location	Crop	Pest	Problems noticed & Level of incidence

1.	May 2020	26.5.2020 28.5.2020 30.5.2020 31.5.2020	Vizianagaram, Cheemidivalas (Pachipentamandal), Snagamvalasa Parvathipurammandal),Vizianagaram district, Atcherla, (Kasimkotamandal), Visakhapatnam dist, Kotturu,Srikakulam district	Calotropis Flower crops	Calotropis grasshopper, *Poekilocerus pictus*	Severe (50-80 % defoliation)
2.	June 2020	28.6.2020	Anakapalle, Visakhapatnam dist; Cheepurupalli, Vizianagaram dist	Cashew, Wrightiatinctonia	Coffee grasshopper/ Spotted grasshopper, *Aularches miliaris*	Severe
		29.6.2020		Sugarcane	Early shoot borer	Moderate to severe (15-21%)
3.	July 2020	25.7.2020	Vizianagaram, Denkada, Pusapatiregam, Vizianagaram district	Maize	Fall army worm (FAW)	Low to moderate (2 to 8 %)
				Coconut	Rugose spiraling whitefly(RSW)	Low (<5%)
4.	August 2020	3.8.2020 26.8.2020	Cheepurupalli, Gurlamandals Vizianagaram dist; Munagapaka, Visakhapatnam dist.	Maize	FAW	Moderate to severe(8-22%)
				Sugarcane	Early shoot borer	Low (<5%)

5.	September 2020	11.9.2020 21.9.2020 26.9.2020	Vizianagaram, denkada, Garividi, Cheepurupallimandals, Vizianagaram dist.	Rice Maize Sugarcane Rice Maize Rice	Sheath blight rice fall army worm in maize ESB in sugarcane yellow hairy caterpillar (*Psalispennatula*) YHC(*Halysidotasps*) Mycosed rice skipper larva	Low to moderate Moderate to severe (12-50%) ESB low (<5%)
6.	October 2020	19.10.2020	Ransthalammandal, Srikakulam district	Rice Maize Coconut	Leaf folder Fall army worm Rugose spiraling whitefly	Low to Moderate
7.	November2020	9.11.2020 30.11.2020	Garividi, Cheepurupallimandals, Vizianagaram dist	Sugarcane Maize	Early Shoot Borer Fall army worm Parasitoids*Telenomusremus, Trichiogrammachilonis*on maize FAW	Low-Moderate (5-12%) Moderate to severe(< 5-20%

8.	December 2020	22.12.2020 24.12.2020	Garividi, Pusapatirega, Gajapathinagarammandals, Vizianagaram dist; Ranasthalammandal, Srikakulam dist	Sugarcane Maize Coconut	Early Shoot Borer Fall army worm (FAW) *T. remus and T. chilonis* on FAW *Encarsia guadeloupae*, *Isaria* fungus on Rugose spiraling whitefly (RSW)	Low (<5%) Low (2-8%)
9.	January 2021	30.1.2021	Gajapathinagaram, Gurla, Denkada, Vizianagaram dist	Maize Rice	Fall army worm leaf folder	Low (2-4%) > ETL (2 adults /sq.m)
10.	February, 2021	10.2.2021	Gajapathinagaram, Denkadamandals, Vizianagaram dist	Sugarcane	Early Shoot Borer Inter Node Borer	Low (<5%) Severe (22%)

Surveillance for pest outbreak and invasive pests

Surveillance for pest outbreak and invasive pests

II. 1.2 AAU Anand

Survey was conducted in various locations of Anand district and other districts of Gujarat. During the survey, severe incidence of fall armyworm in maize (August & September 2020) in Anand district and rugose spiralling whitefly in coconut (November 2020 & January 2021) in Junagadh district was recorded.

II. 1.3 ICAR-IIHR, Bengaluru

During 2020, extensive surveys in the farmers fields, (Kandali village, Hassan district, Karnataka; 76.03^{o} E 12.97^{o} N; cv. PKM-1, n = 500) and at the experimental fields of ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (12°58’ N; 77°35’ E; cv. PKM-1, n = 140) revealed severe damage by the tea mosquito bug on drumstick plants. To study the yield loss and severity of incidence, we randomly selected 20 plants at each place and recorded the number of adults/nymphs of *H. antonii*andnumber of twigs with TMB related dieback symptoms. Monitoring of tea mosquito bug field population was carried out using two different colour sticky traps (yellow and blue) erected at four different heights *viz*., 1.21 m, 1.82 m, 2.13 m and 2.43 m at the drumstick experimental block of ICAR-IIHR with three replications. Data on the weekly (n =8) trap catches (on the number of adult TMB trapped per trap) were recorded.

Tea mosquito bug, *Helopeltis antonii*, was observed to cause severe damage (74-100%) to drumstick, *Moringa oleifera*.The feeding damage by adult as well as nymphal stages of *H. antonii* led to wilting of shoots and the typical damage symptoms on drumstick included the necrotic/silvery patches on the tender shoots/ fruits, leaf loss and die back of tender shoots that led to complete drying of plants(Fig 3). Yellow colour sticky traps found to attract significantly higher number of adult *H. antonii* (7± 2.26; *P*< 0.001) compared to the blue traps (2.37± 0.75).

Fig:3. Incidence of tea mosquito bug (TMB) *H. antonii* Sign. on drumstick (a) adult TMB (b) Necrotic feeding lesions of TMB on tender shoots (c) Die-back of tender growing shoots (d) White silvery feeding patches on pods (e & f) Complete die-back and wilting of plants due to TMB incidence.

II. 1.4. KAU, Thrissur

Survey for invasive alien species

Extensive surveillance was carried out for cassava mealy bug, *Phenacoccus mannihoti*. Which was first reported from Thrissur. Surveys for prevalence of cassava mealybug were carried out in more than 150 locations at Thrissur and Palakkad districts from May 2020 to March 2021 (Fig 4). A total of 161 mealybug samples were collected and were sent to NBAIR for identification. Taxonomic identification of 128 samples showed that four mealybug species *viz*., *Paracoccus marginatus*(36.72%), *Ferrisia virgata* (29.69 %), *Phenacoccus manihoti*(28.90%) and *Pseudococcus jackbeardsleyi* (4.69 %) infested the cassava plants simultaneously, forming a complex.

Fig:4. Survey for cassava mealy bug in Thrissur. Infestation of cassava by mealybug complex

Graphic representation of the mealybug composition in cassava

Among the natural enemies, predators like ape fly and green lacewings were encountered frequently in the field. Two entomopathogenic fungi, *viz*., *Lecanicillium araneicola* and *Simplicillium* sp. were isolated from the mummified cadavers of *Paracoccus marginatus*.

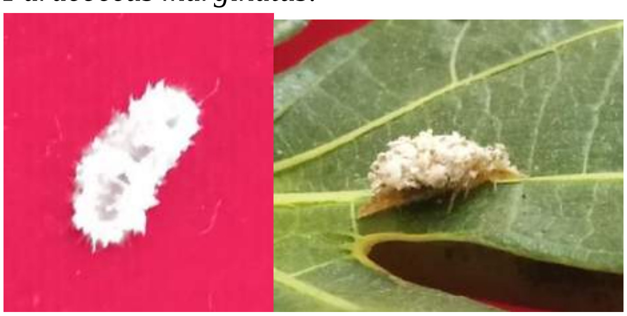


Fig:6. Larvae of Ape fly (*Spalgisepius*) and unidentified green lacewing observed feeding on mealybugs in cassava.

Fig:7. Upper and lower view of EPF- *Lecanicillium araenicola*

Fig:8. Upper and lower view of EPF- *Simplicillium* sp.

II.1.5. MPKV, Pune

Surveillance for pest outbreak and alien invasive pests

Amongst the targeted invasive pests, the mealy bug species, *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya respectively, in Pune, Nadurbar, Dhule and Jalgaon districts.The incidence of American pin worm, *Tuta absoluta* is observed on tomato crop in few pockets in SatanaTahasil of Nashik district and SakurTahasil of Latur district in Maharashtra during February and March, 2021. The fall army worm (FAW) *Spodoptera frugiperda*was recorded in all maize growing areas of Maharashtra. The FAW infestation ranges between 10 to 40 per cent in maize crop. The pest extended its host range and it is also found on sorghum and Bajra crops in Pune, Solapur, Satara and Sangli districts.

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 vegetable samples were collected from the market yards and nearby village markets and observed for alien invasive pest species and natural enemies.

Nymphs and females of mealy bug species, *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya respectively, in Pune and Dhule and Jalgaon districts. The encyrtid parasitoid, *Acerophagus papayae*N& S, predatory larvae of *Spalgisepius*, coccinellids, anthocorids, chrysopids, syrphids and spiders were recorded in Pune and Dhule region. Amongst the target pests, *Tutaabsoluta*was recorded in in few pockets in SatanaTahasil of Nashik district and SakurTahasil of Latur district in Maharashtra during February and March, 2021.

Alien pest, Fall Army Worm (FAW) *Spodoptera frugiperda*was found in all maize growing areas of Western Maharashtra. The FAW infestation ranges between 10 to 40 per cent in maize crop. The pest extended its host range and it is also observed on sorghum and bajra crop in Pune, Solapur, Satara, Sangli districts. Hence, it is became serious concern to these crop

II. 1.6. MPUAT, UDAIPUR

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

Surveys were conducted to record the incidence of fall armyworm, *S. frugiperda*from July, 2020 to March, 2021. The survey indicated that the incidence of fall armyworm was noticedto be moderate to severe in Udaipur, Chittorgarh, Rajasamand and Pratapgarhdistricts of Southern Rajasthan with an average incidence range of 3-10 per cent (Table 24).

Surveys undertaken during July, 2020 to March, 2021 covering Udaipur, Chittorgarh, Rajasamand, Pratapgarh, Banswara and Dungarpurdistricts 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 October 2020 to March, 2021.

Table 24.

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

District	Block	Village	No. of field visited	% FAW infestation
Udaipur	Bhinder	04	13	6-9
	Mavli	05	17	4-8
Chittorgarh	Dungla	02	07	8-10
	Barisadri	01	03	8.0
	Nimbahera	01	02	7.0
Rajsamand	Railmagra	04	11	6-8
Pratapgarh	Chhotisadri	03	05	3-5
	Pratapgarh	03	07	4-4

II. 1.7 OUAT, Bhubaneswar

Survey was made in every month starting from July, 2020 in Odisha for the outbreak of insect pests in different crops. The CPOR reports along with photographs in the specified proforma were given (Table 25).

Table 25. Month wise outbreak of insect pests in Odisha during 2020-21

Month and year	Crop	Pest	Level of infestation	Site	Remarks
July 2020	Rice	Yellow stem borer (*Scirpophaga incertulas)*	Mild to Moderate	Baragarh and Sambalpur areas	Release of *Trichogramma* sp. @50000/ha at an interval of 7 days for 5-6 times or chlorantraniliprole 18.5 SC150 ml/ha
August 2020	Rice	Yellow stem borer (*Scirpophaga incertulas)* Leaf folder *(C. medinalis)*	Mild to Moderate	Baleswor, baragarh	Release of *Trichogramma* sp. @ 50000/ha at an interval of 7 days for 5-6 times or chlorantraniliprole 18.5 SC150 ml/ha

September 2020	Maize (*Zea mays*)	Fall armyworm (*Spodoptera frugiperda*)	Low to Medium	Kalahandi, Koraput, Raygada districts of Odisha.	Emamectin benzoate5%SG(200gm/ha) or Chlorantraniliprole 18.5% SC 200ml/ha
October 2020	Paddy (*Oryza sativa*)	Yellow stem borer (*Scirpophaga incertulas)*	moderate	Baragarh and Balaswar district of Odisha.	Chlorantraniliprole 18.5% SC 200ml/ha or Flubendiamide 20% SG125gm/ha
November 2020	Maize (*Zea mays*) Rice	Fall army worm (*Spodoptera frugiperda)* Green leaf hopper	Moderate Moderate	Koraput and Nawarangapurdistrict, Odisha Cuttack, Puri and Baleswor district of Odisha	Thiamethoxam 12.6% +Lambda cyhalothrin 9.5% EC @ 250 ml/ha Dinatofuran 20SG200gm/ha
December 2020	Mustard (*Brassica juncea)*	Mustard aphid (*Lipaphis erysimi)*	Moderate	Keonjhar and Rayagarh districts of Odisha	Imidacloprid 17.8 SL@0.3ml /l
January 2021	Mustard	Mustard aphid *(Lipaphiserysimi*)	Moderate	Puri District of Odisha	Dimethoate 30 EC@2ml/l or Imidacloprid 17.8% SL 140ml/ha
February 2021	Arhar	Arhar pod borer	Moderate	Kalahandi and Sundargarh	Chlorantraniliprole 18.5% SC 100 ml/ha or Flubendiamide 18.35% SC100ml/ha
March 2021	Brinjal (*Solanum melongena*)	Brinjal fruit and shoot borer (*Leucinodes orbonalis*)	Moderate	Village Aonlamada and Ranipada village of Nayagarh district	Chlorantranilipro LE 18.5% SC 200ml/ha Spinetoram 11.7 % SC 500ml/ha


Fig:9. Release of *Trichogramma japonicum* in rice field

Fig:10. Release of *Trichogramma chilonis* & *T. japonicum* in farmer's field
Fig. Leaves infested with RSW in coconut

II. 1.8 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 to be 5-20 per cent on maize and fodder maize crops in different maize growing districts of Punjab during *kharif*, 2020. No FAW incidence was recorded on any other crop. The overall status of various insect pests and natural enemies recorded on different crops in Punjab is given in Table 26 .

Table 26:Status of insect pests and natural enemies on different crops in Punjab during 2020-21

Crop	Insect pests	Status	Natural enemies recorded
Sugarcane	*Chilo infuscatellus*	Low (May-June)	*Cotesia* sp., *Trichogramma chilonis*, *Fulgorecia melanoleuca*
	Scirpophaga excerptalis	Low (June)	
	Chlo auricillius	Low (July to October)	
	Pyrilla perpusilla	Low (June to September)	
Cotton	*Bemisia tabaci*	Low (June to September)	*Chrysoperla* sp. (eggs and grubs), Spiders
	Thrips tabaci	Low (July-August)	
	Amrasca bigutulla	Low (June to August)	
Maize	*Chilo partellus*	Low to moderate (June to August)	Spiders, yellow wasp,

	Spodoptera frugiperda	Low to moderate (June to August) Low (spring maize - March)	*T. chilonis*, *Coccinella septempunctata*, *Chelonus fomosanus*, *Temeleucha* spp.
Rice	*Scirpophaga incertulas*	Low (July-August)	Spiders, dragonflies, damselflies, *Trichogramma* spp., *Stenobracon*, *Xanthopimpla*
	Cnaphalocrocis medinalis	Low (July to September)	
Wheat	*Rhopalosiphum maidis*, *R. padi*, *Sitobion miscanthi*, *S. avenae*	Low (March)	*Coccinella septempunctata*
Mustard	*Lipaphis erysimi*	Low (March)	*C. septempunctata*

II. 1.9. PJTSAU, HYDERABAD

The trial involved surveys of Mahbubnagar, Rangareddy and Nalgonda districts of Telangana in both Kharif and rabi seasons of 2020-21. Visit, survey and surveillance and interaction with state/line department officials and local farmers will be done.

Periodicity: 1 month

Covering the district where centre is located and 2-3 adjoining districts. In case of pest outbreaks, affected area may be specifically visited. The Pink Bollworm was observed in many cotton growing areas of the state.

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. Locust outbreak was observed in on maize in Thoguntamandal of Siddipet district, *viz.*,Govardhanagiri, Gudikandula, Ghanapur and Varadarajupalli were examined for incidence and damage by the pest.

Surveys in 2020-21 *kharif* revealed that major pests in rice were the yellow stem borer in most of the rice growing areas of Ranga Reddy, Nalgonda and Mahbubnagar districts. Whorl maggot was reported in a few areas including Nalgonda dt. Brown plant hopper was observed in a few areas. Fall armyworm was reported in few pockets of Karimanagar dt and its infestation was less than 15%. Bacterial leafblight was reported in many areas growing rice crop.

In cotton crop in these districts, sucking pests viz., thrips in the very early stages, later leafhoppers, whiteflies and aphids dominated the crop pest scenario. Upward curling and reddening of leaves was a common symptom observed in these areas. After flowering started, around 55 DAS, pink bollworm infested the crop and caused losses of about 50%. Continuous rains and stagnation of water in the field for a week in September last weeks and October, caused stunting of the crop in cotton and lesser flowers and reduced yields in areas with drainage problem. Redgram and other pulse crops were infested by *Maruca*sp in many areas of Ranga Reddy dt.

In vegetable growing regions of Shamshabad, Kothur and Moinabadmandals, leafhoppers were found to be the major pest in the vegetative stage, later shoot and fruit borer of brinjal and shoot and fruit borer in Bhendi were the major pests recorded. Chilli crop was infested by thrips from a week after transplanting to the later stages also, even after fruiting started. Most of the growers reported upward cupping of leaves and stunted growth. Fusarial wilt was noticed in cotton and chilli crops.

In *rabi* 2020-21, rice crop was again infested by yellow stem borer, bitter gourd, kheera, bottle gourd, ridge gourd of Babaguda, Atrazpalli, Ponnala, Mulugu and Shamirpet areas revealed the presence of Snakegourd semilooper *Anadevidia peponis* on bottlegourd. Yellow vein mosaic virus was rampant due to high infestation levels of whitefly in the early crop stage. Grape fields in Turkapalli area was severely infested with leafhoppers and cupping of leaves was observed. Tomato crop in Yeravali and surrounding villages in Shamshabadmandal was severely damaged (more than 75%) by *T.absoluta.*Fusarial wilt was noticed in chick pea, chillies, Colocasia crops

Table 27

S.No	Crop	Pests observed	Areas surveyed	Level of Incidence
1.	Paddy	Yellow stem borer Gall midge Green Leafhopper Brown plant hopper	Ranga Reddy dt Shamshabadmandal Bahadurguda village Laxmi thanda Sayyedguda Pedda Golconda ChinnaGolconka Shahpur Kothurmandal	Moderate to severe incidence
			Mahbubnagar dt Chegoremandal	
			Nalgonda dt Marrigudamandal Nampally Maal Chintapallymandal	Moderate to severe
2.	Cotton	Sucking pests leaf hoppers, whiteflies, thrips, aphids Pink Bollworm	Shamshabadmandal Bahadurguda village Laxmi thanda Syedguda Villages of Chegoremandal Kasimbouli and Moinabadmandal, Aziznagar	Moderate to severe

3	Redgram and other pulses	*Maruca* sp	Mahbubnagar and surrounding areas	Moderate
4.	Vegetables	Brinjal	Ibrahimpatnam Moinabad Maheshwaram, mandal, Chevellamandal Shabadmandal Yacharammandal Sheriguda Bhadraipally	Moderate
		Shoot and fruit borer		Severe
		Leafhopper		Moderate to severe
		Whitefly		Moderate
		Bhendi		Severe
		Shoot and fruit borer		Moderate to severe
		Leafhopper		Moderate
		Whitefly		
		Tomato		
		Pinworm		Moderate
		H. armigera Mirid		Less
		Whiteflies		Less
5.	Leafy vegetables	*Helicoverpa armigera*	Ibrahimpatnam, Moinabad, Shamshabad, Maheshwaram, Abdullapurmet	Severe
6.	Chilli	Sucking pests		Severe
		Blossom midge		
		Fusarial wilt		

Table 28 Crops and Pest outbreak report Vanakalam2020-21

1.	Paddy	Yellow stem borer	Ranga Reddy dt Shamshabadmandal Bahadurguda village Laxmi thanda Sayyedguda Pedda Golconda ChinnaGolconka Shahpur Kothurmandal	Moderate to severe incidence

			Nalgonda dt Marrigudamandal Nampally Maal Chintapallymandal	Moderate to severe
2.	Groundnut	Leafhopper	Mahbubnagar	Severe
		Spodoptera litura		Moderate
3.	Vegetables	Brinjal	Kothurmandal	
		Shoot and fruit borer	Moinabad Maheshwaram, Chevella Shabadmandal Yacharammandal Kothurmandal RR dt Sherigida Bhadraipally	Severe
		Leafhopper		Moderate to severe
		Bhendi		
		Whitefly		Moderate
		Shoot and fruit borer		Moderate
4.	Cabbage	DBM		Severe
		Aphids		Moderate
		Helicoverpaarmigera		Moderate
5.	Cauliflower	DBM		Severe
		Aphids		
6.	Chilli	Sucking pests		Severe
7.	Gourds	Whitefly and YMV	Babaguda, Mulugu, Atrazpalli, Ponnala, Shamirpet areas, Gouraram	Higher incidence level
		Gum blight		Medium incidence

Fig:11. Monthly pest data – Rajendranagar region, Telangana for the period July 2020 to April 2021

Table 29

S.No.	Month	Crop	Pest	Severity (Low/moderate/severe incidence)

1.	July 2020	Rice nursery	Hispa	Low incidence
		Rice main crop	Gall midge	Moderate
		Cotton	Thrips	Severe
			Aphids	Moderate
			Hoppers	Severe
			Whiteflies	Low to Moderate
		Redgram	Hoppers	Severe
		Maize	Stem borer	Low
		Sorghum	Shoot fly	Moderate
		Chilli	Thrips	Severe
		Brinjal, Bhendi	Hoppers	Moderate to Severe
			Aphids	Moderate to Severe
			Whitefly	Moderate
		Tomato	Hoppers	Moderate
			Pinworm	Low incidence
		Castor	Leafhoppers	Severe
2.	August 2020	Rice main crop	Gall midge	Moderate to severe
			Gall midge	Moderate
		Cotton	Thrips	Severe
			Aphids	Moderate
			Hoppers	Severe
			Whiteflies	Low to Moderate
		Redgram	Hoppers	Severe
		Maize	Stem borer	Low
		Sorghum	Shoot fly	Moderate
		Chilli	Thrips	Severe
		Brinjal, Bhendi	Hoppers	Moderate to Severe
			Aphids	Moderate to Severe
			Whitefly	Moderate
		Tomato	Hoppers	Moderate
			Pinworm	Low incidence
		Castor	Leafhoppers	Severe
			Semilooper	Moderate
3.	September 2020	Rice	Yellow stem borer	Moderate
			Brown plant hopper	Moderate to severe
		Redgram	Hoppers, *Maruca*sp	Moderate to severe
		Maize	Stem borer	Low
			Fall army worm	Low to moderate
		Cotton	Pink bollworm	Low to moderate
			Thrips	Severe
			Aphids	Moderate
			Hoppers	Severe
			Whiteflies	Low to Moderate
		Brinjal, Bhendi	Hoppers	Moderate to Severe
			Aphids	Moderate to Severe

			Whitefly	Moderate
		Tomato	Hoppers	Moderate
			Pinworm	Low incidence
		Castor	semilooper	Severe
4.	October 2020	Rice	Gall midge	Moderate
			Yellow stem borer	Moderate to severe
			Whorl maggot	Moderate
			Brown plant hopper	Moderate
		Cotton	Aphids	Moderate
			Hoppers	Moderate
			Pink bollworm	Severe
		Redgram	Hoppers, *Maruca* sp.	Moderate to severe
		Maize	Stem borer	Low
		Chilli	Thrips	Severe
			Hoppers	Severe
			Mites	Moderate
			Blossom modge	Severe
		Brinjal, Bhendi	Hoppers	Moderate to Severe
			Aphids	Moderate to Severe
			Whitefly	Moderate
		Tomato	Hoppers	Moderate
			Pinworm	Low
			Serpentine leafminer	Moderate
		Cabbage, Cauliflower and Broccoli	Aphids	Moderate
			DBM	Severe
		Beans	Aphids	Moderate
		Groundnut	*Spodoptera litura*	Moderate
			Leafhoppers	Severe
		Castor	Semilooper and Shoot and capsule borer	Severe
5.	November 2020	Rice	*Spodoptera exigua*	Low
			Panicle mite	Moderate to severe
		Cotton	Pink bollworm	Severe
		Redgram	Hoppers, *Maruca* sp.	Moderate to severe
		Maize	Stem borer	Low
			FAW	Severe
		Chilli	Thrips	Severe
			Helicoverpa	Low to moderate
			Blossom midge	Severe
		Brinjal, Bhendi	Hoppers	Moderate to Severe
			Aphids	Moderate to Severe
			Whitefly	Moderate

		Tomato	Hoppers	Moderate
			Serpentine leafminer	Moderate
		Cabbage, Cauliflower and Broccoli	Aphids	Moderate
			DBM	Severe
		Beans	Aphids	Moderate
		Groundnut	*Spodoptera litura*	Moderate
			Leafhoppers	Severe
		Gourds	Leafhoppers	Moderate
			Aphids	Moderate
			Fruitflies	Severe
		Greengram, Bengalgram	Whiteflies *Maruca*	Moderate to severe
		Chickpea	*Helicoverpa armigera*	Moderate
6.	December 2020	Cotton	Pink Bollworm	Severe
		Chilli	Thrips	Severe
			Helicoverpa	Low to moderate
			Blossom midge	Severe
		Gourds	Leafhoppers	Moderate
			Aphids	Moderate
			Fruitflies	Severe
		Maize	Stem borer	Low
			FAW	Severe
		Cabbage, Cauliflower and Broccoli	Aphids	Moderate
			DBM	Severe
		Beans	Aphids	Moderate
		Oilpalm, sapota, banana, coconut fruit trees	Rugose spiralling whitefly	Low
		Chickpea	*Helicoverpa armigera*	Moderate
7.	January 2021	Rice	Yellow stem borer	Moderate
			Mythimna separsata	Moderate to severe
			Gall midge	Severe
		Cotton	Pink bollworm	Severe
		Maize	Stem borer	Low
			FAW	Severe
		Chilli	Thrips	Severe
		Tomato	Hoppers	Moderate
			Serpentine leafminer	Moderate
			Pinworm	Low
			Aphids	Moderate

		Cabbage, Cauliflower and Broccoli	DBM	Severe
		Beans	Aphids	Moderate
		Groundnut	*Spodoptera litura*	moderate
			Leafhoppers	Severe
		Gourds	Leafhoppers	Moderate
			Aphids	Moderate
			Fruitflies	severe
		Greengram, Bengalgram	Whiteflies *Maruca*	Moderate to severe
		Chickpea	*Helicoverpa armigera*	Moderate
		Oilpalm, sapota, banana, coconut fruit trees	Rugose spiralling whitefly	Low
8.	February 2021			
		Rice	Yellow stem borer	Moderate
		Maize	Stem borer	Low
			FAW	moderate
		Chilli	Thrips	Severe
		Tomato	Hoppers	Moderate
			Serpentine leafminer	Moderate
			Pinworm	Low
		Cabbage, Cauliflower and Broccoli	Aphids	Moderate
		Bhendi, Brinjal	Hoppers, Mites	Moderate to Severe
			DBM	Severe
		Gourds	Leafhoppers	Moderate
			Aphids	Moderate
			Fruitflies	Severe
		Tomato	Pinworm	Moderate to severe
			Serpentine leafminer	Moderate
		Oilpalm, sapota, banana, coconut fruit trees	Rugose spiralling whitefly	Low
9.	March 2021	Rice	Yellow stem borer	Moderate
		Maize	Stem borer	Low
			FAW	Low
		Chilli	Thrips	Severe
			Mites	severe
		Tomato	Hoppers	Moderate
			Serpentine leafminer	Moderate
			Pinworm	Moderate to severe

		Gourds	Leafhoppers	Moderate
			Aphids	Moderate
			Fruitflies	Severe
10.	April 2021	Rice	Yellow stem borer	Moderate
		Bhendi and brinjal	Mites	Low
		Tomato	Serpentine leafminer	Low
			Pinworm	Low

II. 1.10. SKUAST, Jammu

Crop Pest Outbreak from April, 2020 to March, 2021

Table 30.

S. No.	Month	Date	Locations	Crop	Problems noticed & Level of incidence
1.	April	25/04/2020 25/04/2020 27/04/2020 28/04/2020	Reyian District: Samba Reyian District: Samba District: Samba District: Samba	Cucurbits Mungbean, Urdbean Okra Maize	Red Pumpkin Beetle- Moderate Hairy Caterpillar and other defoliators -Moderate to Severe Okra shoot and fruit borer Moderate Stem borer: Moderate Turcicum leaf blight: Moderate
2.	May	16/05/2020 25/05/2020	PatliMorh, Jakh Mawa, Bainglar, Sadoh, Kangwala, Singychapri District: Samba	Bottle Guard Moong bean, Urdbean	Gummy stem blight Per cent disease incidence: 50 – 60% Hairy Caterpillar and other defoliators: Moderate to Severe
3.	June	09/06/2020 20-06-2020	RajpurKathlai, Pangdour District: Samba Mishriwala District: Jammu	Bottle Guard Maize (hybrid)	Red Pumpkin beetle: Moderate to Severe Stem borer: Moderate
4.	July	21/07/2020 22/07/2020 31/07/2020	Sumb, Patyari, Diani, DeraGanotra District: Samba	Maize	Maize stem borer and *Spodoptera litura:* Moderate to Severe

5.	August	10/08/2020 10/08/2020	Bishnah, DeraGanotra Bari-Brahmana, Sarore District: Samba MeenCharkan Raya Suchani District: Samba	Maize (hybrid), Maize fodder Kinnow, Lemon, Litchi, Mango, citrus Variety : Hybrid	Maize stem borer and *Spodoptera frugiperda* Moderate to Severe Turcicum leaf blight 15 - 20% Fruitfly: Moderate to Severe
		06/08/2020	Rehian, Glar Rehian District: Samba	Rice	(Coccinellids/Chrysopids/Spiders/Others): Foot Rot of Rice (Bakanaedisease): 10 - 15%
		08/08/2020	Patli, Sarore District: Samba	Okra Hybrid	Shoot and fruit borer: Moderate
		18/08/2020	Udhampur District:Udhampur	Maize Hybrid	*Spodoptera frugiperda* Moderate
		19/08/2020	Pangdour District: Samba	Rice Hybrid	Leaf folder: Moderate
		22/08/2020	Khadergal District: Samba	Maize Hybrid	*Spodoptera frugiperda* :Moderate
6.	September	01/09/2020	Patti Vijaypur, Bari Brahmana District: Samba	Sesame	Leaf hopper and whitefly : Moderate
		01/09/2020	Patti Vijaypur, Bari Brahmana District: Samba	Moongbean, Urdbean	Whitefly Moderate Yellow mosaic disease : 35 – 50%
		01/09/2020	Patti Vijaypur, Bari Brahmana District: Samba	Guava	Fruitfly and beetles Moderate to severe
		01/09/2020	Patti Vijaypur, Bari Brahmana District: Samba	Mango	Fruitfly and beetles : Moderate

		01/09/2020	Patti, Vijaypur, Bari Brahmana District: Samba	Brinjal	Hadda beetle (*Epilachna vigintioctopunctata*) Moderate
		07/09/2020 12/09/2020	Khanwal, Raipur, Pangdour Reyian District: Samba	Rice Variety: Basmati Rice, Sharbati Rice	Rice stem borer:: Moderate Brown Spot: 35% and 40 -50 % disease intensity
7.	October	29/10/2020	Raipur Camp Reyian District: Samba	Rice	Leaf blight: 10-15%
8.	November	Nil			
9.	December	Nil			
10.	January	06/01/2021 12/01/2021 21/01/2021	Mandal/Taluk: Samba District: Samba Patti, Samba	Wheat Chickpea Mango	Bacterial Blight : Disease incidence: - 10 – 15% Collar Rot Mealybug and Mango hoppers: Severe
11.	February	15/02/2021 23/02/2021	Reyian, Samba Sadoh, Samba	Tomato Wheat	Whiteflies, Leaf Miner: Moderate Leaf Curl Per cent disease incidence: 20-25% Wheat aphids: Low – moderate Yellow leaf spot Percent disease incidence: 20-25%
12.	March	09/03/2021 29/03/2021	ChanniManassan, Samba ChanniManassan, Samba	Cucumber Watermelon	Leaf spot of cucumber Percent disease incidence: 10-15% Cucumber beetles: Severe

Fig:12. Red pumpkin beetle, Shoot and fruit borer in okra and *Spodoptera frugiperda*in maize

Fig:13. Maize stem borer, *Spodoptera frugiperda* infestation and Turcicum leaf blight of maize

Fig:14. Gummy stem blight of Bottle gourd

Fig:15. Foot rot in Rice, Leaf folder in Rice and Yellow mosaic disease in urdbean

Fig:16. Leaf hopper and white fly in sesame and Fruitfly and beetles in guava

Fig:17. Anthracnose in Mango

Fig:18. Hadda beetle in brinjal and Leaf blight in cauliflower seedling

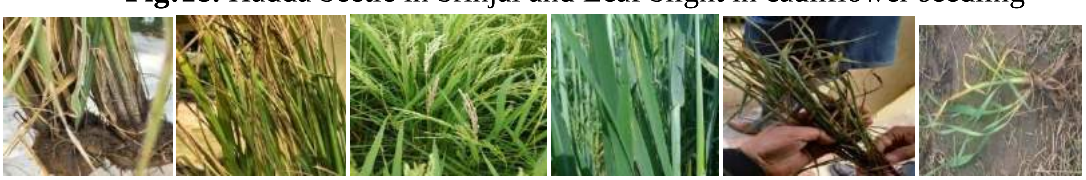


Fig:19. Brown spot of rice, White ears as a result of stem borer infestation and Wheat yellow rustandWheat Bacterial blight

II. 1.11. TNAU, Coimbatore

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.

Bondar's Nesting Whitefly in coconut:

Bondar's nesting whitefly, *Paraleyrodes bondari* (Hemiptera: Aleyrodidae) was observed in coconut gardens in Coimbatore, Tirupur, Erode, Theni, Ariyalur,Kanyakumari, Viruthunagar, Thenkasi, Tirunelveli and Dindigul. *Mallada astur* was found feeding on Bondar's Nesting Whitefly.

Maize fall army worm:

Maize fall armyworm damage was observed in all the maize fields except in a field at Andigoundanur where the farmer has sprayed insecticide. A maximum leaf damage of 40.0 per cent was observed in Vellaravalli during August 2020. Cob damage to the tune of five per cent was observed in Jivalsaragu, R.Velur and Narasipuram.

Roving survey - Incidence of maize fall army worm

II. 1.12. UAS, Raichur

During 2020-21 survey was conducted in major maize growing areas of North Eastern Karnataka to record the status of fall armyworm and its associated biocontrol agents. Incidence of fall armyworm was low to moderate in three districts of North Eastern Karnataka during kharif season while during rabi season very low to negligible population was noticed in both maize and rabi sorghum. On Maize the number of egg patches per plant and number of larvae were highest compared to rabi jowar. Highest parasitization (18.00%) and per cent mycosis (24.50%) was noticed in Ballari district (Table 31).

Table 31. Incidence of fall armyworm, *Spodoptera frugiperda* in North Eastern Karnataka during 2020-21

Districts	Crop	No. of egg patches/plant	No. of larvae/plant	Parasitisation (%)	Mycosis (%)
Raichur					
	Maize	1.04	1.18	12.00	16.50
	Jowar	0.76	0.66	5.00	1.00
Ballari					
	Maize	1.18	1.36	18.00	24.50
	Jowar	0.52	0.48	3.00	2.50
Koppal					
	Maize	1.24	1.42	13.50	10.50
	Jowar	0.64	0.36	2.50	1.50

II. 1.13. UBKV, Pundibari

The outbreak of crop pests of Coochbehar districts have been surveyed throughout the year (April, 2020-March, 2021). We tried our best to reach different blocks in each month to ascertain the infestation of different pests attacking various crops present in the field.

Moderate to severe level of infestation of Rugose Spiralling Whitefly (RSW) was found in coconut during June to October, 2020. Orchards present inside the University campus as well as the vicinity of the UBKV campus were surveyed thoroughly.High level of infestation of Rice Leaf Folder (RLF) was observed in the month of September, 2020. The infestation of RLY has been noticed to become more damaging this year.Moderate to high level of infestation of aphids was observed in vegetables as well as mustard was noticed from January, 2020 to February, 2021. However, moderate level of infestation of trunk borer in mandarin orange as well as tea looper in tea was also found during August, 2020 and November, 2020 respectively.

Surveillance for pest outbreak and alien invasive pests

III. BIOLOGICAL CONTROL OF PLANT DISEASE USING ANTAGONISTIC ORGANISMS

Biological Control of Cereal Diseases

III.1 Biological Control of Rice Diseases

Evaluation of fungal and bacterial isolates for crop health management in rice

1.1. Experimental Details of Glasshouse

Table 32.

Variety	:	Rice: Pant Dhan-4
Layout	:	CRD
Pot size	:	2 kg
Treatment	:	11
Replication	:	03
Seed biopriming	:	05.07.2020
Sowing	:	06.07.2020
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 appliedasseed 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 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, Psf 173, Th14+Psf173 (Consortium) & Carbendazim

Fig:20. 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. Maximum No. of Plants /pot were observed with PBAT-3 (5.50) which was statistically at par withCarbendazim (5.25) and Psf-173 (5.0) but significantly better than control (3.12). In mixed formulations treatments, highest germination percentage was observed in PBAT-3 (91.67 %) followed by, Carbedazim (87.50%) as compared to control (62.40%). Maximum root length was observed with PBAT-3 (22.42 cm) followed by Th14+Psf-2 (22.25 cm), Th-14 (22.00) and Carbendazim (21.42)which did not differ significantly with each other but was significantly better than the control (15.42 cm). Maximum shoot length was recorded with PBAT-3 (56.08 cm), which was statistically at par with Th14+Psf2 (55.25 cm), Th17+Th14 (54.75 cm), Th17+Psf2 (54.67 cm) and Carbendazim (54.32 cm) but significantly different from other treatments including control (38.07 cm). Maximum root fresh weight was observed with PBAT-3 (0.95 gm) followed by Th14+Psf2 (0.94 gm) Th17+Psf173 (0.93 gm), Th17+Psf2 (0.93 gm) and Th17+Th14 (0.92 gm) which did not differ significantly with each other but was superior over control (0.52gm). Maximum shoot fresh weight was recorded with PBAT-3 (3.60 gm) which was statistically at par with Th17+Psf173 (3.49 gm) and Th17+Psf2 (3.47 gm), followed by Carbendazim (3.43 gm) but significantly better than the control (2.14 gm). Maximum dry root weight was observed with PBAT-3 (0.85 gm) followed by Th17+Psf173 (0.72gm), Th17+Psf2 (0.72gm), Th14+Psf2 (0.72gm), Th17+Th14(0.68gm) and Carbendazim (0.67gm) which were statistically at par with each but significantly different from PBAT-3. However minimum dry weight of roots was observed with control (0.58gm) which did not differ significantly from Th-17 (0.63gm), Th-14 (0.64gm), Psf-2 (0.63gm), and Psf-3 (0.64gm). Max. Shoot dry weight was recorded with Th17+Th14 (1.62gm) which was statistically at par with Th17+Psf2 (1.61gm), PBAT-3 (1.58gm), Th17+Psf173 (1.57gm) and Th14+Psf2 (1.53gm). Minimum shoot dry weight was observed with control (0.87gm) which did not differ significantly from carbendazim (0.92gm), Th-17 (0.92gm), Psf-173(0.92gm), Psf-2 (0.94gm) and Th-14 (0.95gm) (Table 33)

Table 33.: Efficacy of promising bio-agentsonplant growth of rice (var. Pant Dhan-4)

Treatments	No. of Plants/ pot	Seed Germination % (10 DAS)	Plant Length(cm)		Fresh Weight (gm)		Dry Weight (gm)	
			Root	Shoot	Root	Shoot	Root	Shoot
Th17+Psf173	4.25	70.83	19.00	45.25	0.93	3.49	0.72	1.57
Th17+Psf2	4.42	73.67	20.32	54.67	0.93	3.47	0.72	1.61
Th17+Th14	4.75	79.17	18.27	54.75	0.92	3.34	0.68	1.62
Th14+Psf2	4.58	76.33	22.25	55.25	0.94	3.34	0.72	1.53
Th-17	4.50	75.00	19.25	53.12	0.87	2.73	0.63	0.92
Th-14	3.92	65.33	22.00	47.75	0.82	2.72	0.64	0.95
Psf-2	4.17	69.50	17.58	48.75	0.88	2.34	0.63	0.94
Psf-173	5.00	83.33	17.75	46.58	0.62	2.68	0.64	0.92
PBAT-3	5.50	91.67	22.42	56.08	0.95	3.60	0.85	1.58
Carbendazim	5.25	87.50	21.42	54.32	0.94	3.43	0.67	0.92
Control	3.12	62.40	15.42	38.07	0.52	2.14	0.58	0.87
C.D.	0.51		1.45	2.47	0.04	0.15	0.06	0.12
C.V.	6.84		4.35	2.87	2.69	3.02	4.87	5.22

*06 counted seeds were sown in each pot

III.1.1 Experimental Detail of Field

A field experiment was conducted with same treatments as that of Glass house at Crop Research Centre, Pantnagar to test efficacy offourpotentialbio-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 appliedasseed 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 View at Crop Research Centre, Pantnagar	Root Dip Treatment of Rice Seedling with Bioagents before Transplanting	Transplanted Rice in field

Field view of Rice trial at Crop Research Center, Pantnagar

Fig:21. Evaluation of consortia of fungal and bacterial isolates for crop health management of rice at Crop Research Centre, Pantnagar

III.1.2 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 (28.04%), which did not differ significantly from Th14+Psf2 (29.24%), Th17+Psf2 (29.46%), Th17+Th14 (29.46%), Carbendazim (29.47%) and Th17+Psf173 ((30.15%), but significantly superior than control (44.85%). Maximum sheath blight disease reduction (37.48%) was observed with PBAT-3, followed by Th14+Psf2 (34.80%), Th17+Psf2 (34.31%), Th17+Th14 (34.31%) and Carbendazim (34.29 %). Minimum percentage of Brown spot (*Drechslera oryzae*) formerly known as *Helminthosporium oryzae* infected panicle/hill was observed with PBAT-3 (42.39%) which was statistically at par with Carbendazim (42.53%)and followed by Th17+Psf2 (43.41%). However, maximum percentage of brown spot infected panicle/hill was recorded with control (58.38%). (Table 34)Maximum brown spot disease reduction (27.39 %) was recorded with PBAT-3 followed by Carbendazim (27.15%).

Fig:22.

 Sheath Blight of Rice	 Brown Spot of Rice

Table 34. 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	25.34 (30.15)	32.78	51.79 (46.01)	21.19
Th17+Psf2	24.23 (29.46)	34.31	47.25 (43.41)	25.64
Th17+Th14	24.24 (29.46)	34.31	53.33 (46.89)	19.68
Th14+Psf2	23.94 (29.24)	34.80	52.66 (46.51)	20.30
Th-17	28.09 (31.98)	28.70	53.33 (46.89)	19.68
Th-14	27.57 (31.65)	29.43	53.07 (46.74)	19.94
Psf-2	28.65 (32.34)	27.89	59.39 (50.40)	13.67
Psf-173	27.01 (31.28)	30.26	54.74 (47.70)	18.29
PBAT-3	22.15 (28.04)	37.48	45.48 (42.39)	27.39
Carbendazim	24.24 (29.47)	34.29	45.72 (42.53)	27.15
Control	49.76 (44.85)		72.53 (58.38)	
C.D.	2.97		1.83	
C.V.	5.47		2.27	

*Figures in parenthesis are angular transformed values

III.1.3 Plant vigour and Yield

Maximum plant height was recorded with PBAT-3 (63.37 cm) followed by Th17+Psf-2 (63.20 cm) and Th17+Psf173 (62.97 cm) which were statistically at par with other treatments but was significantly superior to control (57.95 cm). Maximum number of tillers/hill (60 DAT) was observed in Th17+Th14 (19.00) which was statistically at par with Th17+Psf2 (18.67), PBAT-3 (18.33), Psf-2 (17.67), Th-14 (17.33), Th14+Psf2 (16.33), Carbendazim 16.33 and Psf-173 (16.00). However minimum number of tillers/hill was observed with Control (12.83) which was significantly same with Th17+Psf173 (15.33) and Th-17 (15.68). Maximum number of tillers/hill (120 DAT) was recorded with PBAT-3 (26.27) and followed by Th-14 (22.39) which was statistically at par with Th-17 (21.93), Psf-173 (21.79), Carbendazim (21.77) and Th14+Psf2 (20.93) but different from PBAT-3. However minimum tillers/hill (120 DAT) was recorded with control(19.16) which did not differ significantly from Th17+Psf2 (19.47), Psf-2(19.63), Th17+Th14 (19.89) and Th17+Psf173 (20.37). Maximum yield was obtained with PBAT-3 (57.17 q/ha) followed by Psf-173 (54.67 q/ha), Carbendazim (54.50 q/ha) and was superior than control (38.37 q/ha). Maximum test weight of grain was recorded by PBAT-3 (28.85 gm) which did not differ significantly from Th17+Th14 (28.47 gm) Th-17 (28.37 gm) Psf-173 (27.96 gm), Psf-2 (27.85 gm),Th-14 (27.75 gm), Th14+Psf2 (27.83 gm), Th17+Psf2 (27.47 gm) and Carbendazim (26.68 gm)but better than control (22.08 g). (Table 35)

Table 35. Efficacy of promising bio-agentsonplant growth and yield of rice (var. Pant Dhan-4)

Treatment	Plant height (60 DAT) (no.)	Tillers/hill (60 DAT) (no.)	Tillers/hill (120 DAT) (no.)	Yield			
				Yield / plot (6 m^2) (kg)	Yield (q/ha)	Increase in yield (%)	Test wt(g) (1000 no)
Th17+Psf173	62.97	15.33	20.37	2.77	46.17	20.33	26.60
Th17+Psf2	63.20	18.67	19.47	3.00	50.00	30.31	27.47
Th17+Th14	61.49	19.00	19.89	2.67	44.50	15.98	28.47
Th14+Psf2	60.04	16.33	20.93	3.07	51.17	33.36	27.83
Th-17	61.46	15.68	21.93	2.60	43.33	12.93	28.37
Th-14	60.75	17.33	22.39	2.57	42.83	11.62	27.75
Psf-2	60.89	17.67	19.63	2.53	42.17	9.90	27.85
Psf-173	61.99	16.00	21.79	3.28	54.67	42.48	27.96
PBAT-3	63.37	18.33	26.27	3.43	57.16	48.97	28.85
Carbendazim	59.80	16.33	21.77	3.27	54.50	42.04	26.68
Control	57.95	12.83	19.16	2.32	38.37		22.08
C.D.	1.22	2.86	1.58	0.47			2.06
C.V.	1.16	9.97	4.32	9.46			4.40

III.1.4 ICAR-NRRI, Cuttack

The bio-control efficacy of identified biocontrol agents towards rice sheath blight (*Rhizoctonia solani*) disease under potted plants (ICAR-NRRI, Cuttack)

Detailed report

Replication: 4 Design: CRD Variety: Tapaswini

Treatments:

T1. NBAIR-PFDWD isolate of *Pseudomonas fluorescens*

T2. NBAIR-PEOWN isolate of *Pseudomonas entomophila*

T3. NBAIR-BATP isolate of *Bacillus albus*

T4. NBAIR-BtyoPS isolate of *Lysinibacillus sphaericus*

T5. NBAIR-TATP isolate of *Trichoderma asperellum*

T6. Carbendazim @ 0.1%

T7. Control (Untreated)

Table 36. The biocontrol efficacy against sheath blight disease (*Rhizoctonia solani)*

Treatments	Relative Lesion Height (%)	Percent Disease Index (%)	Disease reduction over control (%)
NBAIR-PFDWD	20.93 (27.22)[b]	25.93 (30.60)[b]	58.83[b]
NBAIR-PEOWN	31.60 (34.18)[c]	48.15 (43.94)[e]	23.53[e]
NBAIR-BATP	26.23 (30.77)[bc]	40.74 (39.66)[d]	35.29[d]
NBAIR-BtoyPS	28.62 (32.34)[c]	40.74 (39.66)[d]	35.29[d]
NBAIR-TATP	22.05 (28.01)[b]	33.33 (35.26)[c]	47.06[c]
Carbendazim	10.05 (18.44)[a]	11.11 (19.47)[a]	82.35[a]
Control	47.52 (43.58)[d]	62.96 (52.52)[f]	

Values are the mean of three replications. Values in the parenthesis are arcsine transformed values. Means followed by a common letter are not significantly different at 5% level by DMRT.

The experiment was conducted at ICAR-National Rice Research Institute, Cuttack, India to test the bio-efficacy of identified biocontrol agents against rice sheath blight pathogen *Rhizoctonia solani* under potted plants during Rabi season of 2021. The virulent *R. solani* (RS-15) was grown on PDA medium and 7 days old mycelial plugs were placed beneath the leaf sheath of 60 days old plants. Results of potted plant experiment studies established that among the biocontrol treatments, application of NBAIR-PFDWD (*Pseudomonas flourescens*) recorded the lesser PDI of 25.92% and RLH (20.93%) followed by NBAIR-TATP (*Trichoderma asperellum*) which was recorded 33.33% PDI and RLH (22.05%). Maximum disease index was recorded in the control (62.96% PDI and 47.52% RLH). The chemical treated plants recorded the least PDI (10.05%) among the treatments. The percent disease reduction over the control was highest for chemical (82.35%) followed by NBAIR-PFDWD (58.83%) and NBAIR-TATP (47.06%).

III.1.5 TNAU, Coimbatore

Management of major diseases of rice with *Bacillus subtilis*

Treatments

T1 – Soil application of *Bacillus subtilis* (TNAU strain) @2.5Kg/ha

T2 – Seed treatment of *Bacillus subtilis* (TNAU strain) @10gm/Kg of seed

T3 - Seedling dip of *Bacillus subtilis* (TNAU strain) @2.5Kg/seedlings required for one ha

T4 – Foliar spraying of *Bacillus subtilis* (TNAU strain) @20gm/lit on 45th and 60th Day After Transplanting

T5 – T1+T2+T3+T4

T6 – Azoxystrobin @0.1% (1ml/lit.)

T7 – Control

Replications -3

TNAU strain of *Bacillus subtilis* available in Department of Plant Pathology, TNAU, Coimbatore will be used in the field trial

Variety : CO-51

Observations recorded:

Severities (PDI) of the following disease of rice

Blast ii. Sheath blight iii. Brown spot iv. Sheath rot v. Grain discoloration

Result: In a field trial conducted to evaluate the effect of *Bacillus subtilis* (TNAU strain) on major diseases of rice, bacterial leaf blight incidence ranged between 27.75 per cent (T3-Soil application of *Bacillus subtilis* -2.5kg/ha) and 28.65 per cent (T4-Foliar sprayof *Bacillus subtilis*- 20g/lit) and all the treatments are on par with T6-Azoxystrobin (1ml/lit). In case of brown spot disease, all the *Bacillus subtilis* treatments were less effective when compared to Azoxystrobin (1ml/lit). Both *Bacillus subtilis* treatments and chemical treatment were statistically on par with control pertaining to the incidence of grain discoloration and sheath blight diseases (Table 37).

Table 37. Management of major diseases of rice with *Bacillus subtilis* (TNAU strain)

Treatments	Disease Damage Level (PDI index)*			
	Bacterial leaf blight	Brown spot	Grain discoloration	Sheath blight
T1-Soil application *Bacillus subtilis* (2.5kg/ha)	27.75 (31.75)[a]	22.80 (28.51)[b]	3.90 (11.38)	2.55 (9.15)
T2-Seed treatment *Bacillus subtilis* (10g/kg)	28.35 (32.16)[a]	22.80 (28.52)[b]	4.65 (12.45)	2.70 (9.36)
T3-Seedling dip *Bacillus subtilis* (2.5kg/ha)	27.90 (31.88)[a]	23.40 (28.92)[b]	4.20 (11.82)	2.85 (9.67)
T4-Foliar spray *Bacillus subtilis* (20g/lit)	28.65 (32.34)[a]	22.35 (28.21)[b]	4.20 (11.82)	3.00 (9.96)
T5-T1+T2+T3+T4	28.35 (32.15)[a]	22.95 (28.61)[b]	3.45 (10.70)	2.55 (9.18)
T6-Azoxystrobin (1ml/lit)	27.60 (31.68)[a]	20.70 (27.06)[a]	4.80 (12.65)	2.40 (8.90)
T7-Control	31.80 (34.31)[b]	25.50 (30.32)[c]	4.20 (11.82)	2.85 (9.67)
SEd	0.4595	0.5123	NS	NS
CD(P=0.05)	0.9650	1.0760	NS	NS

*Values in parenthesis are Arc sine transformed values

** Values in parenthesis are Square root transformed values

III.2 Biological Control of Wheat Diseases

III.2.1 SKUAST, Jammu

Field evaluation of ICAR-NBAIR antagonistic organisms against wheat yellow rust (*Puccinia striiformis* f. sp. *tritici*) **Table 38.**

Plot size	1 x 5 cents for each treatment, 1 cent = 8x5 m^2
Replications	04
Design	RBD
Variety	High yielding variety susceptible to Wheat Yellow Rust – WH-1080

Table 39.

S. No.	Treatments
1.	T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)
2.	T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)
3.	T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)
4.	T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)
5.	T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)
6.	T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)
7.	T_7 - Recommended fungicide application (Propiconazole @ 1 ml/L)
8.	T_8 - Control (Untreated)

Table 40.

Observations	Wheat Yellow Rust Scoring and calculation of Percent disease index (for wheat yellow rust) at 3 and 7 Days After Spray Growth promotion character viz., plant height (cm), biomass (gm) Yield (q/ha)

Four rounds of foliar sprays of talc and liquid formulations antagonistic organisms at the 10^8cfu/ml has been given at 14 days interval starting from 75 Days after Sowing when the disease start appearing

Table 41. :- Yield and Yield attributes of wheat as affected by the application of various antagonistic organisms

Treatments	Plant Height (gm)	Ear length (cm)	no. of seeds / ear	Biomass (gm)	Yield (q/ha)
T_1	77.53	9.96	33.89	9.22	27.83
T_2	74.03	9.50	31.11	7.44	26.02
T_3	80.52	10.11	35.22	10.44	28.6
T_4	75.57	9.84	32.33	9.11	27.07
T_5	71.96	9.44	30.44	6.66	25.58
T_6	74.90	9.78	31.33	8.55	26.08
T_7	70.12	9.14	29.89	6.28	24.91

T_8	69.40	9.00	29.89	5.44	22.85
C.D. at 5%	1.889	N.S.	1.573	0.750	1.090

Table 42. :- Percent wheat yellow rust index in response to the application of various antagonistic organisms

Treatments	Percent disease index							
	1st Spray		2nd Spray		3rd Spray		4th Spray	
	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
T_1	12.40	11.77	11.07	10.03	8.83	8.03	7.47	6.67
T_2	13.60	13.40	12.90	12.60	11.57	10.97	10.43	9.57
T_3	10.67	10.20	9.60	8.90	8.03	7.30	6.77	5.73
T_4	12.80	12.70	11.97	11.50	11.10	10.37	9.67	8.63
T_5	14.30	13.83	13.47	13.23	13.00	12.50	12.30	12.03
T_6	12.87	12.70	12.37	12.03	11.50	11.03	10.13	9.53
T_7	10.50	10.00	9.10	7.77	7.23	6.17	5.87	5.53
T_8	14.80	15.00	15.70	16.00	16.60	17.00	17.70	18.30
C.D. at 5%	1.195	1.253	1.027	0.986	1.255	1.094	1.103	1.207

Two antagonistic organisms *Pseudomonas fluorescens* and *Trichoderma asperellum* (NBAIR strain) both liquid and talc formulations, along with *P. fluorescens* and *T. asperellum* (local strain) and recommended fungicide (Propiconazole @ 1 ml/L), were assessed against Wheat Yellow rust (*Puccinia striiformis* f. sp. *tritici*). NBAIR-PFDWD strain *P. fluorescens* (Liquid formulation) T_3 - recorded lowest percent disease index (5.73%) followed by its talc formulation T_1 - (6.67%). Percent disease index in Propiconazole spray T_7 - (5.53%) was comparable to that of T_3 - *P. fluorescens* (NBAIR-PFDWD strain – liquid formulation), but grain yield was significantly highest in T_3 (28.6 q/ha). The grain yield was lowest in T_8 – control (22.85 q/ha). Other growth and yield attributes (plant height, no. of seeds / ear and biomass) also corresponded respectively with the grain yield.

III.3 Biological Control of Maize Diseases

III.3.1 SKUAST, Jammu

Field evaluation of ICAR-NBAIR antagonistic organisms against Maize Turcicum leaf blight (*Exserohilum turcicum*)

Table 43.

Plot size	1 x 5 cents for each treatment, 1 cent = 8x5 m^2
Replications	04
Design	RBD
Variety	High yielding variety susceptible to Turcicum leaf blight – Double Dekalb

Table 44.

S. No.	Treatments
1.	T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)
2.	T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)
3.	T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)
4.	T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)
5.	T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)
6.	T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)
7.	T_7 - Recommended fungicide application (Carbendazim @ 2 g/L)
8.	T_8 - Control (Untreated)

Observations	Turcicum leaf blight Scoring and calculation of Percent disease index (for maize turcicum leaf blight) at 3 and 7 Days After Spray Growth promotion character viz., plant height (cm), biomass (gm) Yield (q/ha)

Four rounds of foliar sprays of talc and liquid formulations antagonistic organisms at the 10^8cfu/ml has been given at 14 days interval starting from 25 Days after Sowing when the disease start appearing.

Table 45.:- Yield and Yield attributes of maize as affected by the application of various antagonistic organisms

Treatments	Plant Height (gm)	length of cob (cm)	breadth of cob (cm)	no. of rows /cob	no. of grains / row	Biomass (gm/ plant)	Yield (q/ha)
T_1	209.04	18.00	14.99	13.33	33.11	135.69	31.74
T_2	216.76	20.09	15.48	14.00	35.94	148.08	34.31
T_3	211.48	18.50	15.09	14.00	33.11	139.79	31.87
T_4	222.93	20.35	16.63	15.00	37.33	151.27	34.58
T_5	212.10	18.75	15.10	14.00	35.55	146.90	33.74
T_6	201.93	17.82	14.43	13.31	31.78	133.04	26.92
T_7	176.14	16.84	14.27	12.67	30.97	131.56	26.18
T_8	161.03	10.87	11.95	11.33	21.22	117.44	23.05
C.D. at 5%	21.273	1.710	1.441	1.444	5.814	19.098	1.954

Table 46. :- Percent maize Turcicum leaf blight index in response to the application of various antagonistic organisms

Treatments	Percent disease index			
	1^{st} Spray	2^{nd} Spray	3^{rd} Spray	4^{th} Spray

	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
T_1	37.50	36.90	36.00	35.10	33.10	32.50	30.60	29.10
T_2	34.90	34.20	30.50	28.10	26.90	25.00	23.50	21.80
T_3	37.07	36.70	34.10	33.80	32.00	31.90	30.10	27.50
T_4	33.30	32.90	29.50	27.50	25.10	23.20	22.37	21.00
T_5	35.80	35.00	33.70	31.20	29.50	27.70	25.30	23.10
T_6	37.27	37.00	36.50	36.00	34.10	33.10	32.10	30.90
T_7	32.00	31.50	27.50	25.90	23.70	21.60	20.50	19.30
T_8	43.20	43.80	44.80	45.70	46.30	47.00	48.77	49.50
C.D. at 5%	2.275	2.820	3.099	3.460	3.000	2.652	2.337	2.390

Two antagonistic organisms *Pseudomonas fluorescens* and *Trichoderma asperellum* (NBAIR strain) both liquid and talc formulations, along with *P. fluorescens* and *T. asperellum* (local strain) and recommended fungicide (Carbendazim @ 2 g/L), were assessed against Maize Turcicum leaf blight (*Exserohilum turcicum*). Among the various biopesticides assessed, NBAIR-TATP strain *T. asperellum* (Liquid formulation) T_4 - recorded lowest percent disease index (21.00%) and its talc formulation T_2 - (21.80%), followed by T_5 (23.10%). Percent disease index in carbendazim spray T_7 - (19.30%) was comparable to that of T_1 - *P. fluorescens* (NBAIR-PFDWD strain – liquid formulation), but grain yield was significantly highest in T_4 (34.58 q/ha) and T_2 (34.31 q/ha). The grain yield was lowest in T_8 – control (23.05 q/ha). Other growth and yield attributes (plant height, length of cob, breadth of cob, no. of rows / cob, no. of grains / row and biomass) also corresponded respectively with the grain yield.

Biological Control of Pulse Diseases

III.4 Biological Control of Pigeon Pea Diseases

III.4.1 AAU Anand

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 pigeon pea

Year of commencement: 2019-20

Location: Farmer’s field at Manjrol, Sankheda taluka, Vadodara district

Area: 2 ha **Table 47.**

Variety	:	Local variety (Daftari)
Treatments	:	T1: BIPM package Seed treatment – *Trichoderma 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

		T3: Untreated control
Repetitions	:	Each block was divided into 8 equal sized units and each unit was considered as repetition (each unit= one replication)
Design	:	Large plot sampling CRD
Observations recorded	:	Disease incidence (%) Yield (q/ha)

Note: * Figures are $\sqrt{x + 0.5}$ transformed values, whereas those in parentheses are retransformed values: **Table 48.**

Results:

Table : Efficacy different modules on *Fusarium* wilt incidence and yield of pigeon pea		
Treatments	Wilt incidence* (%)	Yield (q/ha)
T1: BIPM package	2.56 (6.05)	13.70
T2: Farmers' practice/ Chemical control	2.82 (7.45)	11.87
T3: Untreated control	4.16 (16.81)	7.40
C.D. at 5%	0.16	1.37
C.V. (%)	14.80	11.99

The data pertaining to efficacy of BIPM module in reducing the *Fusarium* wilt disease incidence in pigeon pea crop is presented in the Table No.48 The BIPM module recorded the significant lowest wilt incidence (6.05 %) in comparison to farmers' practice (7.45 %). Similar trend was documented in yield of the crop. The significant highest yield was recorded in BIPM module (13.70 q/ha). The untreated control treatment witnessed the highest disease incidence (16.81 %) with lowest yield (7.40 q/ha). This result demonstrate the efficacy of *Trichoderma harzianum* as promising biopesticide in minimizing the disease incidence with higher yield in pigeon pea crop.

III.5 Biological Control of Vegetable Cowpea Diseases

III.5.1 KAU VELLAYANI

Title : Management of *Fusarium* wilt in vegetable cowpea using microbial agents

The experiment was carried out during November 2020 to February 2021 at Ammanoorkonam,underMalayinkeezhu Krishi bhavan in an area of 60 cents (0.2ha) of cowpea, variety VellayaniJyothika (KAU variety). The experiments was laid out in RBD with six treatments replicated four times. Unit plot size was 10 x 10 $m^{2.}$ Treatments evaluated were, T1 was seed treatment with *P. flourescence* (KAU srain) @ 10g/ kg + soil drenching 10g/Litre @ fortnightly intervals + foliar drenching @ 10g/L at fortnightly intervals (T2) was basal application of *Trichoderma* sp. KAU strain (multiplied in cowdung + neemcake 9:1 ratio) @ 250 g /plant + monthy soil application of *Trichoderma*; (T3) was TI + T2 and T4 (IDM) was T3 + need based application of copper oxy chloride @ 2g/L foliar spray / 4g/ L soil drenching and T5 which included the need based drenchimg of carbendazim @ 2g/L. Untreated treated plots (T6) served as check.

Fig:23. Field experiment- Management of *Fusarium* wilt of cowpea using microbial agents

Table 49. Efficacy of microbial agents in managing *Fusarium* wilt of cowpea

Treatments	Cumulative disease incidence Weaks after planting						Percentage incidence
	2	4	6	8	10	12	
T1- Seed treatment with *P. flourescence* (KAU srain)@ 10g /kg+ Soil drenching @ fortnightly intervals + foliar drenching @fortnightly intervals	0	1.0	1.0	2.0	3.0	3.0	0.06
T2 – Basal application of *Trichoderma* sp. KAU starin (multiplied in cowdung + neemcake 9:1 ratio) @ 250 g /plant + monthy soil application	2.0	4.0	5.0	6.0	7.0	7.0	0.14
T3 - (TI + T2)	0	1.0	1.0	2.0	2.0	2.0	0.04
T4 - (IDM) T3 + need based application of COC @ 2g/L foliar spray / 4g/ L soil drenching	0	2.0	5.0	7.0	9.0	10.0	0.2
T5 – Chemical fungicide Carbendazim @ 2g/L need based	0	1.0	4.0	7.0	8.0	9.0	0.18
T6- Untreated check	0	1.0	1.0	1.0	5.0	7.0	0.14

As the variation in data was less with respect to number of plants infested, the CD was non significant. Therefore comparison of treatments was done based on percentage incidence. The results revealed that the incidence was least in plots treated with Pseudomonas fluorescence foliar + Trichoderma basal application. Incidence was also found to be reduced in plots treated with Peudomonas alone. However need based application of copper oxychloride or copper oxy chloride along with biocontrol agents were found to be ineffective. This might be due to the fact that CoC is drenching is reducing the population of Trichoderma in soil.

Table 50. Yield of plots treated with microbial agents to manage *Fusarium* wilt in cowpea

Treatments	Yield/ plot (kg)	Yield increase (%)
T1- Seed treatment with *P. flourescence* (KAU strain)@ 10g /kg+ Soil drenching @ fortnightly intervals + foliar drenching @fortnightly intervals	3.95	-5.3
T2 – Basal application of *Trichoderma* sp. KAU starin (multiplied in cowdung + neemcake 9:1 ratio) @ 250 g /plant + monthy soil application	3.79	-0.8
T3 – TI + T2	4.57	9.8
T4 – IDM – T3 + need based application of copper oxy chloride @ 2g/L foliar spray / 4g/ L soil drenching	4.3	3.3
T5 – Chemical fungicide Carbendazim @ 2g/L –need based	4.31	3.6
T6- Untreated check	4.16	
CD(0.05)	NS	

III.6 Biological Control of Chickpea Diseases

III.6.1 GBPUAT, Pantnagar

Wilt Disease

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

Table 51. Experimental Details of Glasshouse

Variety	:	PG-186
Layout	:	CRD
Pot Size	:	2 kg
Treatment	:	11
Replication	:	03
Seed biopriming	:	09.01.2021
Sowing	:	10.01.2021
Treatments	:	Th-17 + Psf-173 Th-17+ Psf-2 Th-17 + Th-14 Th-14+ Psf-2 Th-17 (positive control) Th-14 (positive control) Psf-2 (positive control)

		Psf-173 (positive control) PBAT-3 (Standard check) Carbendazim (chemical check) Control
Mode of application		Soil 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, Pantnagarduring Rabi 2020-21to 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).

45 DAS: Control and Th17+Psf2

45DAS: Carbendazim,Th17+Psf173,PBAT3

View of experiment of bioagent consortium in glasshouse in Chickpea

Fig:24. 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 with PBAT-3 (87.50%) which was statistically at par withPsf-173 (84.92 %) but superior than control (67.92 %). Maximum plant stand (30 DAS) was recorded with PBAT-3 (88.83 %) which did not differ significantly from Psf-173 (86.25 %) but superior than control (69.92 %). Maximum plant stand (45 DAS) was observed with PBAT-3 (89.42 %) which was statistically at par with Th17+Psf173 (88.25 %) but significantly better than control

(64.58 %).Maximum root length was observed with PBAT-3 (21.37 cm) which was statically at par with Th17+Psf173 (20.62 cm) but different from other treatments including control (15.27 cm). Maximum shoot length was observed with PBAT-3 (43.80 cm) which was statistically at par with Th17+Psf2 (43.27 cm). Minimum shoot length was observed in control (34.87 cm) which did not differ from Psf-173 (35.40 cm). Maximum fresh root weight was observed with Th17+Psf173 (0.39gm) which was statistically at par with PBAT-3 (0. 37gm) but significantly better than control (0.14gm). Maximum shoot weight was observed with PBAT-3 (2.91gm) which was significantly samewith Th17+Psf2 (2.87 gm) and Th17+Psf173 (2.82gm) but statistically superior than Control (1.73gm). Maximum dry root weight was observed with PBAT-3 (0.25 gm) which did not differ significantly from Th17+Psf2 (0.24 gm) and Th14+Psf2 (0.23 gm) but better than control (0.14gm). Significantly maximum shoot dry weight was observed with Th17+Psf173 (0.89gm), which was statistically at par with PBAT-3 (0.86gm) but was better than Control (0.54gm)

Table 52. Efficacy of bioagentconsortia under glass house condition

Treatments	Germination % (15 DAS)	Plant Stand (%)		Plant Length(cm)		Fresh Weight (gm)		Dry Weight (gm)	
		30 DAS	45 DAS	Root	Shoot	Root	Shoot	Root	Shoot
Th17+Psf173	81.58	82.92	88.25	20.62	40.80	0.39	2.82	0.20	0.89
Th17+Psf2	81.50	82.50	84.83	19.50	43.27	0.30	2.87	0.24	0.83
Th17+Th14	83.92	84.58	81.50	20.07	40.47	0.31	2.67	0.21	0.85
Th14+Psf2	84.00	83.00	84.33	20.13	40.43	0.33	2.56	0.23	0.85
Th-17	81.33	82.67	82.75	18.47	39.60	0.19	2.14	0.18	0.76
Th-14	82.17	83.50	80.83	18.52	36.03	0.20	2.14	0.17	0.76
Psf-2	82.75	81.75	82.42	17.62	36.27	0.18	1.89	0.18	0.69
Psf-173	84.92	86.25	80.92	17.35	35.40	0.20	1.81	0.16	0.75
PBAT-3	87.50	88.83	89.42	21.37	43.80	0.37	2.91	0.25	0.86
Carbendazim	81.33	81.00	80.75	18.53	39.60	0.18	1.97	0.18	0.69
Control	67.92	69.92	64.58	15.27	34.87	0.14	1.73	0.14	0.54
C.D.	3.29	3.12	2.48	1.04	1.10	0.02	0.12	0.02	0.03
C.V.	2.37	2.22	1.77	3.22	1.64	5.62	3.05	6.24	2.42

*05 counted seeds were sown in each pot

Table 53. Experimental Detail of Field

Variety	:	PG-186
Layout		RBD
Plot size	:	3X2 m^2
Treatment	:	11
Replication	:	03
Seed biopriming	:	14.12.2020

Sowing	:	15.12.2020
Harvesting	:	12.04.2020
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 (85.38 %), while minimum percentage of seed germination was recorded in control (69.05 %). Maximum Plant Stand (15DAS) was recorded with PBAT-3 (213.44) followed by Th17+Psf173 (208.94), Th17+Th14 (208.83), Th14+Psf2 (208.00), Th-14 (207.90), Carbendazim (207.46), Th17+Psf2 (206.58), Th-17 (206.27) and Psf-2 (205.98) which were statistically at par with each other but significantly different from PBAT-3 and better than control (172.62) Maximum plant stand, 60 DAS was recorded with consortium Th17+Psf173 (205.21) which was statistically at par PBAT-3 (203.83) but significantly better than control (164.49). Maximum plant stand, 120 DAS was observed with treatment Th17+Psf173 (195.13) which did not differ significantly from Carbendazim (194.18), PBAT-3 (193.61) and Th17+Th14 (189.51) but superior than control (147.83). Minimum number of mature plant wilt at 120 DAS was observed with consortium Th17+Psf173 (4.17 %), while maximum in control (11.54%) after 120 days of sowing. Maximum yield (15.83 q/ha) was recorded with PBAT-3 and Th17+Psf173, while minimum yield was observed with control (10.83 q/ha).

Fig:25. Field view of chickpea trial at Crop Research Center, Pantnagar

Table 54. 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	Yield/ plot (6 m^2)	Yield/ ha
			60 DAS	120 DAS					
	(No.)	(%)	(No.)	(No.)	(No.)	(No.)	(%)	(kg)	(Q)
Th17+Psf173	208.94	83.58	205.21	195.13	8.50	203.63	4.17	0.95	15.83
Th17+Psf2	206.58	82.63	197.64	186.75	8.58	195.33	4.39	0.88	14.67
Th17+Th14	208.83	83.53	197.07	189.51	8.63	198.14	4.36	0.80	13.33
Th14+Psf2	208.00	83.20	196.78	186.67	10.02	196.69	5.09	0.74	12.33
Th-17	206.27	82.51	192.79	190.24	11.04	201.28	5.48	0.70	11.67
Th-14	207.90	83.16	191.72	187.83	12.05	199.88	6.03	0.73	12.17
Psf-2	205.98	82.39	194.85	188.19	12.15	200.34	6.06	0.72	12.00
Psf-173	204.08	81.63	194.94	187.94	13.72	201.66	6.80	0.75	12.50
PBAT-3	213.44	85.38	203.83	193.61	8.92	202.53	4.40	0.95	15.83
Carbendazim	207.46	82.98	199.07	194.18	9.14	203.32	4.50	0.83	13.83
Control	172.62	69.05	164.49	147.83	19.28	167.11	11.54	0.65	10.83
CD (0.05)	4.49		5.79	5.25	1.18			0.08	
CV (%)	1.28		1.74	1.64	6.22			6.02	

*250 counted seeds were sown in each plot

		
Control	Th17+Psf173	PBAT-3

Wilt symptoms in chickpea plant	Field Observation

Fig:26. Evaluation of bio-agent consortium in field for crop health management in chickpea at Crop Research Centre

III.6.2 SKUAST, Jammu

Field evaluation of ICAR-NBAIR antagonistic organisms against Chickpea *Fusarium* wilt (*Fusarium oxysporum f. sp. ciceris*)

Table 55.

Plot size	1 x 5 cents for each treatment, 1 cent = 8x5 m^2
Replications	04
Design	RBD
Variety	High yielding variety susceptible to Chickpea *Fusarium* wilt – GNG-1569

S. No.	Treatments
1.	T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)
2.	T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)
3.	T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)
4.	T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)
5.	T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)
6.	T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)
7.	T_7 - Recommended fungicide application (Carbendazim @ 2 g/L)
8.	T_8 - Control (Untreated)

Table 56.

Observations	Chick pea Fusarium wilt Scoring and calculation of Percent disease incidence (for Chickpea *Fusarium* wilt) at 3 and 7 Days After Spray Growth promotion character *viz*., plant height (cm), biomass (gm) Yield (q/ha)

Four rounds of foliar sprays of talc and liquid formulations antagonistic organisms at the 10^8cfu/ml has been given at 14 days interval starting from 75 Days after Sowing when the disease start appearing

Table 57. :-Yield and Yield attributes of chickpea as affected by the application of various antagonistic organisms

Treatments	Plant Height (gm)	No. of seeds / pod	No. of pods / plant	Biomass (gm)	Yield (q/ha)
T_1	32.70	1.78	33.77	9.07	7.68
T_2	34.99	1.56	36.44	10.45	8.72
T_3	28.88	1.33	34.44	9.28	8.02
T_4	27.61	1.67	29.55	10.58	9.58
T_5	34.18	1.78	30.33	9.94	8.46
T_6	30.82	1.67	25.11	8.31	7.24
T_7	29.44	1.78	21.11	11.22	9.23
T_8	29.86	1.67	27.78	7.66	6.77
C.D. at 5%	1.904	0.227	1.642	0.749	0.492

Table 58. :- Percent Chickpea *Fusarium* wilt incidence in response to the application of various antagonistic organisms

Treatments	Percent wilt incidence							
	1st Spray		2nd Spray		3rd Spray		4th Spray	
	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
T_1	19.67	20.00	22.50	23.45	26.56	28.17	30.17	31.83
T_2	17.83	18.17	18.72	13.83	20.50	20.83	21.17	21.33
T_3	19.17	19.67	22.17	22.67	25.56	26.83	28.56	28.83
T_4	18.00	18.28	18.56	18.72	18.83	19.00	19.11	19.11
T_5	17.83	18.50	19.17	20.17	21.83	23.06	24.50	24.83
T_6	19.67	21.50	23.33	24.06	27.83	29.56	31.67	33.33
T_7	18.33	19.00	19.33	20.00	20.67	22.00	22.33	22.67
T_8	19.90	24.77	28.50	35.10	42.27	45.27	53.20	54.80
C.D. at 5%	N.S.	0.610	0.956	0.909	0.821	1.064	1.176	1.537

Two antagonistic organisms *Pseudomonas fluorescens* and *Trichoderma asperellum* (NBAIR strain) both liquid and talc formulations, along with *P. fluorescens* and *T. asperellum* (local strain) and recommended fungicide (Carbendazim @ 2 g/L), were assessed against Chickpea *Fusarium* wilt (*Fusarium oxysporum* f. sp. *ciceris*). Among the various biopesticides assessed, NBAIR-TATP strain *T. asperellum* (Liquid formulation) T_4 - recorded lowest percent wilt incidence (19.11%) and its talc formulation T_2 - (21.33%), followed by T_5 (24.83%). Percent wilt incidence in carbendazim spray T_7 - (22.67%) was comparable to that of T_2, but grain yield was significantly highest in T_4 (9.58 q/ha). The grain yield was lowest in T_8 – control (6.77 q/ha). Other growth and yield attributes (plant height, no. of seeds / pod, no. of pods / plant and biomass) also corresponded respectively with the grain yield.

Fig:27.

Biological Control of Oilseed Crops

III.7 Biological Control of Mustard Diseases

III.7.1 SKUAST, Jammu

Field evaluation of ICAR-NBAIR antagonistic organisms against Mustard White rust (*Albugo candida*)

Table 59.

Plot size	1 x 5 cents for each treatment, 1 cent = 8x5 m^2
Replications	04
Design	RBD
Variety	High yielding variety susceptible to Mustard White Rust – NRCHB-101

Table 60.

S. No.	Treatments
1.	T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)
2.	T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)
3.	T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)
4.	T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)
5.	T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)
6.	T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)
7.	T_7 - Recommended fungicide application (Ridomil MZ @ 2.5 g/L)
8.	T_8 - Control (Untreated)

Table 61.

Observations	White rust Scoring and calculation of Percent disease index (for Mustard White rust) at 3 and 7 Days After Spray Growth promotion character viz., plant height (cm), biomass (gm) Yield (q/ha)

Four rounds of foliar sprays of talc and liquid formulations antagonistic organisms at the 10^8cfu/ml has been given at 14 days interval starting from 75 Days after Sowing when the disease start appearing

Table 62. :-Yield and Yield attributes of mustard as affected by the application of various antagonistic organisms

Treatments	Plant Height (gm)	No. of siliquae/plant	No. of seeds / siliquae	seed yield (g/plant)	Biomass (gm)	Yield (q/ha)
T_1	150.66	144.55	18.78	10.33	50.00	8.17
T_2	118.30	71.22	14.55	9.44	36.11	7.09
T_3	151.33	170.55	21.22	11.33	61.11	8.61
T_4	144.81	142.55	17.33	9.89	42.44	7.81
T_5	116.42	68.11	14.55	9.22	37.00	6.79
T_6	130.72	78.22	16.55	9.44	40.77	7.46
T_7	108.18	66.55	13.55	9.22	35.33	6.48
T_8	101.68	58.55	10.89	8.67	20.78	6.27
C.D. at 5%	7.486	6.335	1.274	0.844	2.055	0.646

Table 63. Percent Mustard white rust index in response to the application of various antagonistic organisms

Treatments	Percent disease index							
	1st Spray		2nd Spray		3rd Spray		4th Spray	
	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
T_1	41.50	39.30	37.63	35.33	33.47	30.83	28.20	26.23
T_2	49.80	47.10	46.33	44.30	43.10	42.30	39.90	38.20
T_3	38.90	35.50	33.50	32.13	29.73	27.30	25.17	23.23
T_4	47.20	44.10	43.00	41.20	38.23	36.70	34.70	33.83
T_5	50.70	48.33	47.20	45.50	44.30	42.00	41.20	38.83
T_6	43.23	41.30	40.10	37.60	34.70	33.77	32.13	31.33
T_7	39.20	38.50	32.90	31.00	26.87	25.97	24.80	23.63
T_8	57.30	59.80	60.30	61.57	63.80	65.00	67.47	69.10
C.D. at 5%	2.550	3.088	3.375	3.970	4.763	5.118	5.385	5.042

Two antagonistic organisms *Pseudomonas fluorescens* and *Trichoderma asperellum* (NBAIR strain) both liquid and talc formulations, along with *P. fluorescens* and *T. asperellum* (local strain) and recommended fungicide (Ridomil MZ @ 2.5 g/L), were assessed against Mustard White rust (*Albugo candida*). NBAIR-PFDWD strain *P. fluorescens* (Liquid formulation) T_3 - recorded lowest percent disease index (23.23%) followed by its talc formulation T_1 - (26.23%). Percent disease index in Ridomil spray T_7 - (23.63%) was comparable to that of T_3 - *P. fluorescens* (NBAIR-PFDWD strain – liquid formulation), but seed yield was significantly highest in T3 (8.61 q/ha) and T_1 (8.17 q/ha). The grain yield was lowest in T_8 – control (6.27 q/ha) and T_7 – (6.48 q/ha). Other growth and yield attributes (plant height, no. of siliquae / plant, no. of seeds / siliquae, seed yield g/plant and biomass) also corresponded respectively with the seed yield (q/ha).

Fig:28.

III.8 Biological Control of Sesamum Diseases

III.8.1 ANGRAU at RARS, Anakapalle

Ecofriendly management of stem rot, *Macrophominaphaseolina* in sesame using biocontrol agents

Techniques adopted:

Treatments: 10

T1: NBAIR - *Trichoderma asperillum*seed treatment @ 10 g/kg seed +*Trichoderma asperillum*soil drenching @ 5kg/ha

T2: NBAIR - *Pseudomonas fluorescence* seed treatment @ 10 g/kg seed +*Pseudomonas fluorescence* soil drenching @ 5kg/ha

T3: NBAIR - *Trichoderma asperillum*seed treatment @ 10g/kg seed +*Pseudomonas fluorescence* soil drenching @ 5kg/ha

T4: NBAIR - *Pseudomonas fluorescence* seed treatment @10 g/kg seed+ *Trichoderma asperillum*soil drenching @ 5kg/ha

T5: NBAIR -*Trichoderma harzianum*seed treatment @ 10g/kg seed+*Trichodermaharzianum* soil drenching @ 5kg/ha

T6: NBAIR - *Trichoderma harzianum*seed treatment @ 10g/kg seed

T7: NBAIR - *Trichoderma asperillum*soil drenching @ 5kg/ha

T8: NBAIR - *Pseudomonas fluorescence* soil drenching @ 5kg/ha

T9: Carbendazim seed treatment @1g/kg seed + carbendazim soil drenching @ 5kg/ha

T10: Untreated Control

Soil drenching at 30 and 60 days after sowing

Executive Summary:

During 2020-21, kharif july sown crop, germination was high in T4 - *P. fluorescence* ST + *T. asperillum* SD (92.88%) and was on par with other biocontrol agenst compared to chemical , carbedazim (80.16%) and germination was low in control (66.27%). Stem rot disease was noticed at 60 days crop age as high in control (15.97%) and low in T4 - *P. fluorescence* ST + *T.asperillum*SD (3.1 %) followed by T1 - *Trichoderma asperillum*ST + SD (3.67%) and T2- *Pseudomonas fluorescence* ST + SD (3.43%) (Table 64) . Crop was subjected to severe phyllody at maturity stage resulted in low yields.

Summary of Achievements:

This trial helps to evolve effective Bioagent for the management stem rot, *Macrophomina phaseolina* in sesame to reduce the cost on plant protection andimprove the economic status of sesame farmers.

Fig:29.

Table 64. :Ecofriendly management of stem rot, *Macrophomina phaseolina* in sesame using biocontrol agents

Treatment	Germination %	Stem rot % 60 DAS	Root length cm	Shoot length cm
T1: *Trichoderma asperillum*ST + SD	87.88	3.67	10.67	133.53
T2: *Pseudomonas fluorescence* ST + SD	87.22	3.43	13.4	146.47
T3: *T. Asperillum* ST + *P. fluorescence* SD	83.94	6.87	10.8	126.93
T4: *P. fluorescence* ST + *T.asperillum*SD	92.88	3.1	12.77	146.47
T5:*T.harzianum ST + SD*	86.77	4.23	11.13	137.93
T6:*T. harzianum ST*	87.55	7.33	10.86	132.13
T7:*T. asperillum ST*	87.44	5.13	11.93	134.4
T8: *P. fluorescence ST*	86.94	5.73	13.86	142.87
T9 : Carbendazim ST +SD	80.16	5.93	11.13	128.33
T10- Control	66.27	15.97	9.4	118.33

CD	9.82	2.01	2.49	11.79
CV%	12.03	18.67	12.43	15.06

ST – Seed Treatment: SD: Soil Drenching

Biological Control of Fruit Crop Diseases

III.9 Biological Control of Guava Diseases

III.9.1 Evaluation of bio-agents against root-knot nematode and Fusarium wilt complex in guava under controlled conditions (CISHLucknow)

III.9.1.1 CISH, Lucknow

Treatments:

Purpureocilliumlilacinum@ 10^6 spores/cfu per kg ofsoil

Pochoniachlamydosporia@ 10^6 spores/cfu per kg ofsoil

Trichoderma asperellum@ 10^6 spores/cfu per kg of soil

Bacillus spp. @ 10^6 spores/cfu per kg ofsoil

ICAR-FUSICONT @ 20 g formulation per kg ofsoil

Vermi compost @ 100 g per kg of soil 7. T1 +T4

8. T2 +T4
9. T3 +T4
10. T1 +T6
11. T2 +T6
12. T3 +T6
13. T4 +T6
14. T5 +T6

Inoculated (nematode only) control

Inoculated (*Fusarium oxysporum* only) control

Inoculated (nematode + fungus) control

Uninoculatedcontrol

Nematode inoculums dose: 2000 J2 per kg soil mixture (8: 2 Soil: FYM)

Replicates: 5 per treatment

Methodology:

Bio-agent inoculation: All the treatments (1-14) will be applied 7 days prior to transplantation of seedlings and treatment number 1-9 will be repeated 60 days after transplanting by scrapping top 2-3 mm soil followed by treatment application and replacement of samesoil.

Age of seedlings at transplanting : 45 days (after seedsowing)

Nematode inoculation : Just aftertransplantation

Termination of Experiment: 180 days afterinoculation

Data to be recorded:

Root-knot index (0-4scale)

Number of J2 insoil

Colonization of roots byfungus
Shoot height (cm)
Shoot and root weight (g)
GD Comment: Occurrence of *Meloidogyne enterolobii* has to be confirmed. (CISH Lucknow) The *Meloidogyne* females have been excised from infected roots taken from culture plants and from guava roots collected during survey and have been given for molecular characterization. This work will be continued at least for a year and results will be presented time totime.

Evaluation of bio-agents against root-knot nematode and Fusarium wilt complexin guavaunder controlled conditions (CISH Lucknow)

Treatments:
Purpureocilliumlilacinum@ 10^6 spores/cfu per kg of soil
Pochoniachlamydosporia@ 10^6 spores/cfu per kg of soil
Trichoderma asperellum@ 10^6 spores/cfu per kg of soil
Bacillus sp. @ 10^6 spores/cfu per kg of soil
ICAR-FUSICONT @ 20 g formulation per kg of soil
Vermi compost @ 100 g per kg of soil
T1 + T4
T2 + T4
T3 + T4
T1 + T6
T2 + T6
T3 + T6
T4 + T6
T5 + T6
Inoculated (nematode only) control
Inoculated (*Fusarium oxysporum* only) control
Inoculated (nematode + fungus) control
Uninoculated control
Nematode inoculums dose: 2000 J2 per kg soil mixture (8 : 2 Soil : FYM)
*Fusarium oxysporum*dose: 10^6 spores/cfu per kg of soil mixture (8 : 2 Soil : FYM)
Replicates: 4 per treatment
Method:
Bio-agent inoculation : All the treatments (1-14) were applied 7 days prior to transplantation of seedlings and treatment number 1-9 were repeated 60 days after transplanting by scrapping top 2-3 mm soil followed by treatment application and replacement of same soil.
Age of seedlings at transplanting : 45 days (after seed sowing)
Nematode inoculation : Just after transplantation
Termination of Experiment: 180 days after inoculation

Data to be recorded:
Root-knot index (0-4 scale)
Number of J2 in soil
Colonization of roots by fungus
Shoot height (cm)
Shoot and root weight (g)

Keeping in view the weather factors influencing plant growth and activities of microorganisms, the experiment was conducted twice. The first set of experiment was initiated on May 22, 2020 and the second set of experiment was initiated on September 02, 2020. Transplanting followed by inoculation was done as per technical programme. The first set of experiment was terminated on November 19, 2020 and the second one on March 20, 2021.

Results:

Since, the major purpose of this experiment has been to manage guava wilt complex by managing root-knot nematode and to understand effect of nematode in enhancing the infection of *Fusarium oxysporum*in guava roots, the most important criterion is root-knot development and plant growth.

Data presented in Table 65 indicated that root-knot index (RKI) was significantly reduced in six treatments (T6 to T11) as compared to control. Colonization of roots by the *F. oxysporum*was not significantly different in fungus alone and nematode + fungus treatments, however it was proportionate to RKI. Which indicate that root-knot infection enhanced fungus infection. Shoot weight was significantly high in uninoculated control as compared to different treatments.

In this experiment, no bio-control agent could suppress RKI when applied alone but vermi compost significantly suppressed RKI. When *Bacillus* was applied in combination with other bio-control agents, the RKI was significantly reduced. Still, this reduction in RKI is not enough as desired.

Table 65. Effect of various treatments on plant growth and pathogenic activities (I)

S. No.	Treatments	Shoot height (cm)	Shoot weight (g)	Root weight (g)	RKI (0-4 scale)	No. of J2/g soil	Root colonized
1	*Purpureocillium lilacinum*@ 10^6 spores/cfu per kg of soil	32fgh	4.26f	7.84ab	3.8a	4.8abc	4.95ab
2	*Pochonia chlamydosporia*@ 10^6 spores/cfu per kg of soil	31.4fghi	4.26f	6.6abc	3.84a	4.6abc	4.7ab
3	*Trichoderma asperellum*@ 10^6 spores/cfu per kg of soil	25.2ghi	3.58f	3.64fgh	3.6ab	5.6abc	4.6ab
4	*Bacillus* sp. @ 10^6 spores/cfu per kg of soil	30.6fghi	4.48f	7.04abc	3.9a	5abc	5a

5	ICAR-FUSICONT @ 20 g formulation per kg of soil	25.8ghi	3.24f	4.28	3.55ab	5.4abc	4abc
6	Vermi compost @ 100 g per kg of soil	32.6efgh	4.34f	3.54fgh	1.78e	4.4abc	2f
7	T1 + T4	40.8cdef	7.52de	2.86ghi	1.75e	3.8bc	2.2f
8	T2 + T4	21i	3.9f	3.24ghi	2.35de	3.8bc	2.8cdef
9	T3 + T4	22.6hi	2.84f	1.54i	2.6bcde	6.4a	2.8cdef
10	T1 + T6	42.8cde	11.82bc	8.38a	2.3de	4.4abc	2.4ef
11	T2 + T6	46.4bc	11.1bc	7.22abc	2.43cde	3.6c	3.6bcde
12	T3 + T6	35defg	7.16e	6.76abc	3.5abc	6.6a	3.85abcd
13	T4 + T6	44.9cd	9.54cd	5.74cde	3.2abcd	3.6c	2.5def
14	T5 + T6	61.8a	17.1a	7.18abc	3.15abcd	4.4abc	2.95cdef
15	Inoculated (nematode only) control	50.1bc	12.6b	5.4cdef	3.5abc	3.6c	0g
16	Inoculated (*Fusarium oxysporum* only) control	45.3cd	11.48bc	4efgh	0f	0d	3.1cdef
17	Inoculated (nematode + fungus) control	25.1ghi	4.52f	2.2hi	3.75a	6.2ab	2.3ef
18	Uninoculated control	56.2ab	17.48a	6bcd	0f	0d	0g
	F	10.286	32.484	8.595	9.576	4.393	9.161
	CV	22.328	23.783	30.444	32.191	45.716	36.085
	CD(0.01)	13.9	3.123	2.645	1.469	3.244	1.803
	CD(0.05)	10.47	2.352	1.992	1.106	2.442	1.358

Data presented in Table 66 indicated that shoot weight was significantly reduced in plants inoculated with nematode but not in fungus alone as compared to uninoculated control. In this experiment highest shoot weight was recorded in vermi compost treated plants followed by *Bacillus* alone and combinations of bio-control agents with vermi compost. RKI was significantly reduced in all the bio-control agents alone but in combinations, it was higher.

Table 66. Effect of various treatments on plant growth and pathogenic activities (II)

S. No.	Treatments	Shoot height (cm)	Shoot weight (g)	Root weight (g)	RKI (0-4 scale)	No. of J2/g soil	Root colonized
1	*Purpureocilliumlilacinum*@ 10^6 spores/cfu per kg of soil	27.92bcde	8.4hi	1.72k	0.25f	1.8de	0.25ghi
2	*Pochoniachlamydosporia*@ 10^6 spores/cfu per kg of soil	29.9abcd	9.8fg	2.82ij	0.35f	1.8de	0.2hi
3	*Trichoderma asperellum*@ 10^6 spores/cfu per kg of soil	28.3bcde	9.24gh	2.94ij	0.72f	1.8de	0.35fghi

4	*Bacillus* sp. @ 10^6 spores/cfu per kg of soil	34a	11.68bc	3.6fgh	1.9de	2.6bcd	0.9cdef
5	ICAR-FUSICONT @ 20 g formulation per kg of soil	17.7g	3.8l	1.38k	2.8abc	3.6ab	1.5abc
6	Vermi compost @ 100 g per kg of soil	33.5a	14.58a	4.88bc	2.1cde	4.2a	0.85defg
7	T1 + T4	22.5fg	7.54ij	3.32ghi	1.5e	1.2ef	1.05bcde
8	T2 + T4	26.6cdef	10defg	4.84bc	2.45bcd	2.2cde	1.45abcd
9	T3 + T4	30abcd	10.38def	3.8efgh	2.45bcd	2.6bcd	2.05a
10	T1 + T6	31.2abc	10.9cd	4.52cd	2.65abc	2.4bcde	1.8a
11	T2 + T6	28.9abcd	9.72fg	3.84efg	3ab	2.4bcde	2a
12	T3 + T6	32.4ab	12.16b	5.24b	3ab	4.2a	1.9a
13	T4 + T6	26.1cdef	7.72ij	3.96def	2.7abc	3.2abc	1.5abc
14	T5 + T6	24.9def	10.84cde	6.9a	3.19a	3.2abc	2.05a
15	Inoculated (nematode only) control	29.1abcd	6.96j	3.26hi	2.4bcd	3.2abc	1.7ab
16	Inoculated (*Fusarium oxysporum* only) control	29.2abcd	9.86efg	4.34cde	0f	0f	0.65efgh
17	Inoculated (nematode + fungus) control	23.5ef	5.74k	2.38j	3.12ab	3abcd	0i
18	Uninoculated control	28.2bcde	9.24gh	3.66fgh	0f	0f	0i
	F	4.837	48.5	42.484	19.981	6.787	16.685
	CV	14.708	8.472	12.006	29.87	42.611	41.218
	CD(0.01)	6.891	1.328	0.752	0.96	1.719	0.855
	CD(0.05)	5.19	1.000	0.567	0.723	1.295	0.644

On the basis of these 2 experiments conclusions are:

1. Since guava is perennial crop, long term experiments were conducted to assess long term effect of bio-control agents. The bio-control agents were found less effective in first experiment laid out during the month of May but in experiment laid during September better success was achieved.
2. During the period of first experiment average weekly temperature ranged between 37.4 to 21.7 °C and higher temperature favoured nematode more than bio-control agents.
3. During the period of second experiment average weekly temperature ranged between 34.7 to 5.6 °C and lower temperature suppressed nematode more than bio-control agents.
4. Few treatments were found effective but not as effective as desired.

Suggestions:

1. The better treatments (*Purpureocilliumlilacinum*+ Vermicompost, *Pochoniachlamydosporia*+ Vermi compost, *Bacillus* sp. + *P. lilacinum, P. chlamydosporia*

+ *Bacillus* sp.) and new combinations *Bacillus* sp. + *P. lilacinum*+ Vermi compost and *Bacillus* sp. + *P. chlamydosporia*+ Vermi compost may further be experimented.

2. Duration of experiment may be kept 60 days only.
3. New bio-control agent effective against root-knot nematode, if available, may be added.
4. Standard protocol for formulating bio-control agents may kindly be made available, so that same formulation of different bio-control agents is applied in the experiment which is to be promoted in orchards and nurseries.

III.10 Biological Control of Citrus Diseases

III.10.1 Evaluation of microbial antagonists for the management of foot rot of citrus (Kinnow) caused by *Phytophthora* spp.

III.10.1.1 PAU, LUDHIANA

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 fluorescence* (NBAIR- Pf DWD) (Talc formulation) 1 x 10^{8} cfu/gm
2. *Pseudomonas fluorescence* Commercial (Talc formulation) 1 x 10^{8} cfu/gm
3. *Trichoderma viride* Commercial (Talc formulation) 1 x 10^{9} cfu/gm
4. *Trichoderma harzianum*Commercial (Liquid formulation) 1 x 10^{6} cfu/ml
5. Chemical control (Curzate M-8 @ 25g/10 litre water/ tree) (Mancozeb 64.5%+Cymoxanil 8%)
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 2020. 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 root infected plants selected initially per treatment was non-significant. The per cent recovery in final lesion size was highest in chemical control (43.8%) over untreated control followed by NBAIR- PfDWD *Pseudomonas fluorescence* 22.7 per cent recovery. The mean number of fruit per plant was maximum (508.0) in chemical treatment (Curzate M8) followed by NBAIR-PfDWD *Pseudomonas fluorescence* (491.0). However, minimum number (394.0) of fruits was recorded in untreated control. The yield per tree was 96.5 kg and 107.5 kg in *Pseudomonas fluorescence* NBAIR-PfDWD and chemical control, respectively (Table 67).

It may be concluded that *Pseudomonas fluorescence* (NBAIR-PfDWD) 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 . Evaluation of microbial antagonists for the management of foot rot of Kinnow caused by *Phytophthora* spp.

Table 67.

Treatments	Initial lesion size (cm)	Final lesion size(cm)	Per cent recovery in final lesion size over control	Number of fruits per tree	Yield/tree (Kg)
Pseudomonas fluorescence NBAIR-PfDWD (Talc)	165	139.00[b]	22.70	491	96.5[b]
Pseudomonas fluorescence commercial (Talc)	163.25	145.00[c]	19.40	454	92.7[bc]
Trichoderma harzianum commercial (liquid)	165.5	147.00[cd]	18.33	421	90.7[c]
Trichoderma Viride commercial (Talc)	164	149.00[d]	17.22	405	89.2[c]
Curzate M-8 (chemical control)	163	100.75[a]	43.88	508	107.5[a]
Untreated control	164	180.00[e]	-	394	74[d]
CD (p=0.05)	NS	3.38		0.26	4.11
CV (%)		11.54		8.4	12.97

III.11 Biological Control of Grapes Diseases

III.11.1 MPKV, Pune

Management of Powdery mildew (*Uncinula necator*) of Grape by using biocontrol agents

Powdery mildew,*Uncinula necator* disease of grape was effectively managed with three spraying of *Trichoderma harzianum*@5 g /L + *Ampelomyces quisqualis*@5 ml /L and recorded minimum 6.33 Per cent Disease Index(PDI) and maximum fruit yield 19.567 Mt./ha followed by *Bacillus subtilis* @5 g /L + *Ampelomyces quisqualis*@5 ml /L which recorded 8.23 PDI with fruit yield of 19.453 Mt./ha. as against in chemical check (sulphur 2g/litre of water)recording10.00 PDI andfruit yield 19.033 Mt./ha.

Management of Powdery mildew (*Uncinula necator*) of Grape by using Biocontrol agents (MPKV, Pune)

(Collaboration with Grape Pathologist, Onion and Garlic Research Station, PimalgaonBaswant, Tal. Niphad, Dist. Nashik)

The experiment was laid out on the Research farm of Onion and Grape Research Station, PimalgaonBaswant, Tal. Niphad, Nashik district, with Thompson seedless variety having spacing of 3.0 m x 1.5 m in Randomized block design having eight treatments replicated thrice with four plants/plot. Four sprays were given for powdery mildew management on 5.1.2021, 15.1.2021, 25.1.2021 and 4. 2.2021.

Methodology and Observations:

Percent disease index on leaves and berries 15 days interval

Per cent disease over controlYield

Table 68.

S No.	Treatments	Dose (ml/L)
T_1	*Trichoderma harzianum*(MPKV, Rahuri)	5 g /L
T_2	*Bacillus subtilis* (MPKV, Rahuri)	5 g/L
T_3	*Ampelomycesquisqualis*(Commercial formulation)	5ml /L
T_4	*Trichoderma harzianum*+ *Bacillus subtilis* (MPKV, Rahuri)	5 g /L + 5 g L
T_5	*Trichoderma harzianum* + *Ampelomycesquisqualis*	5 g/L + 5 ml /L
T_6	*Bacillus subtilis* + *Ampelomycesquisqualis*	5 g/L+ 5ml /L
T_7	Sulphur 80%WP	2.0 g/L
T_8	Untreated control	-

Table 69.

Scale	Incidence of disease (%)
0	No disease
1	1-25
2	26-49
3	50-75
4	More than 75

Method of recording observation: All the treatments were applied into three replications at the appearance of disease symptoms. All the Agronomical and Horticultural practices were followed as and when required. Four biocontrol and fungicidal sprays were given at an interval of 10-days, by using knapsack sprayer with hollow cone nozzle with water 1000 l/ha. For recording observations on disease incidence, 10 canes per vine were selected and on each cane 10 leaves starting from the bottom were observed in respect of disease on leaves by following 0-4 scale as given below:

Results:

The data presented in Table 69 revealed that, the Per cent Disease Index (PDI) of downy mildew on leaves was ranged from 3.38 to 3.81 before application of biocontrol agents and fungicides were non-significant. The treatment T_5- *Trichoderma harzianum@* 5 g/L+ *A. quisqualis* @ 5 ml/L recorded the lowest PDI (5.67%, 6.33 %) which was at par with the treatment T_6- *Bacillus subtilis @ 5 g/L + Ampelomyces quisqualis* @ 5 ml/L (6.00% , 6.67% PDI) and the treatment T_3- *Ampelomyces quisqualis@* 5 ml/L (6.33% , 7.00% PDI) at 5 and 10 days after first spray. The untreated control treatment T_1 recorded maximum PDI (12.33 %, 17.33%) at 5 and 10 days after first spray.

The treatment T_5- *Trichoderma harzianum @ 5 g/L + A. quisqualis@ 5 ml/L*recorded the lowest PDI (6.33%, 6.67%) which was at par with the treatment T_3- *Ampelomyces quisqualis @ 5 ml/L*(7.00% , 7.33% PDI) and T_6- *Bacillus subtilis @ 5 g/L + Ampelomyces quisqualis @ 5 ml/L* (8.00% , 8.00% PDI) and the treatment at 5 and 10 days aftersecond foliar application for downy mildew of grape.The untreated control treatment T_1 recorded maximum PDI (21.67 %, 28.67%)at 5 and 10 days after second spray.

Similar trend was found at 5 and 10 days after third foliar application for downy mildew of grape. The treatment T_5- *Trichoderma harzianum @ 5 g/L + A. quisqualis @ 5 ml/L*recorded the lowest PDI (6.00%, 6.33%) which was at par with the treatment T_3- *Ampelomyces quisqualis* @ 5 ml/L (7.33% , 7.67% PDI) and T_6- *Bacillus subtilis @ 5 g/L+ Ampelomyces quisqualis @ 5 ml/L* (8.00% , 8.33% PDI) and the treatment at 5 and 10 days after third foliar application for downy mildew of grape.The untreated control treatment T_1 recorded maximum PDI (32.33%, 34.33%) at 5 and 10 days after third spray.

Grapevine fruit yield

The treatment T_5- *Trichoderma harzianum @ 5 g/L + A. quisqualis @5 ml/L*recorded the highest fruit yield of 19.567 t/ha which was at par with the treatment T_6- *Bacillus subtilis @5 g/L + Ampelomyces quisqualis*@ 5.0 ml/L (19.453 t/ha)and T_3- *Ampelomyces quisqualis*@ 5 ml/L (19.417 t/ha) and treatment T_7- Sulphur 80%WP @ 2.0 g /L (19. 033 t/ha). The untreated control treatment T_1 recorded minimum yield (12.477 t/ha) than rest of the treatment.

Table 70. Effect of Biocontrol agents against Powdery Mildew in Grapes (2020-21)

Sr. No.	Treatments (ml or gm/L)	Powdery Mildew of grapes							Fruit yield (MT/ha)
		PTO (PDI)	5 days After I spray (PDI)	10 days After I spray (PDI)	5 days After II spray (PDI)	10 days After II spray (PDI)	5 days After III spray (PDI)	10 days After III spray (PDI)	
T_1	*Trichoderma harzianum@ 5 g/L*	7.00[a] (15.32)	8.67[b] (17.10)	9.33[b] (17.75)	9.33[b] (17.75)	11.33[b] (19.65)	10.00[b] (18.42)	10.33[b] (18.72)	17.278[b]
T_2	*Bacillus subtilis @5 g/L*	6.67[a] (14.90)	9.33[b] (17.78)	10.00 (18.42)	10.67[b] (18.96)	11.67[b] (19.89)	11.33[b] (19.65)	11.67[b] (19.95)	16.193[b]
T_3	*Ampelomyces quisqualis@5ml/L*	6.33[a] (14.39)	6.33[a] (14.51)	7.00[a] (15.32)	7.00[a] (15.27)	7.33[a] (15.70)	7.33[a] (15.68)	7.67[b] (16.02)	19.417[a]
T_4	*Trichoderma harzianum @5 g/L + Bacillus subtilis @5 g/L*	6.33[a] (14.51)	8.33[b] (16.74)	9.00[b] (17.39)	9.67[b] (18.10)	9.67[b] (18.10)	10.00[b] (18.39)	10.33[b] (18.72)	15.487[c]
T_5	*Trichoderma harzianum@ 5 g/L + Ampelomyces quisqualis @ 5 ml/L*	6.67[a] (14.95)	5.67[a] (13.76)	6.33[a] (14.57)	6.33[a] (14.57)	6.67[a] (14.95)	6.00[a] (14.15)	6.33[a] (14.53)	19.567[a]
T_6	*Bacillus subtilis @ 5 g/L +Ampelomyces quisqualis @ 5 ml/L*	6.67[a] (14.85)	6.00[a] (14.15)	6.67[a] (14.90)	8.00[a] (16.37)	8.00[a] (16.41)	8.00[a] (16.41)	8.33[a] (16.75)	19.453[a]
T_7	Sulphur 80% WP @ 2 g/L	7.00[a] (15.32)	7.33[b] (15.70)	8.67[b] (17.12)	8.67[a] (17.08)	9.67[b] (18.08)	9.67[b] (18.08)	10.00[b] (18.42)	19.033[a]
T8	Control	7.33[a]	12.33[c] (20.54)	17.33[b] (24.60)	21.67[c] (27.73)	28.67[c] (32.36)	32.33[c] (34.23)	34.33[c] (35.87)	12.477[d]
SE±		0.79	0.70	0.55	0.93	0.75	0.77	0.70	0.43
CD at 5%		NS	2.13	1.66	2.84	2.26	2.34	2.11	1.31
CV (%)		9.08	7.48	5.40	8.90	6.66	6.89	6.08	4.30

PTO - Pre-Treatment Observation. PDI - Per cent Disease Index , Values in the parentheses are arc sine transformed values.

Biological Control of Vegetable Diseases

III.12 Biological Control of Tomato Diseases

III.12.1 Bio-efficacy of different bio-agents against the early blight of tomato

Objective: To assess the efficacy of *Trichoderma harzianum* and *Pseudomonas fluorescens* against early blight disease of tomato

AAU Anand

Table 71.

Year of commencement	:	*Kharif*, 2020-21
Scientists involved	:	PI - Dr.Raghunandan, B. L.
		Co. PI – (1) Dr. N. M. Gohel
		(2) Dr. N. B. Patel
Location	:	Agronomy Farm, AAU, Anand
Crop & variety	:	Tomato, AT-3
Treatments	:	8
Replications	:	3
Design	:	Randomized Block Design
Spacing	:	90 x 60 cm
Plot size	:	Gross : 5.4 x 6.0 m Net : 3.6 x 4.8 m

Treatments:

Th (SA + RD + FS)

Pf (SA + RD + FS)

Th + Pf (SA + RD + FS)

Th (SA + RD) + Azoxystrobin 23% SC (FS)

Pf (SA + RD) + Azoxystrobin 23% SC (FS)

Th+ Pf (SA + RD) + Azoxystrobin 23% SC (FS)

Azoxystrobin 23% SC (RD) + Azoxystrobin 23% SC (FS)

Untreated control

Note:

Th = *Trichoderma harzianum* (AAUBC- Th1)

Pf = *Pseudomonas fluorescens*(NBAIR Pf DWD)

SA = Soil application RD = Root dip FS = Foliar spray

Methodology:

Soil application (SA)

Standard protocol was followed for enriching biopesticides. *T. harzianum* (2×10^6cfu/g) and *P. fluorescens* (2×10^8cfu/g) were enriched in vermicompost separately and in combination as per the treatments. The formulation (2.5 kg) was mixed with 100 kg vemicompost for enrichment and applied in 1 ha area. The enriched biopesticide was applied based on plot size of each treatment.

Root dip treatment (RD)

The seedling roots were dipped in the suspension of Th (10 g/litre), Pf (10 g/litre), Th + Pf (5 g each/litre) and Azoxystrobin 23% SC (1.0 ml/litre) for 30 min just before transplanting in the field.

Foliar spray (FS)

Th (5 g/litre), Pf (5 g/litre), Th + Pf (each with 5 g/litre) and Azoxystrobin 23% SC (1.0 ml/litre) were applied as foliar sprays. Two sprays were carried out at fifteen days interval with the initiation of disease.

Observations recorded

Per cent disease intensity (PDI)

Ancillary observations on plant growth parameters (Plant height, Number of branches/ plant, Fruit weight/ plant)

Marketable fruit yield (kg/plot)

Note: The percent disease intensity (PDI) was calculated by using 0–5 disease rating scale given by Pandey *et al.* (2002)

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{Total no. of observations (sample) x 5}} \times 100$$

Table 72.

Scale	Description
0	No symptoms on the leaf
1	0-5 per cent leaf area infected and covered by spot
2	6-20 per cent leaf area infected and covered by spot, some spots on petiole
3	21-40 per cent leaf area infected and covered by spot, spots also seen on petiole, branches
4	41-70 per cent leaf area infected and covered by spot, spots also seen on petiole, branches, stem
5	>71 per cent leaf area infected and covered by spot, spots also seen on petiole, branch, stem, fruits

Results:

The data pertaining to the efficacy of different combinations of *Trichoderma* and *Pseudomonas* against early blight disease is presented in the Table No.72 . Among the different combinations evaluated, the treatment T_7 - Azoxystrobin 23% SC (RD) + Azoxystrobin 23% SC (FS) recorded the lowest disease intensity as compared to other treatments under study. Among the treatments where different combinations of *Trichoderma* and *Pseudomonas* evaluated as soil application, root dip and foliar spray, the treatment T6- Th+ Pf (SA + RD) + Azoxystrobin 23% SC (FS) found effective in reducing the early blight disease intensity. This treatment recorded the disease intensity of 9.26%, which was at par with the treatment T_5 - Pf (SA + RD) + Azoxystrobin 23% SC (FS) (11.74 %). Among the treatments where the biopesticides were evaluated as foliar spray, the treatment T_3 - Th + Pf (SA + RD + FS) recorded the lowest disease intensity (16.50 %). The untreated control treatment recorded the disease intensity of 39.83%. The efficacy of treatments in reducing the disease intensity was depicted in yield of the crop. The chemical control recorded the highest yield (31.33 t/ha) which was followed by the treatment T_6 - Th+ Pf (SA + RD) + Azoxystrobin 23% SC (FS) (29.67 t/ha) and T_5 - Pf (SA + RD) + Azoxystrobin 23% SC (FS) (28.67 t/ha). All these three treatments found statically at par with each other. The lowest fruit yield was recorded in the treatment T_8 – untreated control (9.67 t/ha).

Similarly, the ancillary observations of growth and yield parameters revealed the significant influence of the treatment combinations evaluated (Table No. 73). Among the treatments where biopesticides were evaluated, the treatment T_6 - Th+ Pf (SA + RD) + Azoxystrobin 23% SC (FS) found promising with enhanced plant height, no. of branches/plant and fruit weight/plant and among the treatments where biopesticides evaluated as foliar spray, the treatment T_3 - Th + Pf (SA + RD + FS) found promising with increased plant growth and yield attributes.

Table 73. Efficacy of different combinations of *Trichoderma* and *Pseudomonas* against early blight disease intensity (%) and yield of tomato

Treatments	Early blight disease intensity (%)			Yield (t/ha)
	First spray	Second spray	Pooled over sprays	
T_1	30.20* (25.30)	28.41 (22.64)	29.31 (23.96)	18.33
T_2	27.47 (21.28)	26.36 (19.71)	26.91 (20.48)	20.33
T_3	24.40 (17.07)	23.55 (15.96)	23.97 (16.50)	22.67
T_4	21.36 (13.27)	19.84 (11.52)	20.60 (12.38)	25.33
T_5	20.75 (12.55)	19.33 (10.96)	20.04 (11.74)	28.67
T_6	18.38 (9.94)	17.06 (8.61)	17.72 (9.26)	29.67
T_7	15.85 (7.46)	14.62 (6.37)	15.23 (6.90)	31.33
T_8	37.37 (36.84)	40.89 (42.85)	39.13 (39.83)	9.67
S. Em± (T)	1.27	1.18	0.83	1.20
Spray (S)	-	-	0.41	-
T x S	-	-	1.16	-
C.D. at 5 % (T)	3.85	3.58	2.40	3.64
Spray (S)			1.23	
T x S			NS	
C. V. (%)	8.94	8.61	8.38	8.93

Note: *Figures outside the parentheses are arcsine transformed values, those inside are retransformed values, NS: Non-significant

Table 74. Efficacy of different combinations of *Trichoderma* and *Pseudomonas* on different plant growth parameters and yield attributes of tomato

Treatments	Plant height (cm)			No. of branches per plant	Fruit weight per plant (kg)
	30 DAS	45 DAS	60 DAS		
T_1	20.27	32.00	50.27	5.13	1.40
T_2	20.67	32.93	51.13	5.73	1.57
T_3	22.60	36.07	52.93	5.80	1.73
T_4	24.33	38.07	57.47	6.27	1.80
T_5	25.07	41.07	59.53	6.33	1.93
T_6	25.73	45.53	60.60	6.80	2.07
T_7	25.80	46.33	62.97	6.83	2.27
T_8	17.40	23.73	39.93	3.97	0.71
S. Em ±	2.02	2.18	2.89	0.29	0.11
C.D. at 5 %	NS	6.61	8.76	0.88	0.35
C. V. (%)	15.41	10.22	9.20	8.57	11.80

Note: DAS = Days after spray; NS = Non-Significant

III.12.2 Screening of promising isolates antagonistic fungi and bacteria against bacterial wilt of Tomato (*Ralstonia solanacearum*)

RARS, KUMARAKOM

Table 75.

Variety	:	PKM-1 or Akshay
Plot size	:	4x5m=20 m^2
Replications	:	4
Design	:	RBD
Treatments	:	1. NBAIR-PFDWD isolate of *Pseudomonas fluorescens* 2. NBAIR-BATP isolate of *Bacillus albus* 3. NBAIR-TATP isolate of *Trichoderma asperellum* 4. KAU strain of *P. fluorescens* 5. Soil drenching of Copper hydroxide 2g/L @6 litres/m^2 6. Control (Untreated)
Method of application of bioagents	:	Talc based formulations of the bioagents 2×10^8c.f.u./g will be applied as seed treatment @5g/kg of seed, seedling dip (2%) at the time of transplanting and soil drenching (2%) at 30 DAP, 45 DAP, 60 DAP Chemical check-Copper hydroxide to be applied as soil drenching at the time of transplanting and at 30 DAP, 45 DAP, 60 DAP
Observations	:	Per cent wilt incidence at 15,30,45,60,75 DAP Growth promotion characters *viz*., plant height (cm), biomass (g)Yield (kg/ha)

Table 76. Influence of promising isolates antagonistic fungi and bacteria on growth and yield of tomato var. Akshay

Treatment	Plant height (cm)	Yield (kg/plot)

T1: NBAIR-PFDWD isolate of *Pseudomonas fluorescens*	133.05	30.13
T2: NBAIR-BATP isolate of *Bacillus albus*	99.25	23.26
T3: NBAIR-TATP isolate of *Trichoderma asperellum*	102.05	19.98
T4: KAU strain of *P. fluorescens*	97.35	23.28
T5: Soil drenching of Copper hydroxide 2g/L	96.00	17.98
T6: Untreated control	92.40	17.67
CD (0.05)	19.70	7.68
CV	12.61	23.10

The *P. fluorescens* NBAIR-PFDWD isolate could bring about significant effect on plant height. Isolates NBAIR-PFDWD (*P. fluorescens*), KAU strain of *P. fluorescens* and NBAIR-BATP (*B. albus*) resulted in significant increase in yield also. But the incidence of bacterial wilt did not occur in the crop. There was incidence of leaf curl disease. Hence the experiment will be repeated in the next year. Possibility of conducting the experiment in a hot spot area will be explored.

III.13 Biological Control of Potato Diseases

III.13.1 AAU Anand

Bio-efficacy of different bio-agents against the early blight of potato

Objective: To assess the efficacy of *Trichoderma harzianum* and *Pseudomonas fluorescens* against early blight disease of potato

Table 77.

Year of commencement	:	*Rabi*, 2020-21
Scientists involved	:	PI - Dr.Raghunandan, B. L.
		Co. PI – (1) Dr. N. M. Gohel
		(2) Dr. N. B. Patel
Location	:	Agronomy Farm, AAU, Anand
Crop & variety	:	Potato, KufriLaukar
Treatments	:	8
Replications	:	3
Design	:	Randomized Block Design
Spacing	:	45 x 15 cm
Plot size	:	Gross : 2.70 x 3.00 m Net : 1.80 x 2.70 m

Treatments:

Th (SA + ST + FS)

Pf (SA + ST + FS)

Th + Pf (SA + ST + FS)

Th (SA + ST) + Kresoxim-methyl 44.3% SC (FS)

Pf (SA + ST) + Kresoxim-methyl 44.3% SC (FS)
Th+ Pf (SA + ST) + Kresoxim-methyl 44.3% SC (FS)
Kresoxim-methyl 44.3% SC (ST) + Kresoxim-methyl 44.3% SC (FS)
Untreated control
Note:
Th = *Trichoderma harzianum* (AAUBC- Th1)
Pf= *Pseudomonas fluorescens*(NBAIR Pf DWD)
SA = Soil application ST = Seed treatment FS = Foliar spray
Methodology:
Soil application (SA)
Standard protocol was followed for enriching biopesticides. *T. harzianum* (2×10^6cfu/g) and *P. fluorescens* (2×10^8cfu/g) were enriched in vermicompost separately and in combination as per the treatments. The formulation (2.5 kg) was mixed with 100 kg vemicompost for enrichment and applied in 1 ha area. The enriched biopesticide was applied based on plot size of each treatment.
Seed treatment (ST)
The tubers/planting materialswere dipped in the suspension of Th (10 g/litre), Pf (10 g/litre), Th + Pf (5 g each/litre) and Kresoxim-methyl 44.3% SC (1.0 ml/litre)for 30 min just before transplanting in the field.
Foliar spray (FS)
Th (5 g/litre), Pf (5 g/litre), Th + Pf (each with 5 g/litre) and Kresoxim-methyl 44.3% SC (1.0 ml/litre) were applied as foliar sprays. Two sprays were carried out at fifteen days interval with the initiation of disease.
Observations recorded
Germination%
Per cent disease intensity (PDI)
Ancillary observations on plant growth parameters(Plant height, Number of branches/ plant, Number of tubers/ plant, Tuber weight/ plant)
Marketable tuber yield (kg/ plot)
Note: The percent disease intensity (PDI) for early blight of potato crop was recorded based on the leaf parts affected at 0–5 scale (Granovsky and Peterson, 1954)
0 = Disease free
1 = up to 10%
2 = 11–25%
3 = 26–50%
4 = 51–75%
5 = > 75% leaf area affected

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{Total no. of observations (sample) x 5}} \times 100$$

Results:
The data pertaining to the efficacy of different combinations of *Trichoderma* and *Pseudomonas* against early blight disease is presented in the Table No 78. Among the

different combinations evaluated, the treatment T_7 - Kresoxim-methyl 44.3% SC (ST) + Kresoxim-methyl 44.3% SC (FS) recorded the lowest disease intensity as compared to other treatments under study. Among the treatments where different combinations of *Trichoderma* and *Pseudomonas* evaluated as soil application, seed treatment and foliar spray, the treatment T6- Th+ Pf (SA +ST) + Kresoxim-methyl 44.3% SC (FS)found effective in reducing the early blight disease intensity. This treatment recorded the disease intensity of 8.52 %. Among the treatments where the biopesticides were evaluated as foliar spray, the treatment T_3 - Th + Pf (SA + ST + FS) recorded the lowest disease intensity (17.17 %). The untreated control treatment recorded the disease intensity of 40.60 %. The efficacy of treatments in reducing the disease intensity was depicted in yield of the crop. The chemical control recorded the highest yield (21.00 t/ha) which was followed by the treatment T_6 - Th+ Pf (SA + ST) + Kresoxim-methyl 44.3% SC (FS) (20.33 t/ha), T_5 - Pf (SA + ST) + Kresoxim-methyl 44.3% SC (FS) (19.67 t/ha) and T_4–Th (SA + ST) + Kresoxim-methyl 44.3% SC (FS) (19.00 t/ha). All these four treatments found statically at par with each other. The lowest tuber yield was recorded in the treatment T_8 – untreated control (9.33 t/ha).

Similarly, the ancillary observations of growth and yield parameters revealed the significant influence of the treatment combinations evaluated (Table No. 79). Among the treatments where biopesticides were evaluated, the treatment T_6 - Th+ Pf (SA + ST) + Kresoxim-methyl 44.3% SC (FS) found promising with enhanced plant height, no. of haulms/plant, no. of tubers/plant and tuber weight/plant. Among the treatments where biopesticides evaluated as foliar spray, the treatment T_3 - Th + Pf (SA +ST + FS) found promising with increased plant growth and yield attributes.

Table 78. Efficacy of different combinations of *Trichoderma* and *Pseudomonas* against early blight disease intensity (%) and yield of potato

Treatments	Early blight disease intensity (%)			Yield (t/ha)
	First spray	Second spray	Pooled over sprays	
T_1	31.22 (26.87)	29.02 (23.53)	30.12 (25.18)	13.67
T_2	27.18 (20.87)	27.00 (20.61)	27.09 (20.74)	15.00
T_3	25.06 (17.94)	23.90 (16.41)	24.48 (17.17)	16.67
T_4	21.54 (13.48)	20.44 (80.78)	20.99 (12.83)	19.00
T_5	21.38 (13.29)	19.58 (11.23)	20.48 (12.24)	19.67
T_6	17.50 (9.04)	16.44 (8.01)	16.97 (8.52)	20.33
T_7	16.49 (8.06)	14.92 (6.63)	15.70 (7.32)	21.00

T_8	37.76 (37.50)	41.40 (43.73)	39.58 (40.60)	9.33
S. Em ± (T)	1.20	1.12	0.84	0.98
Spray (S)	-	-	0.41	-
T x S	-	-	1.17	-
C.D. at 5 %	3.64	3.48	2.44	2.96
Spray (S)	-	-	1.23	
T x S	-	-	NS	
C. V. (%)	8.39	8.25	8.32	10.04

Note: *Figures outside the parentheses are arcsine transformed values, those inside are retransformed values, NS: Non-significant

Table 79. Efficacy of different combinations of *Trichoderma* and *Pseudomonas* on different plant growth parameters and yield attributes of potato

Treatments	Germination (%)	Plant height (cm)			No. of haulms per plant	No. of tubers per plant	Marketable tuber weight per plant (g)
		30 DAS	45 DAS	60 DAS			
T_1	89.33	17.97	21.00	27.17	3.07	3.80	144.33
T_2	88.00	18.00	22.07	28.40	3.27	4.20	151.17
T_3	91.33	18.07	24.17	30.13	3.50	4.40	161.00
T_4	87.00	19.40	26.07	33.27	4.03	4.93	188.67
T_5	88.67	20.50	26.27	34.53	4.10	5.30	190.03
T_6	90.67	21.17	27.40	35.67	4.20	5.83	195.83
T_7	87.67	21.93	28.90	38.53	4.63	6.47	203.00
T_8	88.00	14.17	17.03	21.73	2.20	2.27	78.07
S. Em ±	5.21	1.23	1.25	1.50	0.24	0.35	8.02
C.D. at 5 %	NS	3.72	3.78	4.56	0.73	1.07	24.33
C. V. (%)	10.15	11.25	8.95	8.35	11.50	13.16	8.47

Note: DAS= Days after spray; NS = Non-Significant

III.14 Biological Control of Pea Diseases

III.14.1 Field evaluation of ICAR-NBAIR antagonistic organisms against Pea Rust (*Uromyces fabae*) Table 80.

Plot size	1 x 5 cents for each treatment, 1 cent = 8x5 m^2
Replications	04
Design	RBD
Variety	High yielding variety susceptible to Pea Rust - Rachna

Table 81.

S. No.	Treatments
1.	T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)
2.	T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)
3.	T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)
4.	T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)

5.	T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)
6.	T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)
7.	T_7 - Recommended fungicide application (Mancozeb @ 2.5 g/L)
8.	T_8 - Control (Untreated)

Table 82.

Observations	Pea rust Scoring and calculation of Percent disease index (for Pea rust) at 3 and 7 Days After Spray Growth promotion character viz., plant height (cm), biomass (gm) Yield (q/ha)

Four rounds of foliar sprays of talc and liquid formulations antagonistic organisms at the 10^8cfu/ml has been given at 14 days interval starting from 75 Days after Sowing when the disease start appearing

Table 83. Yield and Yield attributes of Pea as affected by the application of various antagonistic organisms

Treatments	Plant Height (gm)	No. of pods/plant	No. of seeds/pod	Biomass (gm / plant)	Yield (q/ha)
T_1	74.44	29.78	5.55	9.42	7.67
T_2	72.89	28.55	5.22	8.59	6.84
T_3	74.44	30.88	5.55	10.38	8.16
T_4	74.22	29.22	5.33	9.22	7.25
T_5	72.33	28.22	5.00	8.15	6.49
T_6	73.66	28.77	5.33	8.62	7.03
T_7	68.33	26.77	5.00	7.61	6.11
T_8	66.22	23.55	4.66	7.39	5.76
C.D. at 5%	2.380	1.427	0.418	0.563	0.375

Table 84. Percent Pea rust index in response to the application of various antagonistic organisms

Treatments	Percent disease index							
	1st Spray		2nd Spray		3rd Spray		4th Spray	
	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
T_1	13.00	12.07	11.33	10.50	9.43	8.63	7.83	6.97
T_2	13.80	13.27	12.83	12.43	11.47	10.83	10.30	9.63
T_3	13.73	10.60	9.80	9.10	8.43	7.67	6.93	6.07
T_4	13.10	12.70	12.13	11.63	11.17	10.37	9.53	8.83
T_5	14.33	13.90	13.53	13.37	13.07	12.80	12.53	12.17
T_6	13.07	12.93	12.50	12.10	11.67	11.03	10.23	9.60
T_7	10.63	9.93	9.37	7.60	7.10	6.50	6.17	5.87
T_8	14.37	14.83	15.57	15.97	16.57	17.00	17.70	18.23
C.D. at 5%	1.628	1.399	1.120	1.258	1.604	1.216	1.123	1.178

Two antagonistic organisms *Pseudomonas fluorescens* and *Trichoderma asperellum* (NBAIR strain) both liquid and talc formulations, along with *P. fluorescens* and *T. asperellum* (local strain) and recommended fungicide (Mancozeb @ 2.5 g/L), were assessed against Pea Rust (*Uromyces fabae*). NBAIR-PFDWD strain *P. fluorescens* (Liquid formulation) T_3 - recorded lowest percent disease index (6.07%) followed by its talc formulation T_1 - (6.97%). Percent disease index in Mancozeb spray T_7 - (5.87%) was comparable to that of T_3 - *P. fluorescens* (NBAIR-PFDWD strain – liquid formulation), but seed yield was significantly highest in T3 (8.16 q/ha), followed by T_1 (7.67 q/ha). The grain yield was lowest in T_8 – control (5.76 q/ha) and T_7 – (6.11 q/ha). Other growth and yield attributes (plant height, no. of pods / plant, no. of seeds / pod and biomass) also corresponded respectively with the seed yield (q/ha).

Fig:30.

III.14.2 Dr YS PUHF, Solan

Management of *Fusarium* wilt/ root rot of pea through biological control agents

A field experiment on the management of Fusarium wilt (*Fusariumoxysporum*f.sp. *pisi*) was laid out during October, 2020 at the Experimental Farm of Department of Entomology, Dr YSPUHF, Nauni, Solan. Pea seeds (var. Punjab-89) were sown in plots of 3x1m^2 along with 7 treatments comprising of seed as well as soil treatments with two biocontrol agents *Trichodermaasperellum* and *Pseudomonas fluorescens,* carbendazim and control. The observations on Fusarium wilt (near wilt as well as true wilt) incidence and green pod yield (kg/ plot) were recorded at the time of harvesting. The treatment details and results of the experiment are presented in Table 85.

Table : Effect of seed treatment and soil application of *Trichoderma asperellum* and *Pseudomonas fluorescens* on Fusarium wilt and yield of pea cv. Pb-89

Table 85.

Treatment	Wilt (%)	Yield per plot (kg)
Seed treatment with *Pseudomonas fluorescens* formulation @ 10g/kg seed	15.33 (4.04)b	2.67b
Seed treatment with *Trichoderma asperellum* formulation @10g/kg seed	14.33(3.91)b	3.09b
Seed treatment with *Pseudomonas fluorescens* formulation @ 10g/kg seed + soil application of *Trichoderma asperellum* formulation after mixing with FYM (10g/Kg FYM) @40g/m^2	12.67 (3.70)ab	3.49ab
Seed treatment with *Trichoderma asperellum* formulation @10g/kg seed+ soil application of	10.67 (3.41)a	3.72a

Trichoderma asperellum formulation after mixing with FYM (10g/Kg FYM) @40g/m^2		
Seed treatment with *Pseudomonas fluorescens* formulation @ 10g/kg seed + soil application of *Pseudomonas fluorescens* formulation after mixing with FYM (10g/Kg FYM) @40g/m^2	12.67 (3.70)ab	3.58a
Seed treatment with carbendazim @2g/kg seed and drenching @2g/L with carbendazim (University recommendation)	12.33 (3.64)ab	3.49ab
Control (no treatment)	24.33 (5.03)c	2.13c
CD(p=0.05)	(0.41)	0.46

Figures in parentheses are square root transformed values

Results depicted that the all the treatments of biological control agents reduced the wilt incidence significantly as compared to control. The lowest incidence of 10.67 per cent was recoded in T4 (Seed treatment with *T. asperellum* formulation @10g/kg seed+ soil application of *T. asperellum* formulation after mixing with FYM (10g/Kg FYM) @40g/m^2). This treatment was, however, statistically on par with T3(Seed treatment with *P. fluorescens* formulation @ 10g/kg seed + soil application of *T. asperellum* formulation after mixing with FYM (10g/Kg FYM) @40g/m^2), T5(Seed treatment with *P. fluorescens* formulation @ 10g/kg seed + soil application of *P. fluorescens* formulation after mixing with FYM (10g/Kg FYM) @40g/m^2) as well as the chemical treatment T6 (Seed treatment with carbendazim @2g/kg seed and drenching @2g/L with carbendazim). Green pod yield was also highest (3.724 kg) in T4, however, statistically at par with T3, T5 and chemical treatment T6.It can be concluded that seed treatment with *T. asperellum* formulation @10g/kg seed+ soil application of *T. asperellum* formulation after mixing with FYM (10g/Kg FYM) @40g/m^2could be an ecofriendly option for this disease management.

III.14.3 PAU Ludhiana

Evaluation of microbial antagonists for the management of diseases (Powdery mildew/Ascochyta blight/Rust) in pea

The experiment was conducted on Pea variety Punjab 89 which was sown at Entomological Research Farm, Punjab Agricultural University, Ludhiana on 23.10.2020 in a randomized block design following agronomic practices. There were six treatments with three replications.

Treatments details have been given below:

(1) *Pseudomonas fluorescence* (NBAIR-Pf DWD)

(2) *Trichoderma harzanium* (NBAIR)

(3) *Trichoderma asperellum* (NBAIR TATP)

(4) *Pseudomonas fluorescence* (local)

(5) Chemical control (spray the crop twice with 200g Sulfex and 400g Indofil M45 per acre at an interval of 10 days)

(6) Untreated control.

The mode of microbial antagonists treatment was seed treatment: @ 10g/kg, soil treatment of mix formulation @1 kg with 100kg FYM per acre which was broadcasted uniformly in one acre of land and two foliar sprays @ 10g/litre at 10 days interval.

Observations on the per cent disease incidence was recorded per square meter by using following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Total number of infected plants}}{\text{Total number of plants}} \times 100$$

Disease severity was recorded by using following formula:

$$\text{Disease severity (\%)} = \frac{\text{Sum of disease score}}{\text{Maximum disease score x Total number of plants observed (4)}} \times 100$$

*Rating scale given by Schoeny et al (2009) was used to score the infected plants.

Ascochyta blight was the only disease observed in the experimental field so, the percent disease incidence and severity of Ascochyta blight was recorded. The percent disease incidence was minimum (40.48 %) in *Pseudomonas fluorescence* (NBAIR-Pf DWD) and was at par with all other microbial antagonists and significantly better than untreated control (57.83%). However, chemical control recorded the lowest (27.15 %) disease incidence. Disease severity was recorded from four plants per plot per replication. Minimum per cent disease severity (33.30%) was observed in *Pseudomonas fluorescence* (NBAIR-Pf DWD) and was at par with all other microbial antagonists (Table 86; Fig.). However chemical and untreated control recorded 22.22 and 49.72 per cent disease severity respectively. Pod yield (q/ha) in all microbial antagonists was at par with each other. However, chemical and untreated control recorded 149.6 and 123.3 q/ha respectively.

Table 86. Evaluation of microbial antagonists for Ascochyta blight in Pea (2020)

Treatments	Disease Incidence (%)	Disease severity (%)	Yield (Q/ha)
Pseudomonas fluorescence (NBAIR-Pf DWD	40.48^{ab} (39.47)	33.30^{b} (35.14)	134^{b}
Trichoderma harzanium (NBAIR)	45.17^{b} (42.20)	34.72^{b} (35.97)	132.3^{b}
Trichoderma asperellum (NBAIR TATP)	45.78^{b} (42.53)	33.33^{b} (35.22)	131.5^{b}
Pseudomonas fluorescence (local)	43.84^{b} (41.35)	34.71^{b} (36.03)	131.7^{b}
Chemical control (Sulfex (200g/acre) and Indofil M 45 (400g/acre)	27.15^{a} (31.28)	22.22^{a} (28.09)	149.6^{a}
Untreated Control	57.83^{c}	49.72^{c}	123.3^{c}

	(49.56)	(44.82)	
CD (5%)	9.31	4.61	4.16
CV	12.47	7.08	1.68

Fig:31. Pea field at Entomological Research Farm Fig. Plants infected with Ascochyta blight

Fig:32. (a) Healthy pods; (b) Ascochita blight infected pods

Biological Control of Commercial Crops

III.15 Biological Control of Sugarcane Diseases

III.15.1 ICAR-SBI Coimbatore

Efficacy of Mechanized sett treatment with antagonistic microbes, fungicide and theirintegration against red rot in sugarcane

Based on our earlier standardization, a pot culture experiment has been laid out with CoC 671 and Co 94012 to study the effect of mechanized means of sett treatment with liquid formulation of biocontrol agents against soil-borne inoculum of red rot. For which, 48hr old *Paenibacillus alvei* in King's B broth and composite of blended mycelium along with spores of *Trichoderma harzianum* @ 10 -6 cfu/ ml at 0.25, 0.5 and 1% concentration were used to treat the setts in Sett Treatment Device (STD) at vacuum level of 150mm/Hg. Results indicated that there was no significant difference with respect to germination and tillering. However shoot thickness, height and greenness were found be improved in treated pots and hence based on that, 0.5% concentration was selected for field application. Accordingly, field experiment was laid out to evaluate mechanized means of sett treatment with *T. harzianum* and *P. alvei* individually and in combination, fungicide (thiophanate methyl) alone and its combination with *P. alvei* with suitable healthy and infected/ inoculated controls for the management of red rot using susceptible variety CoC 671. Preliminary results indicated that treating setts in the Sett Treatment Device (STD) with the combination of thiophanate methyl and *P. alvei* was found to be significantly superior followed by combination of *P. alvei* and *T. harzianum* in protecting the setts from soil-borne inoculum and improving plant survival.

Biological Control of Plantation Crops

III.16 Biological Control ofCocoa Diseases

III.16.1 DRYSRHU, AMBAJIPETA, A.P

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

Methodology:Layout: RBDTreatments: 4

T_1- Spraying of *Trichoderma reesei* spore suspension (2 × 10^6cfu/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.

Results

The experiment was carried out at Avidi village of East Godavari district with quarterly scheduled treatments. Based on the experiment results it was found that after the first round of treatments imposition all the treatments showed significant disease reduction over control. However,T_3 - Spraying of copper oxychloride (3g/litre of water) spray at resulted 56.26 per cent reduction of pod rot followed by T_2 - Soil application of 50 g of *T. reesei* along with 5kg Neem cake and T_1- Spraying of *Trichoderma reesei* spore suspension (2 × 10^6cfu/ml) led to reduction in pod rot 41.34 per cent,27.80 per cent respectively.

The treatment T_2 recorded 65.63 per cent reduction in pod rot after 30 days and 84.19 per cent reduction of pod rot after 45 days While after second spray T_3 and T_1 recorded 55.19 and 46.45 per cent and after third spray 57.89 and 55.18 per cent decrease in pod rot respectively over control . Over all mean disease reduction indicated that T_2 was superior over T_3 and T_1 with 64.24, 56.48 and 43.48 per cent reduction in disease (Table 87)

Table 87. Evaluation of bio control agents against *Phytophthora* Pod rot in cocoa

	Disease incidence								
	Pre-treatment Incidence	Post treatment incidence							
		First spray	Disease reduction over control	Second spray	Disease reduction over control	Third spray	Disease reduction over control	Mean disease incidence	Mean disease reduction

									over control
T1	34.58	24.32* (29.48)	27.80	18.32 (24.97)	46.45	16.32 (23.73)	55.18	19.65	43.48
T2	35.40	19.76 (26.28)	41.34	11.76 (19.86)	65.63	5.76 (13.70)	84.19	12.42	64.26
T3	34.80	14.73 (22.49)	56.26	15.33 (22.99)	55.19	15.33 (22.99)	57.89	15.13	56.48
T4	35.45	33.68 (35.45)	0.00	34.21 (35.76)	0.00	36.41 (37.01)	0.00	34.76	0.00
SEm	-	1.06		1.69		1.43			
CD (5 %)	-	3.30		5.26		4.46			

* Fig in parenthesis are arc sign transformed values

Biological Control of Spice Crops

III.17 Biological Control of Ginger Diseases

III.17.1 AAU, Jorhat

Evaluation of microbial antagonist for the management of ginger rot disease Experimental details:

Target pests: *Ralstonia solanacearum* and *Pythium aphanidermatum*

Location: Joraguri, Dergaon, Golaghat (farmer's field).

Season: *Kharif*, 2020

Date of Planting: 2nd week of June, 2020

Variety: Locally recommended variety

Areacover:1ha (to be covered)

Replication:3 RBD

Treatments:

T_1:Seed treatment with *Pseudomonas fluorescens*(AAUCulture)@1x10^8cfu/ml(5g/ltr)

T_2:T_1+ spraying of *Trichoderma asperellum* (AAUCulture)@1x10^8cfu/ml (5g/ltr)

T_3: T_{1+} spraying of *Trichoderma harzianum* (AAU Culture) @ 1x10^8cfu/ml(5g/ltr)

T_4:T_{1+} spraying of *Trichoderma asperellum* (Commercial formulation) @1x10^8cfu/ml (5g/ltr)

T_5:T_{1+}spraying of *Trichoderma harzianum* (Commercial formulation) @1x10^8cfu/ml (5g/ltr)

T_6:Soil drenching of Copper hydroxide 2g/L @6 litres/m2T_7:Untreated check

Modeofapplication:Seed treatment with biopesticide followed by foliar application at@15,30,45, 60 days after sowing

Observations:

Record of infected plant during vegetative stage

Estimation of disease intensity

Record of infected ginger after harvest

Yield data.

Remarks: The experiment could not be conducted after 2nd treatment due to covid pandemic as the experimental site was far away from AAU, Jorhat campus. It will carry out during 2021-22.

Fig:33. View of Experimental plot of Ginger

III.18 Biological Control of Black Pepper Diseases

III.18.1 KAU, Thrissur

Management of *Phytophthora* disease in black pepper nursery using biocontrol agents

An experiment for the management of *Phytophthora* disease in black pepper nursery using biocontrol agents has been initiated (Plate 20). Cuttings of black pepper were collected from AICRP on Spices during March 2021 and the experiment is in progress.

Fig:34. View of experiment on management of*Phytophthora*disease in black pepper nursery using biocontrol agents

Biological Control of Crop Pests

CEREALS

1. RICE

1.1 Field evaluation of ICAR-NBAIR entomopathogenic strains against Rice stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*), Brown planthopper (*Nilaparvata lugens*) (ICAR-NRRI, Cuttack).

The experiment was undertaken with the treatment details mentioned hereunder

T1. NBAIR-PEOWN isolate of *Pseudomonas entomophila*@ 10^8, 10^7, and 10^9cfu/g

T2. NBAIR-BtyoPS isolate of *Lysinibacillussphaericus*@ 10^8, 10^7, and 10^9cfu/g

T3. NBAIR-BATP isolate of *Bacillus albus* @ 10^8, 10^7, and 10^9cfu/g

T4. NBAIR-PFDWD isolate of *Pseudomonas fluorescens* @ 10^8, 10^7, and 10^9cfu/g

T5. NBAIR-TATP isolate of *Trichoderma asperellum*@ 10^8, 10^7, and 10^9cfu/g

T6. Recommended insecticide

T7. Control (Untreated)

NBAIR isolates i.e., NBAIR-PEOWN, NBAIR-BATP, NBAIR-BtoYPS, NBAIR-PFDWD and NBAIR-TATP shown less dead heart damage caused by yellow stem borer (9.07-12.94%) compared to untreated control where maximum dead heart incidence of 27.20% was observed. Least dead heart incidence caused by YSB was observed in the recommended insecticide application treatment (2.15%) (Table 88). Among the isolates sprayed NBAIR-PEOWN, NBAIR-BATP, NBAIR-BtoYPS was observed to be significantly on par in dead heart incidence reduction followed by the isolates NBAIR-PFDWD and NBAIR-TATP. Similar results were observed with respect to leaf folder damage where highest leaf damage of 5.64% was observed in untreated control and significantly less leaf damage was observed in all the NBAIR isolates sprayed plots. Statistically, NBAIR-PEOWN, NBAIR-BATP and NBAIR-BtoYPS isolates shown on par result followed by NBAIR-PFDWD and NBAIR-TATP in leaf folder damage incidence caused by rice leaf folder. Thus, the experiment shows that all the NBAIR isolates were effective in showing reduced damage caused by rice yellow stem borer and rice leaf folder.

Table 88. The bio-control efficacy of NBAIR isolates against rice insect pests

Treatments	YSB (Dead heart (%))	Per cent reduction over control (%)	Leaf folder damage (Leaf Damage (%))	Per cent reduction over control (%)	Flag leaf length (cm)	Plant height (cm)
NBAIR-PEOWN	9.07 (17.52)^{c}	66.65	2.33 (8.77)^{c}	58.69	29.4 (5.5)^{ab}	71.3 (8.5)^{d}
NBAIR-BTOYPS	9.52 (17.97)^{c}	65.00	2.16 (8.39)^{c}	61.70	29.4 (5.5)^{ab}	72.8 (8.6)^{bc}
NBAIR-BATP	9.57 (18.02)^{c}	64.82	2.32 (8.75)^{c}	58.87	31.6 (5.7)^{a}	73.4 (8.6)^{abc}

NBAIR-PFDWD	12.08 (20.34)[b]	55.59	3.79 (11.23)[b]	32.80	28.3 (5.4)[b]	73.8 (8.6)[ab]
NBAIR-TATP	12.94 (21.09)[b]	52.43	3.95 (11.46)[b]	29.96	28.9 (5.4)[ab]	72.5 (8.5)[cd]
Recommended insecticide	2.15 (8.43)[d]	92.10	0.78 (5.08)[d]	86.17	28.0 (5.3)[b]	74.1 (8.6)[a]
Untreated Control	27.20 (31.44)[a]		5.64 (13.74)[a]		27.2 (5.3)[b]	69.8 (8.4)[e]

Values in the parenthesis are arcsine transformed values.

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

The experiment was undertaken in Regional Agricultural Research Station, Pattambi during the period from December, 2020 to March, 2021 as per the details given below.

T1: *Heterorhabditis indica* (NBAIR strain) @ $1.2x10^9$ IJs ha^{-1}

T2: *Bacillus thuringiensis* (NBAIR strain) 2g/l

T3: *Beauveria bassiana* (NBAIR strain) @10^8 spores/ml

T4: Flubendiamide 25g.a.i.ha^{-1}

T5: Untreated control

Due to the low pest pressure of leaf folder and stem borer, no significant difference in the treatments either in terms of mean number of damaged leaves, dead hearts/white earheads was observed.

1.3 Large scale bio-intensive pest management on rice [PAU (126ha); KAU-Vellayani (100 ha; KAU- Thrissur (200 ha), AAU-J (50 ha); OUAT (5 ha); IGKV (1 ha)]

The experiment was undertaken with the treatment details mentioned hereunder

T1: BIPM

Seed bio-priming *Pseudomonas fluorescens*@ 10g/kg of seeds. *T. harzianum*@ 15g/kg of seeds (for PAU only)

Seedling dip with *Trichoderma harzianum*15g/litre for few minutes (for PAU only)

Seedlings dip with *Pseudomonas fluorescens* 2% solution other centres.

Spray of azadirachtin 1500 ppm@ 3ml/litre at 45 and 65 DAT against foliar and sucking pest.

Erection of bird perches.

Spray of *Pseudomonas fluorescens* @ 1.5 kg/ha against foliar diseases

Release of *Trichogramma japonicum* @ 100,000/ha (6 releases to be made during season) at 10 days interval starting from 25 DAT for stem borer and leaf folder infestation. Release of *Trichogramma chilonis* and *Trichogramma japonicum* @ 100,000/ha (6 releases to be made during season) at 7 days interval starting from 30 DAT for stem borer and leaf folder infestation (for PAU only).

T2: Farmers' practice(pesticides used by farmers' in respective centers)

T3: Untreated control

1.3.1 PAU, Ludhiana

Large scale demonstrations on the bio-suppression of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted in field areas of Patiala, Kapurthala, Sangrur, Amritsar, Ludhiana and Ferozepur districts in organic *basmati* rice (var. Pusa 1121) over an area of 310 acres.

Based on the mean of all locations (Table 89), mean dead heart incidence in biocontrol fields was 1.74 and 2.08 per cent at 45 and 60 DAT, respectively. The corresponding figures in untreated control were 3.63 and 4.57 per cent. The mean reduction of dead heart incidence in release fields was 53.28 per cent over control. Similarly, leaf folder damage was significantly lower in BIPM fields as compared to untreated control. The damage was 1.56 and 1.82 per cent at 45 and 60 DAT, respectively as compared to 3.42 and 4.88 per cent in untreated control with a mean reduction of 58.55 per cent. The mean incidence of white ears was significantly lower in biocontrol field (2.41 %) as against untreated control (4.86 %) resulting in a reduction of 50.41 per cent (Table 90).Grain yield in biocontrol field (28.40 q/ha) was significantly better as compared to 25.21 q/ha in untreated control, respectively. The yield increase in release fields was 12.65 per cent more than untreated control. It can be concluded that BIPM package involving 5-6 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. 7070/- per hectare over untreated control.

Table 89. Large scale demonstrations of biocontrol of rice pests in organic *basmati* rice during 2020

Treatments	Dead hearts (%)				Leaf folder damaged leaves (%)			
	45 DAT	60 DAT	Mean	% reduction over control	45 DAT	60 DAT	Mean	% reduction over control
Biocontrol*	1.74[a]	2.08[a]	1.91[a]	53.28	1.56[a]	1.82[a]	1.69[a]	58.55
Untreated control	3.63[b]	4.57[b]	4.10[b]	-	3.42[b]	4.88[b]	4.15[b]	-

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

Table 90. Large scale demonstrations of biocontrol of rice pests and yield of organic *basmati* rice during 2020

Treatments	White ears incidence (%)	% reduction over control	Paddy yield (q/ha)	% increase over control	Net returns over control (Rs./ha)
Biocontrol*	2.41[a]	50.41	28.40[a]	12.65	7070.00
Untreated control	4.86[b]	-	25.21[b]	-	

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

1.3.2 KAU, Thrissur

Large scale validation of BIPM in rice was carried out over an area of 200 ha in Alathur Grama Panchayat of Palakkad district from November 2020 to March 2021.Adoption of BIPM practices led to substantial reduction in infestation by major pests. The dead heart as well as white ear head symptoms in BIPM plots were approximately 85 per cent lower than in non BIPM plots. Similarly, leaf folder damage was approximately 25 per cent lower than in conventionally managed plots, while the rice bug population was less than 50 per cent of that in farmer's field. The population of predators and parasitoids too was higher in BIPM plots. Similarly, incidence of bacterial leaf blight was mild in BIPM plots.

The yield obtained from BIPM plots, at 6939 kg/ha was approximately 22 per cent more than that obtained from non BIPM plots 5400 kg/ha(Table 91). The cost of cultivation also was nearly three per cent lower in the former. The increased yield as well as reduced cost resulted in an increase in profit by Rs 44,951/ha. The cost benefit ratio, at 1.70 for BIPM fields compared quite favorably with 1.05 for non BIPM fields.

Table 91. Comparison between BIPM and non BIPM plots at Alathur Panchayat

Sl. No.	Particulars	BIPM plot (Mean no/m^2)	Non BIPM plot (Mean no/m^2)
1.	Dead hearts	0.65	5.0
2.	White ear heads	2.76	18.0
3.	Leaf roller damage	3.12	4.0
4.	Rice bug	6.12	15.0
5.	Spiders	20.47	15.0
6.	Other predators	24.12	19.0
7.	Parasitoids	14.94	9.0
8.	Incidence of bacterial leaf blight	Mild	Severe
9.	Yield (kg/ha)	6939.00	5400.00
10.	Returns per ha (@ Rs. 28./kg)	Rs. 1,94,292/-	Rs. 1,51,200/-
11.	Cost of cultivation (Rs/ha)	Rs. 72,066/-	Rs. 73,925/-
12.	Net return per ha	Rs. 1,22,226/-	Rs.77275/-
13.	Benefit cost ratio	1.70	1.05

Encouraged by the results of the large-scale validation trials over the last two years, Alathur Grama Panchayat sanctioned a project for establishment of a mass production unit for *Trichogramma* egg cards. The unit, supported by Thrissur centre of AICRP on BCCP and manned by rural women trained by the centresuccessfully produced and distributed 1000 cc of Tricho cards among the farmers.

1.3.3 AAU- Jorhat

The trial was laid out in Chowdungpothar, Golaghat district and Rajabahar, Jorhat district with Ranjit as the paddy variety in 50 ha area.

No significant difference was observed in the per cent incidence of dead heart at 65 DAT between the two locations. Mean per cent dead heart of two locations were 2.92 and 2.82 in respect of BIPM and farmers practice, respectively at 65 DAT. Similarly, there was no significant difference was observed between the two locations in respect of damaged leaves due to leaf folder after 45 and 65 DAT. The mean per cent damaged leaves observed was 9.51 in BIPM plot whereas it was 3.30 in farmers practice plot at 65 DAT. In case of WEH, the per cent incidence showed non-significant differences in both the locations. On an average, the mean number of WEH was 2.80 in BIPM plots and it was 2.92 in farmers practice plot. Maximum grain yield ranged from 4876.8 to 4825.3 kg/ha was obtained in BIPM plots compared to farmers practice plot (4683.9 to 4651.0 kg/ha). The mean yield of 4851.05 kg/ha in BIPM plots was significantly superior to farmers practice plot with 4667.45 kg/ha. The net return over chemical control in BIPM package was Rs. 96,319.3 as compared to 88,158.3 in farmers practice plot with a cost: benefit ratio of 1: 3.85 and 1: 3.09, respectively (Table 92).

Table 92. Cost benefit analysis (mean yield of two locations)

Treatment	Mean Yield (Kg /ha)	Additional yield over chemical control (Kg /ha)	Value of yield/ ha (Rs/ha)	Cost of bio control/ chemical treatment (Rs /ha)	Net return (Rs/ ha)	Benefit : cost
BIPM plot	4851.05	183.60	1,21,276.3	24,957.00	96,319.3	3.85
Farmers' practice	4667.45		1,16,686.3	28,525.00	88,158.3	3.09

Rs. 25/kg of rice grain

1.3.4 OUAT, Bhubaneswar

The trial was laid out in Aonlamodavillage, Khandapada of Nayagarh district with pooja as the paddy variety in 5 ha area.The silver shoot(SS), dead heart (DH), white ear head (WEH) and leaf folder (LF), incidence in BIPM demonstrated plots were 2.40, 4.32, 3.20 and 4.18%, respectively as compared to 3.12, 3.90, 2.56 and 3.90% infestation in farmers practice (FP) with the use of chemical pesticides. Significantly higher SS (4.84%), DH (9.76%), WEH (10.76%) and LF (10.84%) infestation was noticed in untreated control. Highest yield (40.84/ha) was recorded in FP. But the yield (39.48 q/ha) in BIPM package was at par with FP. Lowest yield (31.20 q/ha) was recorded in untreated control. The benefit cost ratio in BIPM treated plots was found (1.38) as against 1.40 and 1.09 in FP and untreated control, respectively (Table 93).

Table 93. BIPM demonstration in paddy at Aonlamoda village of Nayagarh district

Treatments	SS (%)	DH (%)	WEH(%)	LF (%)	Yield (q/ha)	B:C ratio
BIPM package	2.40 (1.55)	4.32 (2.08)	3.20 (1.79)	4.18 (2.04)	39.48	1. 38
Farmers Practice	3.12 (1.76)	3.90 (1.97)	2.56 (1.60)	3.90 (1.96)	40.84	1.40
Untreated Control	4.84 (2.20)	9.76 (3.12)	10.76 (3.28)	10.84 (3.27)	31.20	1.09
S.E. (m) ±	(0.10)	(0.13)	(0.06)	(0.07)	1.22	
C.D. (0.05)	0.30	0.39	0.17	0.20	3.70	

Figures in the parentheses are square root transformation values

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

The demonstration trials were undertaken in 2 ha of farmer's fields in Neelayagudem village during *kharif* and *rabi*withBPT 5204 variety. Three modules of BIPM interventions were tested which differed in seed treatment with either of three microbials *viz*., *Trichoderma asperellum*(IIRRCK1strain), *Psuedomonas fluorescens* and a new strain of *Bacillus subtilis* along with application of Phosphorous Solubilising Bacteria, alleyways, organic manuring in addition to synthetic fertilizers (dose adjusted), owl perches for rodent management and marigold and pulses grown on bunds to provide floral diversity for conservation of natural enemies. Though, this area is known for hopper outbreaks during the *kharif* season, in 2020 *kharif*, the only pest observed was the leaffolder. The leaffolder incidence was lowest in the BIPMmodule with *Trichoderma* seed treatment (9.61 %) while the highest incidence was observed in untreated control (23.15 %). The number of spiders observed per five hills was highest in untreated control (9.00). Due to heavy rainfall natural zoonosis of leaffolder larvae was observed this year with highest number of diseases larvae being observed in untreated control (15.25/ 5 hills). The yield was highest in *Pseudomonas* and *Bacillus* treatments (8275 and 8475 kg/ha respectively) indicating the economic feasibility of these modules(Table 94).

Due to Covid pandemic, the trial was not taken up in Odisha and taken up again at Nalgonda in *rabi* season in 2 ha with the same treatments as above with the variety KNM 118. The pest incidence was low and only stem borer was observed causing white ears in the range of 1.15 -2.16 per cent. The treatments did not differ significantly with regards to damage. The highest spider population was observed in BIPM module with *Pseudomonas fluorescens* seed treatment (23.75/ 10 hills).

Table 94. Pest and natural enemies' incidence at Nalgonda, Telangana, *Kharif* 2020

Treatments	Leaffolder% damage	Spiders (No./ 5 hills	*Apanteles* (No./10 hills)	Diseased leaffolder (No./ 5 hills)	Yield (kg/ ha)

T1- BIPM with *Pseudomonas fluorescens*	15.47 (22.89)	5.25 (2.32)	0.50 (0.93)	6.75 (2.53)	8275
T2- BIPM with *Trichoderma* IIRR Strain	9.61 (17.95)	5.00 (2.28)	0.50 (0.93)	3.75 (1.97)	7750
T3 - BIPM with Bacillus IIRR Strain	13.68 (21.69)	5.25 (2.38)	2.00 (1.50)	4.50 (2.21)	8475
T4- Farmers practice -1	5.27 (13.14)	1.50 (1.35)	2.00 (1.50)	1.75 (1.41)	7825
T5 - Untreated control	23.15 (28.66)	9.00 (3.07)	13.00 (3.64)	15.25 (3.95)	7050
T6 - Farmers practice -2	13.48 (21.48)	5.75 (2.48)	2.00 (1.50)	7.00 (2.67)	7250
SEM	1.40	0.23	0.26	0.31	281
SED	1.98	0.33	0.37	0.44	397
CD (0.05)	4.22	0.70	0.79	0.95	847

1.5 Biointensive pest management in rice (KAU-Vellayani)

The trial was laid out with the treatments mentioned below atKalliyoor in an area of 1 ha with Sreyas variety.

T1: Biological control

Seed priming with *B. bassiana* @ 10g/Kg of seeds

Seedling dip with *P .flourescens* @ planting @ 10g/L

Foliar spray with *B. bassiana* @ 20 g/L at fortnightly intervals during vegetative phase

Foliar spray of chitin enriched oil formulation of *L. saksenae* at fortnightly intervals twice during reproductive phase

Placement of *T. japonicum* + *T. chilonis* from 30 DAP at 10 days interval till panicle formation

T2: Farmers practice

Analysis of data on leaf folders revealed that the population was less in farmers practice during the crop period, compared to BIPM plots, until 14 DAP the population of both the plots attained a non-significant variation. The mean population was 0.28/plot in BIPM while it was nil in farmer's practice. The population of rice bug was statistically on par in both the fields after 7 days of spray I and spray II. Thereafter at 14th day the bug population was significantly high in farmer's practice(Table 95). Population of stem borer was lowered significantly14 DAS in BIPM plots. It was equivalent to chemical treatment by farmers during the first week of first spray and second spraying. Obviously, the natural enemy population accounted a significantly high count in BIPM plots, both in the vegetative as well as reproductive phases of the crop.

Table 95. Effect of BIPM on population of rice bug

Treatments	Population of Rice bug/plot						
	Pre count	First spray			Second spray		
		3DAS	7 DAS	14 DAS	3DAS	7 DAS	14 DAS
T1 Biological control	28.57 (5.34)	26.57 (5.15)	20.71 (4.55)	9.85 (3.13)	7.71 (2.77)	5.28 (2.29)	0.28 (0.85)
T2 Farmer's practices	30.28 (5.49)	17.14 (4.13)	14.71 (3.83)	12.57 (3.53)	8.71 (2.94)	6.71 (2.58)	1.42 (1.61)
CD (0.05%)	NS	(0.28)	(0.19)	(0.35)	NS	(0.14)	(0.39)
CV	6.11	4.60	3.55	8.12	7.02	4.44	24.17

1.6 Validation of BIPM practices against pest complex of organic Black rice (AAU-Jorhat)

The trial was laid out with the treatments mentioned below at Dungdhora, Jorhatin an area of 1 ha. with Kola Choul variety.

T1: Organic package

Seedlings root dip with *Pseudomonas fluorescens*@ 2% solution.

Application of organic manure MUKTA 2t/ha

Application of *Beauveria bassiana* 10^{13}spores/haagainstsuckingpests.
Use of bird perch (10/ha)
6 releases of *Trichogramma japonicum* @ 50,000/ha at 10 days interval starting from 30 DAT for stem borer and leaf folder infestation.
Need based application of botanicals NSKE 5% (5 ml/lit)
T2: Farmers practice (chemical control).Two rounds of Chlorantraniliprole 18.5 SC were sprayed against insect pests of rice.

The result indicated that the incidence of dead heart and White ear head (WEH) and damage leaf due to leaf folder were much lower (<3.0%) in both BIPM and farmers practice field. However, the mean dead heart and WEH incidence in BIPM fields were 2.82 and 2.60% at 65 Days after transplanting, respectively. The corresponding figures in farmers practice were 2.78 and 2.99 %. Similarly leaf folder damage in BIPM field was 2.64 % as compared to 2.95 % in farmer's practice. As regards to grain yield, maximum yield of 3124.8 kg/ha was significantly superior as compared to 2882.6 kg/ha in farmers practice plots.

1.7 Comparative efficacy of entomopathogenic fungi against sucking pests of rice, *Leptocorisa acuta*(ICAR-IIRR, Hyderabad)

The experiment was laid out at Aduthurai, Tamil Nadu, and the Centre used their local strain of *L. lecanii* as one of the treatments. Two sprays were given. The pre count data of earheadbugs ranged from 5.5 -6.7 / hill and were on par. Three days after spray the lowest population per hill of 2.33 was observed in *Metarhizium anisopliae*@ 10^7spores ml $^{-1}$and thiamethoxam 2.40. But only the efficacy of thiamethoxam lasted beyond a week. After the second spray, the cumulative per cent control ranged from 31.92 – 85.33 per cent among the entomopathogens while the highest of 97.18 per cent was recorded in thiamethoxam. However, all treatment were significantly higher than untreated control (Table 96).

Table 96. Comparative efficacy of entomopathogenic fungi against ear head bug of rice at Aduthurai, *rabi* 2020

Treatments	I Spray					II spray				
	No. of bugs / hill									
	Pre count	3 DAS	5 DAS	7 DAS	11 DAS	3 DAS	5 DAS	7 DAS	%control	% reduction over control
T1 *Metarhizium anisopliae* @ 10^7 spores ml^{-1}	6.27	3.63	4.77	5.73	6.30	5.57	4.23	4.27	31.92	56.90
T2 *Beaueria bassiana* @ 10^7 spores ml^{-1}	5.50	3.33	4.60	5.07	5.93	4.77	4.10	3.97	27.88	59.93
T3 *L. saksenae* @ 10^7 spores ml^{-1}	6.37	3.50	4.77	4.33	5.63	3.63	2.63	1.40	78.01	85.86
T4 *Thiamethoxam* 0.2 g/L	5.90	2.40	1.77	1.67	2.73	1.53	0.53	0.17	97.18	98.32
T5 Untreated Control	6.70	7.83	8.40	8.80	9.20	9.53	9.70	9.90	-47.76	
SEM		0.15	0.33	0.34	0.23	0.32	0.29	0.25		
SED		0.22	0.47	0.49	0.33	0.45	0.40	0.35		
CD(0.05)	NS	0.48	1.04	1.09	0.73	1.00	0.90	0.78		

2. MAIZE

2.1 Laboratory bioassay of *Metarhizium rileyi*(Anakapalle strain AKP-Nr-1) against Fall armyworm, *Spodoptera frugiperda* (ANGRAU- Anakapalle)

The experiment was undertaken with the treatment details mentioned hereunder Seven concentrations of *Metarhizium rileyi* isolate from 1×10^6 to 1×10^{12} spores / ml prepared by 1-10 fold dilution from main stock culture and tested under controlled conditions (26 ± 2°C and 65 ± 5% RH) against third instar and fourth instar larva.

1. Fresh maize leaves sprayed with desired fungus concentration as larval feed with untreated leaves as control.
2. Topical application of *M. rileyi* spore suspension of seven concentrations from 1×10^6 to 1×10^{12} spores/ ml prepared by 1-10fold dilution from main stock culture on larvae of *S. frugiperda.* Ten third instar larvae of *S. frugiperda* per each concentration was used.

Results from the laboratory investigation revealed, fall armyworm larval mortality recorded high in T6-*M. rileyi* (AKP-Nr-1) $1x10^9$ spores/ml (93.3 %) followed by T5-*M. rileyi* (AKP-Nr-1) $1x10^8$spores/ml (86.67%) and T4-*M. rileyi* (AKP-Nr-1) $1x10^8$spores/ml (80%) and recoded lesser mortality in T1-*M.rileyi* (AKP-Nr-1) $1x10^4$spores/ml (66.66%) (Table 97).

Table 97. Laboratory bioassay of *Metarhizium (Nomuraea) rileyi* (Anakapalle strain AKP-Nr-1) against maize fall armyworm, *Spodoptera frugiperda.*

Treatment	Larval mortality %
T1: M. rileyi (AKP-Nr-1) $1x10^4$spores / ml	66.6
T2: M. rileyi (AKP-Nr-1) $1x10^5$spores / ml	70.0
T3: M. rileyi (AKP-Nr-1) $1x10^6$spores / ml	73.33
T4: M. rileyi (AKP-Nr-1) $1x10^7$spores / ml	80.0
T5: M. rileyi (AKP-Nr-1) $1x10^8$spores / ml	86.67
T6: M. rileyi (AKP-Nr-1) $1x10^9$ spores / ml	93.3

2.2 Field efficacy of *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) against fall armyworm, *Spodoptera frugiperda* in maize (ANGRAU, Anakapalle; UAS, Raichur)

The experiment was undertaken with the treatment details mentioned hereunder

T1: *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) concentration 1×10^8 spores/ml
T2: *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) concentration 1×10^{10} spores/ml
T3: *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) concentration 1×10^{12} spores/ml
T4 :*Metarhizium rileyi* (UASR strain KK-Nr-1) concentration 1×10^8 spores/ml
T5 :*Metarhizium rileyi* (UASR strain KK-Nr-1) concentration 1×10^{10} spores/ml
T6 :*Metarhizium rileyi* (UASR strain KK-Nr-1) concentration 1×10^{12} spores/ml
T7: Untreated control

2.2.1 ANGRAU, Anakapalle

Percent reduction in Fall army worm incidence after two sprays of *M. rileyi* was high in T2- *M. rileyi* (Anakapalle strain AKP-Nr-1) 1x10^{10} spores / ml(84.01 %) and was on par with other treatments(Table 98). Cob yield recorded high in T2-*M. rileyi* (Anakapalle strain AKP-Nr-1)1x10^{10} spores/ml (56.53 q/ha) and T4-(UAS, Raichur KK-Nr-1) 1x10^{8} spores / ml (53.81 q/ha) and low in control (29.43 q/ha)

Table 98. Field efficacy of *Metarhizium* (*Nomuraea*) *rileyi* isolate (Anakapalle strain AKP-Nr-1; UAS, RaichurKK-Nr-1) against fall armyworm, *Spodoptera frugiperda* in maize

Treatment	FAW damage %			Percent reduction in FAW damage after two sprays	Cob yield Q/ha
	Before first spray	After first spray	After second spray		
T1: *M. rileyi* (Anakapalle strain AKP-Nr-1) 1x108 spores / ml	35.36 (36.48)	20.45 (26.75)	7.45 (15.77)	78.93	55.79
T2: *M. rileyi* (Anakapalle strain AKP-Nr-1) 1x1010 spores / ml	41.09 (39.84)	20.67 (26.99)	6.57 (14.84)	84.01	52.53
T3: *M. rileyi* (Anakapalle strain AKP-Nr-1) 1x1012 spores / ml	40.59 (39.55)	26.78 (31.12)	12.9 (20.67)	68.22	50.87
T4: *M. rileyi* (UAS, Raichur KK-Nr-1) 1x108 spores / ml	41.47 (40.07)	25.98 (30.54)	11.46 (19.29)	72.37	53.81
T5: *M. rileyi* (UAS, Raichur KK-Nr-1) on 1x1010 spores / ml	38.36 (38.25)	20.26 (26.64)	8.21 (16.2)	78.6	52.13
T6: *M. rileyi* (UAS, Raichur KK-Nr-1)1x1012 spores / ml	39.58 (38.97)	24.93 (29.92)	10.71 (18.86)	72.94	47.74
T7: Untreated control	42.52 (40.7)	38.81 (38.53)	28.22 (32.01)		29.43
CD (0.05)	NS	4.6	7.23		8.39
CV%	8.1	8.61	20.68		10.74

Values in parenthesis are arc sin transformed values

2.3 Evaluation of entomopathogenic fungi and *Bt*against maize stem borer (PAU, Ludhiana)

The experiment was undertaken with the treatment details mentioned hereunder

T1: *Beauveria bassiana*(NBAIR Bb45) 1x 10^{8} spores /ml)-10 ml/lt.

T2: *Metarhizium anisopliae* (NBAIR Ma4) 1x 10^{8} spores /ml)-10 ml/lt.

T3: Two sprays of *Bt* formulation (NBAIR formulation) @ 2%

T4: Two sprays of *Bt* formulation (commercial)@ 600 ml/ac
T5: Chemical control (chlorantraniliprole 18.5 SC @ 75 ml/ha)
T6: Control

The experiment conducted during *kharif* 2020 with PHM 1 variety revealed, chemical control was significantly better than other treatments in reducing the leaf injury incidence (1.75%) and dead hearts (1.68 %) due to maize stem borer (Table 99). Leaf injury and dead heart incidence in different fungal and *Bt* based biopesticides varied from 7.82 to 11.52 and 4.63 to 7.09 per cent, respectively as compared to 16.67 and 10.48 per cent in untreated control. Among biopesticides, lowest dead heart incidence was recorded in commercial *Bt* formulation (4.63%) and it did not differ significantly from NBAIR *Bt* (5.32%) and *Bb*-5a (5.58%). The dead heart damage in *Ma*-35 was 7.09 per cent and it was not significantly different from *Bb*-5a. Grain yield was highest in chemical control (46.23 q/ha). It was followed by commercial *Bt* formulation (42.06 q/ha), NBAIR *Bt* (40.82 q/ha), *Bb*-5a (40.72 q/ha), and *Ma*-35 (39.04 q/ha) which were not significantly different from each other. The yield was lowest in untreated control (36.11 q/ha).

The pooled data for the year 2019 and 2020 also revealed the same trend. Among biopesticides, lowest dead heart incidence was recorded in commercial *Bt* formulation (4.63%). The dead heart damage in NBAIR *Bt* (6.97 %) and *Bb*-5a (7.08 %) was not significantly different from each other. Grain yield was highest in chemical control (47.75 q/ha). It was followed by commercial *Bt* formulation (44.06 q/ha), NBAIR *Bt* (42.13 q/ha), *Bb*-5a (42.41 q/ha) which were not significantly different from each other. The grain yield in *Ma* 35 (40.54 q/ha) did not differ significantly from NBAIR *Bt* and *Bb*-5a(Table 100).The yield was lowest in untreated control (37.78 q/ha).

Table 99. Evaluation of entomopathogenic fungi and *Bt* against stem borer, *Chilopartellus* in maize during 2020

Treatments	Leaf injury (%)	Dead hearts (%)	Grain yield (q/ha)
T1	11.52^{cd} (3.53)	5.58^{bc} (2.56)	40.72^{b}
T2	13.03^{d} (3.74)	7.09^{c} (2.84)	39.04^{bc}
T3	9.51^{bc} (3.24)	5.32^{b} (2.51)	40.82^{b}
T4	7.82^{b} (2.96)	4.63^{b} (2.37)	42.06^{b}
T5	1.75^{a} (1.65)	1.68^{a} (1.63)	46.23^{a}
T6	16.67^{e} (4.20)	10.48^{d} (3.39)	36.11^{c}

CD (p=0.05)	(0.40)	(0.28)	4.07
CV %	6.82	6.14	5.48

Figures in parentheses are square root transformed values

Table 100. Evaluation of entomopathogenic fungi and *Bt* against stem borer, *Chilo partellus* in maize (Pooled data of 2019 and 2020)

Treatments	Leaf injury (%)	Dead hearts (%)	Grain yield (q/ha)
T1	13.81[c] (3.83)	7.08[c] (2.82)	42.41[bc]
T2	15.57[c] (4.05)	9.13[d] (3.16)	40.54[c]
T3	12.51[bc] (3.62)	6.97[c] (2.80)	42.13[bc]
T4	9.33[b] (3.20)	5.54[b] (2.55)	44.06[b]
T5	2.00[a] (1.72)	2.23[a] (1.78)	47.75[a]
T6	19.47[d] (4.51)	12.84[e] (3.70)	37.78[d]
CD (p=0.05)	(0.43)	(0.24)	2.92
CV %	10.24	7.17	5.72

Figures in parentheses are square root transformed values

2.4 Biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis* (PAU.Ludhiana; MPUAT, Udaipur)

2.4.1 PAU, Ludhiana

The demonstrations on the biological control of maize stem borer, C*hilo partellus* using *T. chilonis* releases were conducted at farmer's fields on an area of 60 acres in Hoshiarpur, Jalandhar, SBS Nagar and Gurdaspur districts of Punjab. Each demonstration area was divided into three blocks representing three treatments, viz. two releases of *T. chilonis* @ 1,00,000 parasitoids/ha, chemical control (farmers' practice) and untreated control. The observations were recorded on dead heart incidence and the yield was recorded at harvest on whole plot basis.

Based on the mean of all locations (Table 101), dead heart incidence in fields with the releases of *T. chilonis* was 2.35 per cent and in chemical control, it was 0.85 per cent. However, both the treatments were significantly better than untreated control (5.23 %). The reduction in incidence over control was 55.07 and 84.13 per cent in biocontrol and chemical control, respectively. Similarly, yield in biocontrol (43.60 q/ha) and chemical control (46.78 q/ha) fields were significantly more than in untreated control (40.00 q/ha).

The yield increase over control was 9.00 per cent in biocontrol as compared to 16.95 per cent in chemical control. The net returns over control in biocontrol package were Rs. 6160/- as compared to Rs.11368/- in chemical control (Table 102).

Table 101. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2020

Treatments	Dead hearts (%)	% reduction in incidence over control	Yield (q/ha)	% yield increase over control
T. chilonis@ 1,00,000 per ha (two releases – 10 and17 days old crop)	2.35[b]	55.07	43.60[b]	9.00
Chlorantraniliprole 18.5 SC@ 75 ml/ha	0.85[a]	84.13	46.78[a]	16.95
Untreated control	5.23[c]	-	40.00[c]	-

Table 102. Cost Benefit analysis (2020)

Treatments	Yield (q/ha)	Additional yield over control (q/ha)	Gross returns (Rs.)	Cost of treatment* (Rs./ha)	Net return over control (Rs./ha)
Biocontrol (release of *T. chilonis*)	43.60	3.60	6660.0	500.00	6160.00
Chlorantraniliprole 18.5 SC@ 75 ml/ha	46.78	6.78	12543.00	1175.00	11368.00
Untreated control	40.00				

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

2.4.2 MPUAT, Udaipur

The demonstrations on the releases of *T. chilonis* were conducted atfarmer's fields in an area of 10 hectares in Udaipur district of Rajasthan. Each demonstration area was divided into threeblocks representing three treatments, *viz*., three releases of *T. chilonis*@100,000 parasitoids/ha/release at 15, 22 and 29 days after crop germination (T1), chemical control (T2), spinosad 45 SC @ 1.0ml/ 3 lit (farmers' practice) and untreated control.

The dead heart incidence in fields with the releases of *T. chilonis* was 11.67 per cent and in chemical control, it was 8.94 per cent. The reduction in incidence over control was 42.93 and 56.28 per cent in T1 and T2, respectively. The yield in *T. chilonis* (T1) (30.22q/ha) and Spinosad 45 SC(T2) (34.60 q/ha) fields were significantly more than in untreated control (24.10 q/ha).

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

The experiment was undertaken with the treatment details mentioned hereunder

Table 103.

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) + napier (border crop)
T6:	Maize + mash (intercrop) + napier (border crop)
T7:	Maize + cowpea (intercrop) + napier (border crop)
T8:	Maize + sesamum (intercrop) + napier (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)

A buffer distance of 14 m shall be maintained in between the treatments with napier and sorghum as border crop, so as to nullify their effect on each other.

The results revealed,percent plant damage by *C. partellus* on maize was significantly lower in T7 – Maize + cowpea + napier (4.44%) as compared to that of 24.45% in sole maize plots (Table 103). Irrespective of the different intercrops, sorghum as border crop attracted significantly more infestation by *C. partellus*, in comparison to napier as border crop.Number of whiteflies per five leaves of various intercrops were significantly lowest in T_7 - Maize + cowpea + napier (16.30 whiteflies) (Table 104). The natural enemies like Coccinellid spp. and spiders were more active in okrainercrops, where the population of whiteflies and *S. litura* larvae were also more(Table 105).Significantly highest maize equivalent yield was obtained in T7 – Maize + cowpea + napier (46.39 q/ha) and the B:C ratio was also highest in T7 (2.553) (Table 106).

Table 104. 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	
	30DAS	50DAS	70DAS	30DAS	50DAS
T1	3.13(10.19)	5.62(13.71)	6.95(15.28)	2.00(8.13)	11.67 (19.97)
T2	2.24(8.61)	4.15 (11.75)	7.10(15.45)	2.67 (9.40)	12.00 (20.27)
T3	2.05(8.23)	3.96 (11.47)	6.23(14.45)	0.67 (4.69)	9.33 (17.79)

T4	3.76(11.18)	5.25(13.25)	7.45 (15.84)	2.67 (9.40)	15.67 (23.32)
T5	3.18(10.27)	4.54 (12.30)	6.16(14.37)	19.33(26.08)	29.33(32.79)
T6	2.25(8.63)	3.82(11.27)	5.35 (13.37)	12.33 (20.56)	32.33(34.65)
T7	1.45(6.91)	2.51(9.12)	4.44 (12.16)	14.33(22.24)	25.00 (30.00)
T8	2.65 (9.37)	4.74(12.57)	5.56(13.64)	15.00(22.79)	27.33(31.52)
T9	13.22(21.32)	20.36(26.82)	24.45(29.63)	-	-
T10	6.32(14.56)	8.25(16.69)	10.12(18.55)	3.67 (11.04)	13.67 (21.70)
T11	4.23(11.87)	5.28(13.28)	7.65(16.06)	26.00 (30.66)	41.00 (39.82)
T12	3.10(10.14)	12.45 (20.66)	21.45 (27.59)	-	-
CD	(2.45)	(3.10)	(2.93)	(2.04)	(2.56)

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

Table 105. 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	
	20DAS	32DAS	20DAS	32DAS	20DAS	32DAS
T1	3.70 (2.17)	4.30 (2.30)	2.70 (1.92)	9.00 (3.16)	105.30 (10.31)	65.30 (8.14)
T2	2.70 (1.92)	3.30 (2.07)	1.00 (1.41)	7.00 (2.83)	123.00 (11.14)	76.00 (8.77)
T3	2.30 (1.82)	3.00 (2.00)	1.30 (1.52)	8.30 (3.05)	38.30 (6.27)	23.00 (4.89)
T4	2.70 (1.92)	3.30 (2.07)	2.00 (1.73)	8.70 (3.11)	101.00 (10.10)	79.70 (8.98)
T5	3.00 (2.00)	3.70 (2.17)	1.00 (1.41)	3.30 (2.07)	86.70 (9.36)	47.30 (6.95)
T6	2.30 (1.82)	3.70 (2.17)	0.70 (1.30)	2.00 (1.73)	113.00 (10.68)	56.00 (7.55)
T7	2.70 (1.92)	4.00 (2.24)	0.30 (1.14)	3.70 (2.17)	27.70 (5.36)	16.30 (4.16)
T8	2.30 (1.82)	3.30 (2.07)	1.00 (1.41)	4.30 (2.30)	74.30 (8.68)	53.30 (7.37)

T9	4.00 (2.24)	5.30 (2.51)	-	-	-	-
T10	3.00 (2.00)	4.30 (2.30)	-	-	-	-
T11	2.70 (1.92)	3.70 (2.17)	-	-	-	-
T12	4.30 (2.30)	5.70 (2.59)	-	-	-	-
CD	(0.30)	(0.36)	(0.20)	(0.44)	(0.53)	(0.46)

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

Table 106. 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
T1	2.60 (1.90)	3.30 (2.07)	6.00 (2.65)	8.33 (3.05)	1.00(1.41)	2.00(1.73)
T2	2.30 (1.82)	3.00 (2.00)	5.67 (2.58)	6.00 (2.65)	0.33(1.15)	1.33(1.53)
T3	3.00 (2.00)	3.60 (2.14)	3.67 (2.16)	3.67 (2.16)	0.33(1.15)	0.67(1.29)
T4	3.30 (2.07)	3.30 (2.07)	4.00 (2.24)	5.00 (2.45)	0.00(1.00)	1.00(1.41)
T5	2.60 (1.90)	3.30 (2.07)	5.67 (2.58)	7.00 (2.83)	0.67(1.29)	1.67(1.63)
T6	2.00(1.73)	2.60 (1.90)	4.00 (2.24)	5.00 (2.45)	0.33(1.15)	1.00(1.41)
T7	2.00(1.73)	3.00 (2.00)	3.33 (2.08)	4.00 (2.24)	0.33(1.15)	0.33(1.15)
T8	2.60 (1.90)	3.00 (2.00)	3.67 (2.16)	4.33 (2.31)	0.00(1.00)	0.67(1.29)
T9	-	-	1.00 (1.41)	1.67 (1.63)	0.00(1.00)	0.00(1.00)
T10	2.30(1.82)	2.60 (1.90)	1.33 (1.53)	2.00 (1.73)	0.00(1.00)	0.00(1.00)
T11	1.30(1.52)	2.30 (1.82)	1.00 (1.41)	1.33(1.53)	0.00(1.00)	0.33(1.15)
T12	-	-	0.00(1.00)	0.67(1.29)	0.00(1.00)	0.00(1.00)

CD	(0.32)	(0.35)	(0.55)	(0.47)	(0.24)	(0.33)

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

2.6 Demonstration of BIPM module against fall army worm, *Spodoptera furgiperda* on *rabi* maize (AAU-Jorhat).

The experiment was undertaken with Vijoy variety in RARS(AAU, Jorhat) during *rabi*, 2020 as per the treatment details given below.

T1: BIPM package

Rogue out of infested plants as early as possible.

Collection and destruction of egg masses.

Erection of bird perches@ 10nos./ha

Installation of pheromone trap (Fawlure) @15traps/ha

3 sprays of NSKE5% (3ml/lit) starting from 25days after germination.

Six releases of *Trichogramma pretiosum*@ 100,000/ha at 10 days interval, starting from 30days after germination.

T1:	*Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & second one after one week of first release) + NBAIR *Bt* 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:	*Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *Metarhizium 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:	*Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + B*eauveria 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:	*Trichogramma chilonis* 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* NBAIIH38 (1-2 whorl sprays @ 4kg/acre, first spray after 30 days of planting & if required next spray should be at 10 days interval)
T5:	*Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *Pseudomonas fluorescens* (Pf DWD 2%) (2-3 sprays @ 20 gm/litre depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)

T6:	*Trichogramma chilonis* 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:	*Trichogramma chilonis* 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)

T2:Farmers practice (Alternate spray of lamdacyhalothrin1.9 EC@1.5ml/lit and emamectinbenzoate 5%SG@0.4gm/lit) **Table 107.**

Results from the experiment indicated, at 7 days after treatment, a significant difference was observed, where BIPM module recorded 1.63 larvae per plant as against 1.82 larvae in case of farmers practice (chemical plot). Similar trend of result was also recorded at 10 days after treatment with 1.23 and 1.38 larvae per plant in BIPM module and farmers practice, respectively and both the treatments were significantly different with each other. In terms of per cent plant damage, BIPM module was significantly different (16.57%) after application of treatment as against farmers practice plot (23.76%). However, highest yield of 43.0 q/ha was recorded in BIPM module, which was significantly superior to farmers practice plot with 35.7 q/ha (Table 108).

Table 108. Evaluation of BIPM module in comparison with farmers practice against the incidence of FAW on Maize

Treatment	Larval count (No/plant)*			Plant damage	Yield (Q/ha)
	1 DAS	7DAS	10DAS		
BIPM plot	1.74	1.63	1.23	16.57	43.0
Chemical	1.72	1.82	1.38	24.86	35.7
"t" value	0.188	1.168	1.00	12.28	10.7
	NS	S	S	S	S

*Mean of three observations: #DAS= Days after spraying

2.7 Field trial against Fall armyworm in maize at AICRP-BC centres (IIMR, Maize Hyderabad, PAU, PJTSAU, AAU-Anand, OUAT, MPKV, CAU and TNAU).

The experiment was undertaken with the treatment details mentioned hereunder

2.7.1. Winter Nursery Centre, ICAR-IIMR, Hyderabad

The experiment was conducted at Winter Nursery Centre, ICAR-IIMR, Hyderabad (var.DHM 117) during *kharif* 2020. Among the treatments, minimum per cent plant infestation was observed in *T. chilonis*1 card/ acre+ *B. bassiana* NBAIR -Bb 45 (30.68), *T. chilonis*1 card/ acre+ *M. anisopliae* NBAIR -Ma 35 (31.21) and *T. chilonis* 1 card per acre + NBAIR *Bt* 2% (35.88). The next best treatments were *T. chilonis*1 card per acre + EPN

H. indica NBAIIH38 (36.40) *T. chilonis* 1 card/ acre+ SpfrNPV (NBAIR1) (38.80), *T. chilonis* 1 card per acre + *P. fluorescens* recorded per cent plant infestation of 36.40, 38.80 and 41.97, respectively at ten days after first spray. Treatment *T. chilonis* alone recorded per cent plant infestation of 44.05, respectively. However, standard check Emamectin benzoate (19.30) was significantly different as compared to biopesticides treatments and untreated control (55.45)(Table 109).

Egg masses laid were minimum in *T. chilonis*1 card/ acre +NBAIR *Bb 45* (3.00) and *T. chilonis* 1 card/ acre+ NBAIR *MA* 35- 0.5% (3.78) and *T. chilonis*1 card/ acre + Spfr NPV (NBAIR 1) (3.89) and were significantly different compared to control (6.00). The next best treatments were *T. chilonis*1 card per acre + EPN *H. indica* NBAIIH38, *T. chilonis*1 card per acre + NBAIR Bt 2% recorded egg masses of 4.00 and 4.23, respectively. Minimum number of larvae were observed in *T. chilonis*1 card per acre + EPN *H. indica* NBAIIH38 (3.38), *T. chilonis*1 card per acre + *B. bassiana* NBAIR -Bb 45, 0.5% (3.43) and *T. chilonis*1 card per acre + *P. fluorescens* (Pf DWD 2%) (3.44) and were significantly different compared to untreated control (5.82).

Maximum number of natural enemies were observed in *T. chilonis*1 card per acre + EPN *H. indica* NBAIIH38 (5.47) followed by *T. chilonis* 1 card per acre + *B.bassiana* NBAIR -Bb 45, 0.5% (5.26) and *T.chilonis* alone (1 card per acre) (4.93). Lowest number of natural enemies were observed in Emamectin benzoate (2.98). Yield data has not been taken due to flooding of the crop from flowering due to heavy rains.

Table 109. Evaluation of different bio pesticides against FAW during *Kharif 2020*

Treatment	Mean per cent infestation		No. of Egg masses /10 plants		No. of live larvae/10 plants		No. of predators/10 plants	
	Pre treatment Count	10 days after 1st Spray	Pre treatment Count	10 days after 1st Spray	Pre treatment Count	10 days after 1st Spray	Pre treatment Count	10 days after 1st Spray
T1-*T.chilonis* 1 card per acre + NBAIR Bt 2%	54.47 (47.61)	35.88 cde (36.79)	1.25 (1.10)	4.23 b (2.19)	2.00 (1.40)	4.04 b (2.00)	2.98 (1.73)	3.79bc (1.94)
T2-*T.chilonis* 1 card per acre + *M. anisopliae* NBAIR -Ma 35, 0.5%	53.78 (47.23)	31.21 de (33.94)	1.32 (1.14)	3.78 b (2.19)	1.69 (1.30)	3.72 b (1.93)	3.34 (1.83)	4.32 bc (2.07)
T3-*T. chilonis* 1 card per acre + *B.bassiana* NBAIR -Bb 45, 0.5%	58.41 (50.12)	30.68 e (33.62)	1.11 (1.04)	3.00 d (1.53)	2.16 (1.44)	3.43 b (1.85)	2.56 (1.60)	5.26 ab (2.29)
T4-*T. chilonis*1 card per acre + EPN *H. indica* NBAIIH38	54.93 (47.85)	36.40 cd (37.09)	1.31 (1.13)	4.00 d (1.53)	2.31 (1.52)	3.38 b (1.83)	3.19 (1.78)	5.47 ab (2.34)
T5-*T. chilonis* 1 card per acre + *P. fluorescens* (Pf DWD 2%)	44.61 (41.82)	41.97 b (10.38)	0.94 (0.96)	4.53 cd (1.75)	1.64 (1.28)	3.44 b (1.84)	3.58 (1.89)	4.87 b (2.20)
T6-*T. chilonis*1 card per acre + SpfrNPV (NBAIR1)	59.74 (50.85)	38.80 bc (38.53)	1.47 (1.19)	3.89 bc (1.95)	2.55 (1.57)	3.88 b (1.97)	3.44 (1.85)	3.90bc (1.95)
T7-*T.chilonis* alone (1 card per acre)	53.61 (47.10)	44.05 b (41.58)	1.36 (1.16)	4.86b c (1.94)	1.98 (1.40)	4.25 b (2.06)	2.64 (1.62)	4.93 b (2.21)
T8- (Emamectin Benzoate 5 SG @ 0.4g /L)	55.04 (47.98)	19.30 f (26.01)	1.26 (1.10)	1.67 d (1.40)	2.33 (1.49)	1.87 c (1.37)	2.42 (1.55)	2.98 c (1.71)
T9-Untreated check (control)	44.93 (41.92)	55.45 a (48.14)	1.22 (1.09)	6.00 a (2.76)	2.18 (1.47)	5.82 a (2.41)	2.93 (1.71)	7.48 a (2.73)
CD	NS	3.26	NS	0.38	NS	0.25	NS	0.45
CV (%)	17.17	5.04	17.18	11.36	13.13	7.56	9.60	12.18

2.7.2. PAU, Ludhiana

The experiment was conducted at Entomological Research Farm, PAU, Ludhiana (var.PMH 11) during *kharif* 2020. Based on the pooled mean of two sprays, significantly lower plant infestation (2.41 %) was recorded in chemical control. It was followed by Tc + NBAIR-Bt 25 (8.83 %), Tc + NBAIR-Ma 35 (10.69 %) and Tc + NBAIR-Bb 45 (11.27 %), all three did not differ significantly among each other. The plant infestation in treatments, Tc + Pf DWD and Tc alone was 15.92 and 16.02, respectively. Significantly higher plant damage (17.28 %) was recorded in untreated control (Table 110). Similarly, lowest larval population (1.00/ 10 plants) was recorded in chemical control. It was followed by Tc + NBAIR-Bt 25 (3.50/ 10 plants), Tc + NBAIR-Ma 35 (4.17/ 10 plants) %) and Tc + NBAIR-Bb 45 (4.33/ 10 plants). However, the larval population was significantly higher in untreated control (6.83/ 10 plants). Grain yield was also significantly higher in chemical control (50.16 q/ ha) followed by Tc + NBAIR-Bt 25 (45.57 q/ ha), Tc + NBAIR-Ma 35 (42.51 q/ ha) and Tc + NBAIR-Bb 45 (42.10 q/ ha). Significantly lower grain yield was recorded in untreated control (36.58 q/ ha).

Table 110. Field evaluation of biocontrol agents against fall armyworm in maize during 2020

Treatments	Plant infestation (%)				No. of larvae/ 10 plants				Grain yield (q/ha)
	Before spray	10 days after 1st spray	10 days after 2nd spray	Pooled mean	Before spray	10 days after 1st spray	10 days after 2nd spray	Pooled mean	
T1-*T. chilonis* 1 card per acre + NBAIR Bt 2%	13.00	8.93 (3.14)	8.73 (3.09)	8.83 (3.11)	4.00	3.33 (2.08)	3.67 (2.16)	3.50 (2.12)	45.57
T2-*T. chilonis* 1 card per acre + *M. anisopliae* NBAIR -Ma 35, 0.5%	12.46	10.83 (3.43)	10.55 (3.38)	10.69 (3.41)	4.33	4.00 (2.23)	4.33 (2.29)	4.17 (2.26)	42.51
T3-*T. chilonis* 1 card per acre + *B.bassiana* NBAIR -Bb 45, 0.5%	12.38	11.29 (3.50)	11.25 (3.50)	11.27 (3.50)	4.00	4.00 (2.24)	4.67 (2.38)	4.33 (2.31)	42.10
T4- *T. chilonis* 1 card per acre + *P. fluorescens* (Pf DWD 2%)	13.22	15.00 (4.00)	16.83 (4.22)	15.92 (4.11)	4.67	5.33 (2.51)	6.67 (2.76)	6.00 (2.64)	40.16

T5-*T. chilonis* alone (1 card per acre)	11.00	14.66 (3.95)	17.37 (4.28)	16.02 (4.12)	2.67	4.67 (2.38)	6.33 (2.70)	5.50 (2.54)	40.00
T6- (Emamectin Benzoate 5 SG @ 0.4g /L)	13.76	2.74 (1.93)	2.10 (1.76)	2.41 (1.84)	4.00	1.33 (1.52)	0.67 (1.28)	1.00 (1.40)	50.16
T7-Untreated check (control)	12.68	16.11 (4.12)	18.44 (4.39)	17.28 (4.26)	4.33	6.00 (2.64)	7.67 (2.93)	6.83 (2.79)	36.58
CD (p=0.05)	NS	(0.51)	(0.55)	(0.50)	NS	(0.28)	(0.40)	(0.23)	5.34
CV %	10.28	8.37	8.78	8.58	11.16	7.15	9.64	8.56	7.07

2.7.3. PJTSAU, Hyderabad

The trial was carried out at College Farm, Rajendranagar with nine treatments. The Pheromone treatment alone was laid out in the research plots of Maize Research station (MRC) in Rajendranagar. The parameters wise observation recorded from the trial was enumerated hereunder.

Egg patches/plot: All treated plots recorded significantly lesser egg patches/plot. However, minimum egg patches were noticed in pheromone treated plots and chemical treated plots (2.33/plot).Controlplot recorded maximum egg patches/plot (11.00) (9.92 MRC). *Bt* 2% spray, NBAIR *Ma* 35, NBAIR Bb45, NBAIR H38, *Pseudomonas* 1%, SpNPV, *Tc* cards alone recorded egg patches between 5.33 and 6.67/plot.

No.of damaged plants/plot:Significantly least number of damaged plants/plots were seen in *Bt* treated plots (37.89%) apart from chemical treated plots (33.62 %) and highest were seen in *Pseudomonas* (91.07%), *Tc* plots 89.93% and control plots (88.93%) (73.66 MRC). Damage in all other treatments recorded was between 63.38% - 91.07 %.

No.of dead larvae/plot:*Bt* (8.0/plot) and chemical treated plots (8.67/plot) recorded significantly highest no. of dead larvae, while *Trichogramma* 1.30)and control plot (1.30) recorded minimum dead larvae.No.of dead larvae in other treatments ranged between 1.33 and 7.67.

No.of predators/plot:Was maximum in *Tc* released plots (59.00), pheromone plots (59.33) and control plots (61.67), while minimum were seen in chemical treated plots (12.67). In the other treatments, it was between 25.00 and 29.33/plot.

Egg parasitisation (%):Was highest in *Tc* released plots (44.43%) and control plot (47.50%) and these were on par with each other. Least was seen the chemical treated plot (7.21%).It was between 25.60 and 34.07 % in other treatments.

Larval parasitisation (%): Was significantly highest in *Tc* released plots (11.24%) andsignificantly least in chemical treated plots (5.08%). In other treatments it was between 5.23% and 10.50%.

Yield: Significantly highest yield was seen in Trichocards + *Bt* treated plots (29.27q/a) and apart from chemical treated plots (29.33 q/a) and least was seen in control plots (11.71 q/a). In other treatments yield ranged between 12.65 and 19.69 q/acre(Table 111).

Table 111. Data on FAW attributes of pheromone traps recorded in Maize research station

Treatments	Egg patches/ plot	% damaged plants/plot	No.of dead larvae/plot	No.of predators/plot	Egg parasitisation (%)	Larval parasitisation (%)	Yield (q/acre)	t_{obs}
T8 Pheromone traps 15/acre	2.33	36.74	1.30	59.33	47.50	10.83	28.90	0.73*
Control	9.92	73.66	2.30	43.55	56.78	15.68	15.45	

Treatments	Observations on FAW (mean of five counts)						Yield (q/acre)
	Mean Egg patches/plot	% damaged plants/plot	No. of dead larvae/plot	No. of predators/plot	Egg parasitisation (%)	Larval parasitisation (%)	
T1-*Tc* cards + NBAIR *Bt 2%* @2ml/L	5.33 (2.31)[c]	37.89 (37.62)[a]	8.0 (2.90)[a]	26.67 (5.21)[b]	33.43 (35.30)[b]	6.73 (15.03) [abcd]	29.27[a]
T2-*Tc* cards + NBAIR *Ma* 35 @5ml/L	5.67 (2.38)[bc]	63.38 (53.22)[b]	6.33 (2.61)[ab]	29.33 (5.46)[b]	28.17 (32.05)[bc]	7.38 (15.62)[abcd]	13.01[bc]
T3-*Tc* cards + NBAIR *Bb* 45	6.33 (2.52)[bc]	73.70 (60.53)[bc]	6.33 (2.61)[ab]	25.00 (5.05)[b]	25.60 (30.36)[c]	6.17 (14.28) [cd]	14.10[bc]
T4-*Tc* cards + NBAIR H38 whorl application @4kg/acre	6.33 (2.52)[bc]	83.33 (68.97)[cd]	1.33 (1.34)[c]	26.00 (5.15)[b]	32.83 (34.95)[b]	9.03 (17.42)[abc]	18.95[abc]
T5-*Tc* cards + *Pf* @20g/L	6.33 (2.52)[bc]	91.07 (73.87)[d]	5.0 (2.29)[b]	28.33 (5.36)[b]	31.83 (34.32)[b]	5.23 (13.14)[cd]	12.65[bc]
T6-*Tc* cards + NBAIR *1 Sp*NPV @2ml/l	6.67 (2.58)[b]	84.91 (70.24)[cd]	7.67 (2.85)[ab]	26.00 (5.15)[b]	34.07 (35.68)[b]	6.51 (14.61)[bcd]	22.56[ab]
T7- *Tc* cards only	5.33 (2.31)[c]	89.93 (74.64)[d]	1.30 (0.71)[d]	59.00 (7.71)[c]	44.43 (41.80)[a]	11.24 (19.55)[a]	19.69[abc]
T9- Emamectin Benzoate @0.4g/L spray	2.33 (1.52)[a]	33.62 (33.56)[a]	8.67 (3.00)[d]	12.67 (3.62)[a]	7.21 (15.49)[d]	5.08 (12.45) [d]	29.33 [a]
T-10 Control	11.00 (3.31)[d]	88.83 (75.84)[d]	1.30 (0.71)[d]	61.67 (7.88)[c]	47.53 (43.58)[a]	10.50 (18.88)[ab]	11.71[c]

CD 0.05	0.24	11.79	0.57	0.42	3.71	4.52	10.47
CV	5.72	19.32	15.53	13.96	6.35	16.65	20.46

Table 112. Field trial on evaluation of bioagents against fall Armyworm in Maize

2.7.4. OUAT, Bhubaneswar

The experiment was conducted atOUAT, Bhubaneswar (var.Nilesh-51) during *rabi* 2020-21.The number of egg patches and larvae per 10 plants, plant damage due to fall army worm (FAW) and number of predators/10 plants were highest in untreated check and lowest in chemical control as compared to different bio-products. On the other hand, green cob yield was highest (15.80 t/ha) in chemical check and lowest (8.16t/ha) in untreated control. Among the tested bio-modules, trichocard releases+ *Bt* sprays expressed highest yield (14.40 t/ha) and lowest pest damage which is comparable to emamectin benzoate and closely followed by tricho card releases+*Metarhizium* sprays (Table 113).

Table 113. Bio-efficacy of bio-modules against fall army worm 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: *T. chilonis* 2 releases + Bt 2 sprays	2.27 (1.51)*	3.50(1.87)*	35.0	0.33 (0.57)*	14.40
T_2: *T. chilonis* 2 releases + *Metarhizium* 2 sprays	2.38 (1.54)	4.00(2.00)	47.3	0.34 (0.58)	12.60
T_3: *T. chilonis* 2 releases + *B.bassiana* 2 sprays	2.45(1.57)	3.90(1.97)	53.0	0.49(0.70)	12.32
T_4: *T. chilonis* 2 releases +2 sprays of EPN	2.57 (160)	4.80(2.19)	57.3	0.84 (0.91)	9.26
T_5: *T. chilonis* 2 releases +2 sprays of *Pseudomonas*	2.42 (1.55)	3.80(1.94)	50.7	0.43 (0.66)	12.92
T_6: *T. chilonis* 2 releases +2 sprays of SpfrNPV	2.47 (1.57)	4.40(2.10)	53.6	0.58 (0..76)	11.16
T_7: *T. chilonis*2 releases	2.46(1.57)	4.20(2.05)	52.0	0.55(0.74)	11.46
T_8: Pheromone traps @15 traps/ac	2.59(1.61)	4.60(2.13)	57.0	0.72 (0.84)	10.27
T_9: Emamectin benzoate @0.4g/l 2 sprays	2.09(1.45)	3.20(1.79)	32.4	0.21 (0.45)	15.80
T_{10}: Untreated check	3.10(1.76)	5.00(2.24)	63.0	0.97(0.98)	8.16
S.E. (m)±	0.04	0.06	2.71	0.034	0.65
C.D. 0.05	0.11	0.19	8.05	0.10	1.82

*Figure in parentheses are square root transformed values

2.7.5 CAU, Imphal

The experiment was conducted at CHF, Pasighat(var.Sona) during summer2021.Among different biocontrol agents tested, significantly lowest number of *S. frugiperda* larvae/ 10 plants (Table 114) was recorded in the treatment T1(1.85 larvae/10 plants) which was at par with the treatment T5(1.96 larvae/10 plants), T2 (2.05 larvae/10 plants) and T6 (2.11 larvae/10 plants). The next best treatments were T3(2.32larvae/10 plants) and T4 (2.44larvae/10 plants). With regard to the efficacy of biocontrol agents in reducing the plant damage (Table 115), lowest plant damage (%) was recorded in the treatment T1(15.19%) followed by T5 (16.08 %), T2 (17.77 %) and T6 (19.02 %). The untreated control treatment (T10) recorded the plant damage of 35.23 percent. The natural enemies (coccinellids, spiders and parasitoids) were found highest in untreated control T10 (3.65/10 plants) and lowest in emamectin benzoate (0.80/10 plants). However, maize treated with different biocontrol agents recorded the comparatively lower natural enemies in the range of 1.39 to 3.23/10 plants possibly due to lesser availability of host larvae after treatment imposition. With regard to yield of the crop, the treatments T9and T10 respectively recorded the highest (41.61 q/ha) and lowest (21.25 q/ha) grain yield. Among the bioagents, T1 documented with grain yield of 34.13 q per ha which was statistically at par with the T5 (33.80 q/ha) closely followed by T2 (32.88 q/ha) and T6 (32.22 q/ha).

The following three centres (AAU-Anand, MPKV and TNAU) have laid out the experiments with the set of treatments mentioned hereunder **Table 114.**

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* NBAII 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)

Table 115. Influence of different biocontrol agents on Fall armyworm incidence in maize

Treatments	Mean number of larvae per 10 plants										
	Before application	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	3.25 (1.94)*	2.51 (1.69)	2.35 (1.67)	2.43 (1.69)	1.81 (1.62)	1.79 (1.40)	1.80 (1.50)	1.35 (1.36)	1.28 (1.33)	1.32 (1.35)	1.85 (1.53)
T2	3.10 (1.90)	2.66 (1.76)	2.60 (1.76)	2.63 (1.75)	2.20 (1.63)	2.04 (1.59)	2.12 (1.62)	1.68 (1.48)	1.29 (1.34)	1.49 (1.41)	2.05 (1.60)
T3	2.98 (1.87)	2.88 (1.79)	2.68 (1.78)	2.78 (1.81)	2.42 (1.75)	2.24 (1.63)	2.33 (1.68)	1.98 (1.57)	1.72 (1.49)	1.85 (1.53)	2.32 (1.68)
T4	3.23 (1.93)	3.08 (1.90)	2.86 (1.83)	2.97 (1.84)	2.61 (1.77)	2.46 (1.72)	2.54 (1.73)	1.83 (1.53)	1.80 (1.51)	1.81 (1.52)	2.44 (1.70)
T5	3.16 (1.91)	2.65 (1.77)	2.49 (1.73)	2.57 (1.75)	2.19 (1.64)	1.84 (1.53)	2.02 (1.59)	1.40 (1.38)	1.19 (1.30)	1.30 (1.34)	1.96 (1.57)
T6	3.15 (1.91)	2.76 (1.81)	2.63 (1.77)	2.70 (1.79)	2.25 (1.66)	2.05 (1.60)	2.15 (1.63)	1.74 (1.50)	1.38 (1.37)	1.56 (1.44)	2.11 (1.62)
T7	3.05 (1.88)	3.15 (1.90)	2.82 (1.82)	2.99 (1.87)	2.65 (1.77)	2.56 (1.74)	2.60 (1.76)	2.15 (1.63)	2.02 (1.59)	2.09 (1.61)	2.56 (1.75)
T8	3.09 (1.89)	3.35 (1.97)	3.01 (1.87)	3.18 (1.92)	2.80 (1.82)	2.73 (1.79)	2.77 (1.81)	2.35 (1.69)	2.20 (1.64)	2.28 (1.67)	2.74 (1.80)
T9	3.04 (1.88)	1.67 (1.47)	1.64 (1.46)	1.66 (1.47)	1.21 (1.30)	1.01 (1.23)	1.11 (1.27)	0.66 (1.08)	0.66 (1.08)	0.66 (1.08)	1.14 (1.28)
T10	3.02 (1.88)	3.34 (1.95)	4.21 (2.02)	3.78 (2.02)	4.25 (2.02)	3.68 (2.02)	3.96 (2.10)	3.47 (1.98)	3.28 (1.93)	3.37 (1.97)	3.70 (2.04)
S.Em±	0.06	0.08	0.07	0.09	0.08	0.10	0.07	0.05	0.05	0.05	0.07
C.D. at 5 %	NS	0.23	0.22	0.28	0.24	0.29	0.22	0.15	0.16	0.15	0.20

* Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values, NS: Non significant DAS: Days After Spray

Table 116. Effect of different biocontrol agents on defoliation by Fall armyworm and grainyieldin maize

Treatments	Plant damage (%)											Grain yield (q/ha)
	Before application	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	25.78 (30.45)*	22.85 (28.53)	20.84 (27.13)	21.85 (27.78)	18.39 (25.28)	15.31 (22.93)	16.85 (24.10)	13.04 (20.95)	10.71 (18.98)	11.88 (20.01)	15.19 (22.86)	34.13
T2	28.30 (32.12)	23.84 (29.20)	22.26 (28.11)	23.05 (28.67)	20.00 (26.47)	18.41 (25.27)	19.21 (25.96)	15.78 (23.12)	14.02 (21.87)	14.90 (22.60)	17.77 (24.85)	32.88
T3	26.57 (30.99)	25.18 (30.11)	21.89 (27.82)	23.54 (29.01)	26.12 (19.47)	18.86 (25.63)	22.49 (28.27)	16.46 (23.68)	14.81 (23.68)	15.64 (23.15)	20.21 (26.58)	29.94
T4	23.85 (29.19)	22.89 (28.56)	21.09 (27.29)	21.99 (27.92)	20.79 (27.07)	25.39 (25.39)	23.09 (28.67)	17.38 (24.59)	16.86 (24.17)	17.12 (24.31)	21.10 (27.32)	28.18
T5	24.14 (29.36)	23.47 (28.95)	27.42 (21.29)	25.45 (30.24)	18.98 (25.76)	16.57 (23.95)	17.78 (24.90)	13.64 (21.59)	11.73 (19.85)	12.69 (20.75)	16.08 (23.53)	33.80
T6	24.50 (29.60)	22.49 (28.29)	27.90 (27.96)	25.20 (30.04)	20.91 (27.19)	19.22 (25.92)	20.07 (26.50)	17.68 (24.76)	16.19 (23.51)	16.94 (23.51)	19.02 (25.81)	32.22
T7	23.85 (29.20)	24.98 (29.95)	28.72 (28.16)	26.85 (31.16)	23.73 (29.09)	22.12 (28.02)	22.94 (28.55)	20.74 (27.74)	25.81 (25.81)	23.28 (28.80)	23.04 (28.64)	27.76
T8	26.06 (30.66)	24.31 (29.48)	28.89 (28.38)	26.60 (31.02)	28.15 (22.37)	21.12 (27.25)	24.64 (29.74)	19.69 (26.21)	24.57 (24.57)	22.13 (28.00)	23.80 (28.00)	26.70
T9	26.06 (30.69)	19.78 (26.36)	15.43 (23.05)	17.61 (24.76)	11.72 (19.88)	7.71 (15.82)	9.72 (17.93)	4.66 (12.39)	2.34 (12.39)	3.50 (10.62)	7.64 (15.88)	41.61
T10	26.31 (30.82)	30.78 (33.65)	38.54 (38.36)	34.66 (36.01)	39.92 (41.22)	41.99 (44.77)	34.66 (36.01)	38.18 (38.12)	34.57 (35.99)	36.38 (37.08)	35.23 (36.39)	21.25
S.Em±	0.11	1.14	1.49	1.54	1.75	1.77	1.74	2.07	1.76	1.83	1.48	0.21
C.D. at 5 %	NS	3.39	4.44	4.57	5.21	5.26	5.18	6.15	5.22	5.43	4.39	0.61

*Figures in the parentheses are arcsine transformed values, NS: Non significant, DAS: Days after spray

2.7.6 AAU-Anand

The experiment was conducted at Agronomy farm, AAU, Anand (var.GAYMH-1).Among different biocontrol agents tested, significantly lowest number of *S. frugiperda* larvae/ 10 plants (Table 117) was recorded in the treatment T1 - (1.96 larvae/ 10 plants) which was at par with the treatment T5(2.39 larvae/10 plants). The next best treatment was T2(3.66 larvae/ 10 plants). With regard to the efficacy of biocontrol agents in reducing the plant damage (Table 118), lowest plant damage (%) was recorded in the treatment T1(9.27 %) which was followed by the treatment T2 (12.48 %). The untreated control treatment (T10) recorded the plant damage of 44.95 %. Similarly, the lowest cob damage (%) was recorded in the treatment T1(3.00 %) which was at par with the treatment T5(3.65 %) and T2(3.95 %). With regard to yield of the crop (Table 119**), the treatment T1 recorded the highest grain and fodder yield (3817 and 4778 kg/ha) which was at par with the treatment T5(3783, 4600 kg/ha) and T2(3770, 4570 kg/ha).

Table 117. ** Effectiveness of different biocontrol agents on yield in maize

Treatments		Yield (kg/ha)	
		Grain	Fodder
T1	*Trichogramma pretiosum* @ 1 card/ acre + *B. thuringiensis* - NBAIR BTG4 - 1% WP	3817	4778
T2	*T. pretiosum* @ 1 card/ acre + *Metarhizium anisopliae* - NBAIR Ma4 - 1% WP	3770	4570
T3	*T. pretiosum* @ 1 card/ acre + *Beauveria bassiana* - NBAIR Bb5a - 1% WP	2950	3417
T4	*T. pretiosum* @ 1 card/ acre + *Heterorhabdtis indica* NBAIR H38 -1.5% WP	2583	3260
T5	*T. pretiosum* @ 1 card/ acre + *Pseudomonas fluorescens* NBAIR P*f*DWD- 1% WP	3783	4600
T6	*T. pretiosum* @ 1 card/ acre + S*f* NPV – S*f* NBAIR – 1% AS	2817	3550
T7	*T. pretiosum* @ 1 card/ acre	2617	3350
T8	Pheromone trap S*fp*NBAIR @ 20/acre	2033	2517
T9	Emamectin benzoate 5 SG	4417	6383
T10	Untreated control	1567	1917
S. Em ±		142.34	211.83
C.D. at 5%		422.92	629.39
C. V. (%)		8.12	9.57

Table 118. Bio-efficacy of different biocontrol agents against fall army worm, *Spodoptera frugiperda* in maize

Treatments		No. of larvae/10 plants										
		Before application	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	*Trichogramma pretiosum* @ 1 card/ acre + *Bacillus thuringiensis* - NBAIR BTG4 - 1% WP	2.53 (5.90) *	2.11 (3.95)	1.86 (2.96)	1.99 (3.46)	1.56 (1.93)	1.34 (1.30)	1.45 (1.60)	1.34 (1.30)	1.23 (1.01)	1.28 (1.14)	1.57 (1.96)
T2	*T. pretiosum* @ 1 card/ acre + *Metarhizium anisopliae* - NBAIR Ma4 - 1% WP	2.61 (6.31)	2.20 (4.34)	2.12 (3.99)	2.16 (4.17)	2.12 (3.99)	2.04 (3.66)	2.08 (3.83)	1.95 (3.30)	1.84 (2.89)	1.90 (3.11)	2.04 (3.66)
T3	*T. pretiosum* @ 1 card/ acre + *Beauveria bassiana* - NBAIR Bb5a - 1% WP	2.54 (5.95)	2.35 (5.02)	2.41 (5.31)	2.38 (5.16)	2.47 (5.65)	2.40 (5.26)	2.44 (5.45)	2.27 (4.65)	2.20 (4.34)	2.23 (4.47)	2.35 (5.02)
T4	*T. pretiosum* @ 1 card/ acre + *Heterorhabdtis indica* NBAIR H38 - 1.5% WP	2.53 (5.90)	2.55 (6.00)	2.61 (6.31)	2.58 (6.16)	2.55 (6.00)	2.48 (5.65)	2.52 (5.85)	2.41 (5.31)	2.35 (5.02)	2.38 (5.16)	2.49 (5.70)
T5	*T. pretiosum* @ 1 card/ acre + *Pseudomonas fluorescens* NBAIR P*f*DWD- 1% WP	2.54 (5.95)	2.19 (4.30)	2.04 (3.66)	2.11 (3.95)	1.68 (2.32)	1.46 (1.63)	1.57 (1.96)	1.34 (1.30)	1.46 (1.63)	1.40 (1.46)	1.70 (2.39)
T6	*T. pretiosum* @ 1 card/ acre + S*f* NPV – S*f* NBAIR – 1% AS	2.68 (6.68)	2.41 (5.31)	2.41 (5.31)	2.41 (5.31)	2.48 (5.65)	2.48 (5.65)	2.484 (5.65)	2.34 (4.98)	2.26 (4.61)	2.30 (4.79)	2.40 (5.26)
T7	*T. pretiosum* @ 1 card/ acre	2.74 (7.01)	2.48 (5.65)	2.48 (5.65)	2.48 (5.65)	2.54 (6.31)	2.41 (5.31)	2.48 (5.65)	2.34 (4.98)	2.34 (4.98)	2.34 (4.98)	2.43 (5.40)
T8	Pheromone trap S*fp*NBAIR @ 20/acre	2.24 (4.52)	2.68 (6.68)	2.61 (6.31)	2.64 (6.47)	2.48 (5.65)	2.55 (6.00)	2.51 (5.80)	2.47 (5.60)	2.48 (5.65)	2.48 (5.65)	2.54 (5.95)
T9	Emamectin benzoate 5 SG	2.54 (5.95)	1.48 (1.69)	1.29 (1.16)	1.39 (1.43)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.93 (0.36)

T10	Untreated control	2.68 (6.68)	2.74 (7.01)	2.92 (8.02)	2.83 (7.51)	2.92 (8.03)	2.92 (8.03)	2.92 (8.03)	2.80 (7.34)	2.86 (7.68)	2.83 (7.51)	2.86 (7.68)
	S. Em ± Treatment (T)	0.15	0.15	0.11	0.10	0.09	0.09	0.06	0.09	0.13	0.08	0.05
	Period (P)	-	-	-	0.04	-	-	0.03	-	-	0.04	0.02
	Spray (S)	-	-	-	-	-	-	-	-	-	-	0.03
	T x P	-	-	-	0.14	-	-	0.09	-	-	0.11	0.07
	T x S	-	-	-	-	-	-	-	-	-	-	0.08
	S x P	-	-	-	-	-	-	-	-	-	-	0.04
	T x S x P	-	-	-	-	-	-	-	-	-	-	0.12
	C.D. at 5 % T	NS	0.45	0.34	0.28	0.28	0.26	0.18	0.27	0.37	0.22	0.13
	C. V. (%)	10.18	11.19	8.71	10.36	7.63	7.32	7.33	7.98	11.02	9.57	9.55

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, Sig.= Significant

Significant parameters and its interaction – S and TxS

Table 119. Influence of different biocontrol agents on plant and cob damage in maize												
Treatments	Plant damage (%)											Cob damage (%)
	Before application	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	28.78 (23.18)*	23.85 (16.35)	21.14 (13.01)	22.49 (14.63)	18.43 (9.99)	18.43 (9.99)	18.43 (9.99)	12.29 (4.53)	12.29 (4.53)	12.29 (4.53)	17.73 (9.27)	9.97 (3.00)
T2	26.57 (20.01)	23.85 (16.35)	23.85 (16.35)	23.85 (16.35)	23.84 (16.34)	21.14 (13.01)	22.49 (14.63)	21.14 (13.01)	18.43 (9.99)	19.78 (11.45)	22.04 (14.08)	11.47 (3.95)
T3	28.78 (23.18)	30.98 (26.50)	32.99 (29.65)	31.99 (28.07)	26.06 (19.30)	26.06 (19.30)	26.06 (19.30)	23.85 (16.35)	23.85 (16.35)	23.85 (16.35)	27.30 (21.04)	12.87 (4.96)
T4	33.21 (30.00)	33.20 (29.98)	39.22 (38.98)	36.21 (34.90)	30.98 (26.50)	30.98 (26.50)	30.98 (26.50)	30.98 (26.50)	28.77 (23.16)	29.88 (24.82)	32.36 (28.65)	15.31 (6.97)
T5	26.57 (20.01)	23.85 (16.35)	23.85 (16.35)	23.85 (16.35)	21.14 (13.01)	18.43 (9.99)	19.78 (11.45)	18.43 (9.99)	18.43 (9.99)	18.43 (9.99)	20.69 (12.48)	11.01 (3.65)
T6	28.78 (23.18)	30.98 (26.50)	32.99 (29.65)	31.99 (28.07)	26.55 (19.98)	26.06 (19.30)	26.31 (19.65)	26.55 (19.98)	23.85 (16.35)	25.20 (18.13)	27.83 (21.79)	12.87 (4.96)
T7	31.00 (26.53)	32.99 (29.65)	35.00 (32.90)	33.99 (31.25)	26.55 (19.98)	26.55 (19.98)	26.55 (19.98)	28.77 (23.16)	26.55 (19.98)	27.66 (21.55)	29.40 (24.10)	13.26 (5.26)
T8	33.21 (30.00)	35.20 (33.23)	41.14 (43.28)	38.17 (38.19)	30.98 (26.50)	33.20 (29.98)	32.09 (28.22)	33.20 (29.98)	28.77 (23.16)	30.98 (26.50)	33.75 (30.87)	17.11 (8.66)

T9	28.78 (23.18)	6.74 (1.38)	0.91 (0.03)	3.83 (0.45)	0.91 (0.03)	0.91 (0.03)	0.91 (0.03)	0.91 (0.03)	0.91 (0.03)	0.91 (0.03)	1.88 (0.11)	7.33 (1.63)
T10	35.22 (33.26)	44.98 (49.97)	44.98 (49.97)	44.98 (49.97)	41.14 (43.28)	41.14 (43.28)	41.14 (43.28)	41.14 (43.28)	39.22 (39.98)	40.18 (41.63)	42.10 (44.95)	20.83 (12.64)
S.Em± (T)	4.74	3.03	2.34	1.92	2.08	1.87	1.41	2.61	2.33	1.73	0.98	0.66
Period (P)	-	-	-	0.86	-	-	0.63	-	-	0.78	0.44	-
Spray (S)	-	-	-	-	-	-	-	-	-	-	0.54	-
T x P	-	-	-	2.72	-	-	1.98	-	-	2.45	1.39	-
T x S	-	-	-	-	-	-	-	-	-	-	1.70	-
S x P	-	-	-	-	-	-	-	-	-	-	0.76	-
T x S x P	-	-	-	-	-	-	-	-	-	-	2.40	-
C.D. at 5 % T	NS	9.01	6.96	5.49	6.18	5.56	4.01	7.76	6.93	4.96	2.75	1.96
C. V. (%)	12.43	18.31	13.71	16.16	14.61	13.33	14.06	19.08	18.28	18.54	16.33	8.66

Note: * Figures outside the parentheses are arcsine transformed values, those inside are retransformed values DAS= Days after spray Sig= Significant

Significant parameters and its interaction – S

2.7.7 MPKV, Pune

The experiment was carried out during 2021 at Research Farm, College of Agriculture, Pune with Panchganga variety. Results revealed, lowest (0.13) egg patches were observed in T2 (*T. pretiosum* 1 card (2 Rel.) +*M. anisopliae*Ma 35, 0.5%@ 2.0 g/l) and it is at par with T9 (Emamectin benzoate 0.4g/l), T4: *T. pretiosum* 1 card (2 Rel.)+EPN *H. indica* NBAIR H38 @ 4kg/acre, *T. pretiosum* 1 card (2 Rel.)+*Spfr*NPV(NBAIR1) 2-3 sprays @ 2ml/litre and T8 Pheromones traps @15 /acre recording egg patches of 0.15, 0.20, 0.20, 0.22 /10 plants /plot. The highest egg patches of 0.62 /10 plants /plot were observed in the untreated control (Table 120).

The lowest larval population (0.02) was observed in the T9treatment (Emamectin benzoate 0.4g/l) which was significantly superior over rest of the treatments. The next best treatment recording larval population of 0.22 larvae is observed in T4: *T. pretiosum* 1 card (2 Rel.)+EPN *H. indica* NBAIR H38 @ 4kg/acre. The highest larval count of 0.76 larvae /10 plants/plot was recorded in untreated control.

The lowest pooled mean per cent of plant damage/plot (2.22 %) was observed in the chemical treatment (Emamectin benzoate 0.4g/l) which was significantly superior over rest of the treatments including untreated control which recorded highest 75.56 % plant damage/plot. The next best treatment T4: *T. pretiosum* 1 card (2 Rel)+EPN *H. indica* NBAIR H38 @ 4kg/acre recorded lowest plant damage (22.22 %) and it is at par with treatment T1 : *T. pretiosum* 1 card 2 Rel.) + *Bt*25 2 % @ 2.0 ml/l and recorded plant damage (24.44 %) , T2: *T. pretiosum* 1 card (2 Rel)+*M. anisopliae*Ma 35, 0.5%@ 2.0 g/l (26.67%), T6: (*T. pretiosum* 1 card (2 Rel.)+*Spfr*NPV(NBAIR1) (27.78%) , T3 : *T. pretiosum* 1 card (2 Rel.)+*B. bassiana*-Bb 45, 0.5% @ 2.0 g/l (28.89 %)and T8: Pheromones traps @15 /acre. (30.00 %). Crop is yet to beharvested; hence, yield data is awaited.

Table 120. Effect of biocontrol agents against Fall armyworm in Maize during 2020-21

Treatment	Egg patches /10 plants/plot (Nos)			Mean	% egg parasitization		Mean	Larvae /10 plants/plot (Nos)				Mean
	Pre Count	Post count	Post count		Post count	Post count		Pre count	Post count 1st appln	Post count 2nd ppln	Post count 3rd appln	
T1: *T. pretiosum* 1 card (2Rel) + *Bt*25 2 % @ 2.0 ml/l.	0.37 [a] * (0.93)	0.30 [b] (0.89)	0.50 [c] (1.00)	0.40 [c] (0.95)	23.33 [a] ** 28.85)	17.86 [a] (20.48)	20.60 [a] (25.29)	0.20 [a] * (0.94)	0.27 [b] (0.87)	0.30 [b] (0.89)	0.17 [b] (0.82)	0.24 [b] (0.86)
T2: *T. pretiosum* 1 card (2Rel)+*M. anisopliae* Ma 35, 0.5%@ 2.0 g/l.	0.37 [a] (0.93)	0.13 [a] (0.79)	0.13 [a] (0.79)	0.13 [a] (0.80)	16.67 [a] (16.91)	20.00 [a] (22.10)	18.33 [a] (19.51)	0.23 [a] (0.98)	0.30 [b] (0.89)	0.37 [b] (0.93)	0.13 [a] (0.80)	0.27 [b] (0.87)
T3: *T. pretiosum* 1 card (2Rel)+*B,bassiana*-Bb 45, 0.5% @ 2.0 g/l	0.43 [a] (0.97)	0.30 [b] (0.89)	0.27 [b] (0.87)	0.28 [b] (0.88)	11.11 [a] (13.60)	19.44 [a] (22.70)	15.28 [a] (18.19)	0.30 [a] (1.04)	0.33 [b] (0.91)	0.33 [b] (0.91)	0.20 [b] (0.84)	0.29 [c] (0.89)
T4: *T. pretiosum* 1 card (2Rel)+EPN *H. indica* NBAIR H38 @ 4kg/acre.	0.30 [a] (0.89)	0.20 [a] (0.84)	0.20 [a] (0.84)	0.20 [a] (0.84)	16.67 [a] (16.91)	16.67 [a] (16.91)	16.67 [a] (16.91)	0.20 [a] (0.94)	0.20 [a] (0.83)	0.30 [b] (0.89)	0.17 [b] (0.81)	0.22 [b] (0.85)
T5: *T. pretiosum* 1 card (2Rel)+ *P. fluorescens (Pf DWD 2%)*@ 2ml/l.	0.50 [a] (1.0)	0.33 [b] (0.91)	0.27 [b] (0.87)	0.30 [b] (0.89)	19.44 [a] (22.70)	22.22 [a] (24.45)	20.83 [a] (23.59)	0.37 [a] (1.10)	0.37 [b] (0.93)	0.43 [b] (0.97)	0.33 (0.91)	0.41 [d] (0.95)
T6: *T. pretiosum* 1 card (2Rel)+*Spfr*NPV(NBAIR1) 2-3 sprays @ 2ml/litre	0.37 [a] (0.93)	0.20 [a] (0.84)	0.20 [a] (0.84)	0.20 [a] (0.84)	16.67 [a] (16.91)	16.67 [a] (16.91)	16.67 [a] (16.91)	0.33 [a] (1.08)	0.33 [b] (0.91)	0.40 [b] (0.95)	0.10 [a] (0.77)	0.28 [c] (0.88)
T7: *T. pretiosum* 1 card per acre alone (2 release).	0.50 [a] (1.00)	0.33 [b] (0.91)	0.33 [b] (0.91)	0.33 [b] (0.91)	16.67 [a] (20.96)	19.44 [a] (21.04)	18.06 [a] (21.83)	0.23 [a] (0.97)	0.33 [b] (0.91)	0.57 [c] (1.11)	0.37 [c] (0.93)	0.42 [c] (0.96)
T8:Pheromones traps @15 /acre.	0.33 [a] (0.91)	0.23 [b] (0.85)	0.20 [a] (0.84)	0.22 [a] (0.84)	11.11 [a] (13.66)	11.11 [a] (13.02)	11.11 [a] (13.66)	0.20 [a] (0.95)	0.20 [b] (0.84)	0.43 [c] (1.04)	0.27 [b] (0.87)	0.30 [c] (0.89)

T9: Chemical control (Emamectin benzoate .4g/l).	0.33 [a] (0.91)	0.20 [a] (0.84)	0.10 [a] (0.77)	0.15 [a] (0.81)	0.00 [a] (2.87)	0.00 [a] (2.87)	0.00 [a] (2.87)	0.20 [a] (0.94)	0.07 [a] (0.75)	0.00 [a] (0.71)	0.00 [a] (0.71)	0.02 [a] (0.72)
T10 :Untreated control	0.33 [a] (0.91)	0.53 [c] (1.02)	0.70 [d] (1.10)	0.62 [d] (1.06)	17.78 [a] (21.56)	15.59 [a] (17.78)	16.69 [a] (22.36)	0.20 [a] (0.94)	0.83 [c] (1.15)	0.97 [c] (1.13)	0.60 [c] (1.05)	0.76 [d] (1.12)
SE ±	0.11	0.03	0.02	0.02	10.81	10.57	7.53	0.06	0.03	0.04	0.02	0.03
CD at 5%	NS	0.08	0.07	0.05	N.S.	N.S.	N.S.	NS	0.08	0.12	0.06	0.07
CV (%)	6.57	5.44	4.57	4.78	27.60	25.80	27.81	10.14	5.38	7.60	4.23	4.98

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

Table 121. (Cont...) Effect of biocontrol agents against Fall armyworm in Maize during 2020-21

Treatment	Pre count	Damaged plants (%)/ plot			
		Post count 1st appln.	Post count 2nd appln	Post count 3rd appln	Mean
T_1: *T. pretiosum* 1 card (2Rel) + *Bt*25 2 % @ 2.0 ml/l.	20.00 [a] ** (25.00)	26.67 [b] (30.99)	30.00 [b] (33.21)	16.67 [b] (23.85)	24.44 [b] (29.47)
T_2: *T. pretiosum* 1 card (2Rel)+*M. anisopliae* Ma 35, 0.5%@ 2.0 g/l.	23.33 [a] (27.71)	30.00 [b] (33.00)	36.67 [b] (37.22)	13.33 [b] (17.71)	26.67 [b] (30.63)
T_3: *T. pretiosum* 1 card (2Rel)+*B,bassiana*-Bb 45, 0.5% @ 2.0 g/l	30.00 [a] (32.19)	33.33 [b] (35.26)	33.33 [b] (35.01)	20.00 [b] (26.56)	28.89 [b] (32.36)
T_4: *T. pretiosum* 1 card (2Rel)+EPN *H. indica* NBAIR H38 @ 4kg/acre.	20.00 [a] (25.00)	20.00 [a] (26.07)	30.00 [b] (33.00)	16.67 [b] (23.36)	22.22 [b] (27.96)
T_5: *T. pretiosum* 1 card (2Rel)+ *P. fluorescens (Pf DWD 2%)*@ 2ml/l.	36.67 [a] (36.41)	36.67 [b] (37.22)	43.33 [c] (42.82)	33.33 [c] (35.22)	41.11 [c] (39.87)

T_6: *T. pretiosum* 1 card (2Rel)+*Spfr*NPV(NBAIR1) 2-3 sprays @ 2ml/litre	33.33 [a] (33.08)	33.33 [b] (34.15)	40.00 [b] (39.23)	10.00 [b] (15.00)	27.78 [b] (30.98)
T_7: *T. pretiosum* 1 card per acre alone (2 release).	30.00 [a] (31.93)	33.33 [b] (35.01)	56.67 [c] (48.85)	36.67 [c] (37.22)	42.22 [c] (40.45)
T_8:Pheromones traps @15 /acre.	20.00 [a] (26.56)	20.00 [a] (26.56)	43.33 [c] (42.82)	26.67 [c] (30.99)	30.00 [b] (32.94)
T_9: Chemical control (Emamectin benzoate 0.4g/l).	20.00 [a] (25.00)	6.67 [a] (13.25)	0.00 [a] (2.87)	0.00 [a] (287)	2.22 [a] (6.90)
T_{10} :Untreated control	20.00 [a] (25.00)	83.33 [c] (73.41)	96.67 [d] (90.00)	60.00 [c] (50.77)	75.56 [d] (62.82)
SE ±	3.30	5.73	2.88	3.31	3.94
CD at 5%	NS	17.03	8.56	9.85	11.17
CV (%)	19.88	28.87	11.97	24.61	14.87

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

2.7.8 TNAU, Coimbatore

The experiment was carried out during 2020 in TNAU, Coimbatore(GPS:11.012778° N, 76.9415° E), with Co-6variety.Among the biocontrol agents, 43.62 per cent damaged plants was observed in *T. pretiosum*+ NBAIR Bt 2% followed by *T. pretiosum*+ *M. anisopliae* Ma (48.31%), *T. pretiosum*+ *B. bassiana* NBAIR -Bb 45 35 (50.78%), and *T. pretiosum*+EPN*H. indica* NBAIR H38 (52.71%) and *T. pretiosum*+Spfr NPV(NBAIR1) (53.96%) on 10th day after first spraying of entomopathogens and insecticide, while in insecticide treated plots 41.42 per cent damage was observed. Similar trend was observed on 10th day after second spraying. Numbers of larvae in different treatments ranged between 4.00 (*T. pretiosum*+ NBAIR *Bt* 2%) and 6.00 (*T. pretiosum*+*P. fluorescens (Pf DWD 1%)* in biocontrol treatments whereas in untreated control 7.00 numbers of larvae were observed on10th day after first spraying of entomopathogens and insecticide. A maximum of 33.33 per cent egg parasitisation by *Telenomus* sp. was observed in *T. pretiosum*+NBAIR *Bt* 2% and *T. pretiosum* alone. Tassel damage ranged between 20.33 and 23.33 per cent in different treatments. Yield was maximum (5310Kg/ha)in *T. pretiosum*+NBAIR Bt 2% plots followed by *T. pretiosum*+ *M. anisopliae* Ma35(5211Kg/ha) and these two treatments statistically on par with each other while in the insecticide treated plots the yield was 5561 Kg/ha

Table 122. Effect of biocontrol agents on natural enemies of fall armyworm and yield of maize

Treatments	*Egg parasitisation % (T*elenomus* sp.)	**Numbers of dead larvae /plot	**Numbers of coccinellid beetles /plot	*Tassel damage %	**Yield Kg/ha	CB ratio
	I Spray 10DAT	II Spray 10DAT	II Spray 10DAT			
T1 *T. pretiosum*+ NBAIR *Bt* 2%	33.33 (35.264)[a]	0.00 (0.71)[f]	2.33 (1.68)[b]	22.50 (28.31)	5310.00 (72.87) [ab]	1.92
T2 *T. pretiosum*+ *M.anisopliae* Ma 35	22.22 (28.131)[b]	1.00 (1.23)[c]	1.67 (1.47)[c]	21.50 (27.64)	5211.67 (72.19)[bc]	1.87
T3 *T. pretiosum*+ *Beauveria bassiana* NBAIR -Bb 45	0.00 (2.866)[e]	1.00 (1.225)[c]	2.67 (1.78)[a]	20.25 (26.92)	5043.33 (71.01) [cd]	1.78
T4 *T.pretiosum*+ EPN *H. indica* NBAIR H38	0.00 (2.866)[e]	2.00 (1.58)[a]	1.00 (1.226)[d]	21.76 (27.80)	5148.33 (71.75)[bc]	1.83
T5 *T. pretiosum*+*Pseudomonas*	14.29 (22.189)[c]	0.67 (1.08)[d]	1.00 (1.22)[d]	22.50 (28.31)	5001.67 (70.72)[cd]	1.75

fluorescens (Pf DWD 1%)						
T6 *T. pretiosum*+Spfr NPV(NBAIR1)	0.00 (2.866)[e]	1.67 (1.47)[b]	1.67 (1.47)[c]	23.25 (28.82)	5175.00 (71.93)[bc]	1.85
T7 *T. pretiosum* alone	33.33 (35.263)[a]	1.00 (1.23)[c]	1.67 (1.47)[c]	22.75 (28.48)	5081.67 (71.28)[bc]	1.79
T8 Pheromone traps	14.29 (22.192)[c]	0.33 (0.91)[e]	2.67 (1.78)[a]	21.50 (27.64)	5005.00 (70.75) [cd]	1.83
T9 Insecticide Emamectin benzoate	0.00 (2.866)[e]	1.67 (1.47)[b]	0.67 (1.08)[e]	22.50 (28.31)	5561.33 (74.58) [a]	2.06
T10 Control	3.33 (10.519)[d]	0.33 (0.91)[e]	2.33 (1.68)[b]	22.25 (28.14)	4837.50 (69.55) [d]	-
SEd	0.266	0.011	0.011	NS	0.822	-
CD(P=0.05)	0.558	0.023	0.024	NS	1.726	-

DAT – Days After Treatment

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

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

Values are mean of three replications

2.8 Evaluation of BIPM module for fall armyworm, *Spodoptera frugiperda*in maize ecosystem (UAS-Raichur)

The experiment was carried out during 2020 with the treatment details mentioned below with Syngenta NK 6240 hybrid.

T1: BIPM

• *Trichogramma preteosum*@ 1.0 lakh/ha at 10 and 20 DAS

• *Metarhizium rileyi*1×108 spores/g @ 2.0 gm/l at 30 DAS

• *Heterorhabditis indica* NBAIIH-138 @ 4 kg/acre at 40 and 50 DAS

T2: Farmers' practice

Application of Emamectin benzoate 5 SG @ 0.2 G/lit at 20, 30 and 40 DAS

T3: Control

Results revealed,one day before imposition of treatment, egg patches ranged from 2.06 to 2.24 egg patches per plant. Ten days after second release of the trichocards lowest egg patch of 1.06 per plant was noticed in BIPM while in FP and control it was 1.58 and 2.16 egg patches per plant. Ten days after treatment imposition lowest larval population of 0.12 larva per plant was noticed in FP which was followed by BIPM (0.84 larva/plant) while untreated control recorded 1.28 larvae per plant. Similar trend was noticed with plant damage where in FP recorded lowest plant damage of 6.14 per cent which was followed by BIPM (10.56 %) while untreated control recorded highest per cent plant damage of 15.50. Highest parasitisation of 26.50 per cent was noticed in BIPM while in FP it was 4.25

and untreated control recorded 6. 50 per cent. Similarly, highest per cent of mycosis was noticed in BIPM (18.50 %) which was followed by untreated control which recorded 4.75 per cent while FP recorded lowest of 1.50 per cent mycosis. Highest grain yield of 54.25 q/ha was noticed in FP and it was followed by BIPM (48.50 q/ha) while untreated control recorded lowest of 43.75 q/ha grain yield (Table 123).

Table 123. Evaluation of BIPM module for fall armyworm in maize ecosystem during 2020-21

Sl. No.	Treatment	Egg patches per plant (No.)*		Larvae per plant (No.) *		Damaged plant (%)#	Parasitisation (%)#	Mycosis (%)#	Grain yield (q/ha)
		IDBS	10 DAS	IDBS	10 DAS				
T_1	BIPM *T.preteosum* @ 2.5 lakh/ha @ 10 and 20 DAS *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) @ 30 DAS *H. indica* (ICAR-NBAIIH-138) @ 4 kg/acre at 40 and 50 DAS	2.10 (1.61)	1.06 (1.25)	1.28 (1.33)	0.84 (1.16)	10.56 (18.96)	26.50 (30.98)	18.50 (25.47)	48.50
T_2	F P Emamectin benzoate 5 SG @ 0.2 g/lit at 30 and 40 DAS	2.24 (1.66)	1.58 (1.49)	1.26 (1.33)	0.12 (0.78)	6.14 (14.35)	4.25 (11.90)	1.50 (7.04)	54.25
T_3	Untreated control	2.06 (1.60)	2.16 (1.63)	1.32 (1.35)	1.28 (1.33)	15.50 (23.18)	6.50 (14.77)	4.75 (12.59)	43.75
S Em±		0.08	0.03	0.16	0.05	0.11	0.38	0.53	0.71
CD (P=0.05)		NS	0.13	NS	0.16	0.34	1.15	1.61	2.15

*Figures in parentheses are square root transformed values

#Figures in parentheses are arcsine transformed values

2.9 Large scale demonstration of management of fall armyworm using biological control agents and biopesticides (ANGRAU, Anakapalle)

The experiment was undertaken with the treatment details mentioned hereunder

T1: *Trichogramma pretiosum* 3 cards (50,000 eggs per ha) 2 releases (first release after one week of sowing & second one after one week of first release) + NBAIR *Bt* @ 2g/lt(2-3 sprays depending on pest incidence, first spray after 20-25 days of sowing & then the next sprays at 10 days intervals)

T2: *Trichogramma pretiosum* 3 cards (50,000 eggs per ha) 2 releases (first release after one week of sowing & then second one after one week of first release) + *Metarhizium anisopliae* NBAIR -Ma 35 @ 5g/lt (2-3 sprays depending on pest incidence, first spray after 20-25 days of sowing & then the next sprays at 10 days intervals)

T3: *Trichogramma pretiosum* 3 cards (50,000 eggs per ha) 2 releases (first release after one week of sowing & then second one after one week of first release) + *Beauveria bassiana* NBAIR -Bb 45 @ 5g/lt (2-3 sprays depending on pest incidence, first spray after 20-25 days of sowing & then the next sprays at 10 days intervals)

T4: Insecticidal check: Spraying Azadirachtin 10000 ppm @ 2 ml/lt at 15 days after sowing + Chlorantraniliprole 18.5 SC@ 0.4 ml/lt at 25 days after sowing + Emamectin benzoate 5SD@ 0.4gm/lt at 35 days after sowing

Results revealed,maize fall armyworm damage was high in insecticidal sprays with Azadirachtin+ Chlorantraniliprole +Emamectin benzoate (13.02%) and low in T1- Two releases of *T. pretiosum* and two sprays with *Bt* (5.88%) followed by T2- Two releases of *T. pretiosum* and two sprays of *M. anisopliae*35 (7.57%) and T3- *T. pretiosum* and two sprays of *B.bassiana* 45 (7.76%) (Table 124). Yield data to be analysed.

Table 124. Large scale demonstration of Management of fall armyworm using biological control agents and Biopesticides

Treatment	Fall army worm incidence up to 60 DAS				Average
	Location: Chollangipeta, Vizianagaram dist		Location: Pidisila, Vizianagaram dist		
	Damaged plants /plot	Damage %	Damaged plants /plot	Damage %	Damage %
T1 :*T. pretiosum* release +*Bt* spray	12.0	5.33	13.2	6.42	5.88
T2 :*T. pretiosum* release + *M. anisopliae* sprays	15.37	6.83	18.5	8.31	7.57
T3 :*T. pretiosum* release + *B. bassiana* spray	15.57	6.92	19.03	8.6	7.76

T4: Insecticidal check 3 sprays Azadirachtin+ Chlorantraniliprole +Emamectin benzoate	21.38	12.5	21.38	13.53	13.02

2.10 Evaluation of BIPM module for fall armyworm, *Spodoptera frugiperda*in maize ecosystem (MPKV-Pune)

The experiment was carried out during 2021 at Research Farm, College of Agriculture, Pune with Panchganga variety. The treatment details as follows: **Table 125.**

T1: BIPM *Trichogramma pretiosum*@ 1.0 lakh/acre at 10 and 20 DAS *Metarhizium rileyi*1×108 spores/g @ 5 g /l at 30 DAS *Heterorhabditis indica* NBAIIH38 @ 4 kg/acre at 40 and 50 DAS T2: Farmers practice Application of Emamectin benzoate 5 SG @ 0.2 g/L at 10, 20, 30, 40 and 50 DAS
T3: Control

Results revealed, significant reduction in the egg patches was observed after first and second release of *T. pretiosum* treatments. The pooled mean of egg patches of FAW ranges from 0.18 to 0.58 egg patches /10 plants /plot. The lowest (0.18) egg patches/10 plants/plot was observed in farmers practice (i.e application of Emamectin benzoate 5 SG @ 0.4 g/L at 10, 20, 30, 40 and 50 DAS) which was at par with BIPM treatment (*T. pretiosum*@ 1.0 lakh/acre at 10 and 20 DAS, *M. rileyi*1×10^{8} spores/g @ 5 g /l at 30 DAS, *H. indica* NBAIIH38 @ 4 kg/acre at 40 and 50 DAS) and recorded 0.26 / egg patches/10 plants/plot, whereas untreated control recorded 0.54 egg patches/10 plants/plot (Table 126).

In terms of plant damage, mean per cent plant damage/ plot varied from 0.83 % to 80.00 %. The lowest pooled mean plant damage (0.83%) /plot was observed in farmers practice treatment followed by BIPM treatments *viz.*, *T. pretiosum*@ 1.0 lakh/acre at 10 and 20 DAS, *M. rileyi*1×10^{8}spores/g @ 2.0 gm/l at 30 DAS and *H. indica* NBAIIH38 @ 4 kg/acre at 40 and 50 DAS with 34.55 % damaged plants/plot as against untreated control with 80.00 % damaged plants/plot (Table 127). Crop is yet to be harvested; hence, yield data is awaited.

Table 126. (contd.) Effect of BIPM treatment on fall armyworm in maize during 2020-21

Treatment	Damaged plants (%)/ plot				Mean
	Pre count	Post count 1stappln.	Post count 2nd appln.	Post count 3rd appln.	
T1:BIPM *T. pretiosum*@ 1.0 lakh/acre at 10 and 20 DAS *M. rileyi*1×10^8 spores/g @ 2.0 gm/l at 30 DAS *H. indica* NBAIIH38 @ 4 kg/acre at 40 and 50 DAS	30.00 ^{a} **(33.15)	40.00 ^{b} (39.20)	35.00 ^{b} (36.22)	28.75 ^{b} (32.14)	34.55 ^{b} (35.96)
T2:Farmers practice Application of emamectin benzoate 5 SG @ 0.2 g/L at 10, 20, 30, 40 DAS and 50 DAS	21.25 ^{a} (26.95)	2.50 ^{a} (6.76)	0.00 ^{a} (2.87)	0.00 ^{a} (2.87)	0.83 ^{a} (4.94)
T3:Untreated control	33.75 ^{a} (34.99)	82.50 ^{c} (65.65)	95.00 ^{c} (83.54)	62.50 ^{c} (52.31)	80.00 ^{c} (64.86)
SE ±	2.28	1.85	2.82	1.73	2.18
CD at 5%	NS	5.62	8.56	5.24	6.22
CV (%)	15.24	10.57	14.64	12.59	17.48

Table 127. Effect of BIPM treatment on fall armyworm in maize during 2020-21

Treatment	Egg patches /10 plants/plot (Nos)			Mean	Larvae /10 plants/plot (Nos)				Mean
	Pre count	Post count	Post count		Pre count	Post count 1st appln.	Post count 2nd appln.	Post count 3rd appln.	
T1:BIPM *T. pretiosum* @ 1.0 lakh/acre at 10 and 20 DAS *M. rileyi* 1×10^8 spores/g @ 2.0 gm/l at 30 DAS *H. indica* NBAIIH38 @ 4 kg/acre at 40 and 50 DAS	0.28 [a] * (0.63)	0.21 [a] (0.84)	0.30 [b] (0.89)	0.26 [a] (0.87)	0.30 [a] * (0.76)	0.40 [b] (0.95)	0.35 [b] (0.92)	0.29 [b] (0.89)	0.35 [b] (0.92)
T2:Farmers practice Application of emamectin benzoate 5 SG @ 0.2 g/L at 10, 20, 30, 40 DAS and 50 DAS	0.21 [a] (0.75)	0.19 [a] (0.83)	0.16 [a] (0.81)	0.18 [a] (0.82)	0.21 [a] (0.84)	0.03 [a] (0.73)	0.00 [a] (0.71)	0.00 [a] (0.71)	0.01 [a] (0.71)
T3:Untreated control	0.30 [a] (0.82)	0.45 [b] (0.97)	0.71 [c] (1.04)	0.58 [b] (1.04)	0.34 [a] (0.91)	0.83 [c] (1.15)	0.95 [c] (1.20)	0.63 [c] (1.06)	0.88 [c] (1.17)
SE ±	0.13	0.02	0.02	0.04	0.05	0.01	0.01	0.01	0.013
CD at 5%	NS	0.06	0.07	0.12	NS	0.03	0.04	0.05	0.036
CV (%)	11.53	6.31	6.97	6.31	16.26	2.90	3.64	3.56	3.81

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

2.11. Evaluation of NIPHM white media for production of *Nomuraea rileyi (Metarhizium rileyi)* NIPHM MRF-1 strain for management of maize fall armyworm (*Spodoptera frugiperda*) (NIPHM, Hyderabad)

Forproduction of *Metarhizium rileyi* two media viz. NIPHM White media and broken rice were used. To standardize the production technology, the media under test were made into six treatments, broken rice (without yeast extract), broken rice (with yeast extract), 1% NIPHM white media, 2% NIPHM white media, 3% NIPHM white media, 4% NIPHM white media and for each treatment two replications were maintained.

Among the different media tested frequent contamination and very slow growth rate of *M. rileyi* was observed in broken rice media. The growth of *M. rileyi* was comparatively good in case of 2% NIPHM white media. The quality of the fungus was tested for the 2% NIPHM white mediaand it was found that the quality of *M. rileyi* was six times (6 x10^8) higher than the standard (1x10^8). The laboratory bioassay on *S. frugiperda* with 2% NIPHM white media is under progress.

3. SORGHUM, FINGER, BARNYARD, FOXTAIL MILLETS

Evaluation of entomopathogenic fungi formulations against millet borers in finger millet, *kharif*2020 (IIMR, Hyderabad)

Three each isolates of *Beauveria bassiana* (Bb 5a, Bb 23 and Bb 45), three isolate of *Metarhizium anisopliae* (Ma 4, Ma 6 and Ma 35) were evaluated for their efficacy against pink borer of finger millet (*Sesamia inferens*) during *Kharif* 2020 at ICAR-IIMR, Hyderabad. The spray treatments were imposed twice at 20 and 40 DAE of the crop. The parameters wise observation recorded from the trial was enumerated hereunder.

Deadhearts (DH):There were significant differences in the treatments in terms of deadhearts (DH) by 40 DAE of crop. The DH caused in finger millet due to pink borer were significantly least in T4 (3.01%) and it was on par with T3 (3.74%) and statistically on par with application of Fipronil 3G @ 17.5 kg /ha) at sowing + whorl application of Fipronil 3G @ 7.5 kg at 30 DAE(2.95%). There was 67.5 and 59.7 % reduction in DH over the control in T4 and T3, respectively while T7(Application of Fipronil) resulted in 68.0% reduction in deadhearts over the untreated control(Table 128)

White earheads (WEH): White ear heads caused in finger millet were recorded at harvest. WEH were least in T7 (Application of Fipronil) (2.53 %) and it was statistically on par with T2, T3, T4, T5, T6. There were over 70% reduction in WEH over the control in T4 and T3, while application of Fipronil 3G @ 17.5 kg /ha) at sowing + whorl application of Fipronil 3G @ 7.5 kg at 30 DAEresulted in 73.8% reduction in WEH over the untreated control (Table 128).

Grain yield (Kg/plot):Highest grain yield was obtained in T4 (3.790 kg/plot) which was on par with T2 (3.557kg/plot) and T3 (3.653kg/plot). There was 47.6 % and 42.3% increase in grain yield over the control in T4 and T2. Soil application of application of Fipronil 3G @ 17.5 kg /ha) at sowing + whorl application of Fipronil3G @ 7.5 kg at 30 DAEresulted in 49.2% increase in yield over the 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 application of Fipronil 3G @ 17.5 kg /ha) at sowing + whorl application of Fipronil 3G @ 7.5 kg at 30 DAE.

Table 128. Evaluation of entomofungal formulations against pink borer infinger millet during *kharif* 2020

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	8.65	5.42c	41.5	7.82	3.85bc	60.1	3.237b	26.1
T2	Bb-23 @ 10 ml /lt	8.42	5.26c	43.3	8.24	3.19abc	67.0	3.557ab	38.6
T3	Bb-45 @ 10 ml /lt	8.35	3.74ab	59.7	8.52	2.89abc	70.1	3.653ab	42.3
T4	Ma-35 @10 ml /lt	8.46	3.01a	67.5	7.91	2.90abc	70.0	3.790a	47.6
T5	Ma 4 @10 ml /lt	8.52	4.27b	53.9	7.77	3.36abc	65.2	3.200b	24.7
T6	Ma 6 @10 ml /lt	8.48	3.93b	57.6	7.84	3.16abc	67.3	3.183b	24.0
T7	Fipronil 3G @ 17.5 kg /ha) at sowing + whorl application of Fipronil 3G @ 7.5 kg at 30 DAE	8.61	2.95a	68.2	8.17	2.53a	73.8	3.830a	49.2
T8	Untreated/Control	8.48	9.27d	-	8.53	9.66d		2.567	-
	Mean	8.49	4.73		8.10	3.94		3.352	
	CD (0.05)	NS	0.81		NS	1.00		3.377	
	CV (%)	4.46	12.60		6.40	14.40		8.76	

PULSES

GREENGRAM

4.1 Integration of botanicals, microbials and insecticide spray schedule for the management of pod borer complex in Greengram

4.1.1 ANGRAU, Anakapalle:

Treatments comprising integration of botanicals/microbials and insecticides were evaluated against pod borer complex in green gram during 2020-21. Two sprays were given at pod formation stage at 15 days interval. Treatment details has been given below:

T1: *Bacillus thuringiensis* @ 1.25 l/ha + Azadirachtin 1 % @ 1.25 l/ha

T2: *Bacillus thuringiensis* @ 1.25 l/ha + *Bacillus thuringiensis* @ 1.25 l/ha

T3: *Bacillus thuringiensis* @ 1.25 l/ha + Spinosad 45 SC@ 150 ml/ha

T4: Azadirachtin 1% @ 1.25 l/ha +*Bacillus thuringiensis* @ 1.25 l/ha

T5:Azadirachtin 1% @ 1.25 l/ha + Azadirachtin 1 % @ 1.25 l/ha

T6: Azadirachtin 1% @ 1.25 l/ha + Spinosad 45 SC@ 150 ml/ha

T7: Spinosad 45 SC@ 150 ml/ha + Azadirachtin 1 % @ 1.25 l/ha

T8: Spinosad 45 SC@ 150 ml/ha + *Bacillus thuringiensis* @ 1.25 l/ha

T9: Chlorantaniliprole 18.5 SC@ 150 ml/ha + Spinosad 45 SC@ 150 ml/ha

T10: Untreated Control

Results:Experimental results indicated that leaf webs per plant was negligible in all the treatments except in untreated control (2.46 %). Lowest pod damage was observed in T9- Spinosad two sprays (1.02%) followed by T7-Spinosad+ Azadirachtin (1.73%), T8 – spinosad + *Bt*(2.65%), T1 – *Bt* + Azadiractin (4.82%) and T2 - Bt two sprays (5.84%). Highest pod damage was observedin control (52.14%). Highest grain yield was recorded in T3 – *B*t+ spinosad (5.51 q/ha) followed by T4 – Azadirachtin + *Bt* (5.38 q/ha) and T2 - *Bt* two sprays (5.33 q/ha).

Table 129. Integration of botanicals / microbials and insecticide spray schedule for the management of pod borer complex in Greengram

Treatment	Leaf webs /plant#	Total pods /plant	Damaged pods /plants	% Pod damage*	Grain Yield q/ha
T1- *Bt* + Azadirachtin	0.2 (0.078)	14.5	0.7	4.82 (12.06)	5.26
T2-*Bt* + *Bt*	0.2 (0.075)	13.7	0.8	5.84 (18.44)	5.33
T3-*Bt* + Spinosad	0.16 (0.026)	12.96	0.83	6.4 (14.14)	5.51
T4- Azadirachtin+ *Bt*	0.0 (0.0)	13.43	1.06	7.89 (16.26)	5.38

T5-Azadiractin + Azadirachtin	0.3 (0.014)	12.8	1.4	10.93 (18.19)	5.14
T6-Azadirachtin + Spinosad	0.6 (0.026)	13.96	1.3	9.31 (13.59)	5.24
T7-Spinosad+ Azadirachtin	0.1 (0.04)	13.23	0.23	1.73 (7.29)	5.32
T8-Spinosad + *Bt*	0.0 (0.0)	15.06	0.4	2.65 (9.10)	5.25
T9-Spinosad +Spinosad	0.0 (0.0)	15.63	0.16	1.02 (5.83)	5.27
T10-Control	2.46 (0.613)	8.63	4.5	52.14 (46.66)	3.05
CD(0.05)	0.072	2.46	0.85	8.11	0.104
CV%	48.2	10.75	43.47	29.27	5.645

Bt : *Bacillus thuringiensis*

#Values in parenthesis are logarithmic transformed values

* Values in parenthesis are arc sin transformed values

5. Biological Control Cowpea Pests

5.1 Evaluation of entomopathogenic biopesticide against *Aphis craccivora*in cowpea (*Vigna unguiculata*)

5.1.1 AAU Jorhat:

Experimental details:

Target pests: *Aphis craccivora*

Location: Experimental farm, Dept.of Horticulture

Season: *Kharif*, 2020

Date of Sowing: 11.08.2020

Variety: Green Fall (Yard long bean)

Plot size: 3m×3.5m

Experiment design:4RBD

Treatment details:

T_1 :*Beauveria bassiana*1×10^8cfu/ml@5gm/lit

T_2 :*Metarhizium anisopliae*1×10^8cfu@5gm/lit

T_3 :*Verticilium lecanii*1×10^8cfu/ml@5gm/lit.

T_4 :Spinosad 45SC@0.3ml/lit.

T_5 :Malathion 50EC@2ml/lit (standardcheck)

T_6 :Untreated control

Observations on aphid population were recorded on five randomly selected plants (terminal shoots) for each plot before as well as 3, 7 day and 10 days after each treatment. Three rounds of spray was made.The firsts pray was applied on the basis of initial occurrence of aphid and rest was based on abundance of pests.

Table 130. Bio efficacy of microbial agents against cowpea aphid, *A. craccivora*

Treatments	Pre treatment count	Post treatment count *				Reduction over control (%)	Yield (Qtl/ha)
		Ist spray	IInd spray	IIIrd spray	Mean of 3 sprays		
T_1	25.64	16.84	12.25	7.92	12.34[a]	43.83	34.53 [c]
T_2	26.13	22.17	15.42	10.33	15.97 [b]	27.31	30.08 [d]
T_3	27.63	15.49	10.34	7.17	11.00 [a]	49.93	38.68 [a]
T_4	26.35	15.41	11.58	8.33	11.78 [a]	46.38	36.48 [c]
T_5	27.10	15.25	11.75	8.67	11.89 [a]	45.88	33.13 [b]
T_6	27.55	23.33	23.17	19.42	21.97 [c]		26.80 [e]
CD =0.05	NS	3.28	1.81	1.14	1.43		1.67
CV %		12.03	8.51	7.36	6.70		3.33

Mean of three observations

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

Results: Results exhibited that the mean number of *A. craccivora* per terminal shoots of cowpea was significantly lower in the untreated control plot. However, minimum number of *A. craccivora* (11.00/ terminal shoots) was recorded in the T3 (*Verticilium lecanii*1×10^{8}cfu/ml@5gm/lit) and T4 (spinosad 45 SC @ 0.3 ml/lit) (11.78/ terminal shoot) with a yield of 38.68 and 36.48 q/ha, respectively followed by *Beauveria bassiana* and chemical control plot (malathion 50 EC @2ml/lit). It was observed that all the tested microbial agents were equally effective in their efficacies in suppressing the *A. craccivora* .

Fig:35. View of Experimental plot of Cowpea

5.1.2 KAU Thrissur:

Field evaluation of ICAR-NBAIR strains of entomopathogenic fungi (*Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium lecanii*) against cowpea aphid (*Aphis* *craccivora*) was carried out at College of Agriculture, Vellanikkara from October 2020 to January 2021. However, the experiment couldn't be completed as per the technical programme due to the delayed incidence of aphids as well as due to unseasonal rains. The experiment is being repeated in 2021-22.

Fig:36. Experimental plot for evaluation of entomopathogenic fungi against cowpea aphid at CoA, Vellanikkara

5.1.3 MPKV, Pune:

The experiment was laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. The cowpea *var*. "Phule Vithai" was sown on 10.7.2020, but germination was hampered up to 50 to 60% and therefore resowing of crop was done on 25.7.2020. However, germination was still hampered and hence third time resowing of cowpea was done on 5.8.2020 in plot size 4.5 x 3.0 m with 45 x 10 cm spacing in Randomized Block Design with five treatments replicated four times. However, cowpea aphid (*Aphis craccivora*) population was below ETL (20 aphids /2.5 cm shoot length) in early stage of crop due to intermittent rains and hence, result could not be derived and trial is vitiated. The experiment will be repeated during 2021-22.

5.2 Evaluation of oil formulation of *Lecanicillium* spp. against sucking pests of cowpea

5.2.1 KAU Vellayani

The experiment was carried out during September 2020 to November 2020 at Aralummoodu, under Balaramapuram Krishi bhavan in an area of 50 cents(0.2ha) using hybrid cowpea variety Polo Experiment was laid out in RBD with 6 treatments replicated thrice. Unit plot size was 10 x 10 $m^{2.}$ Treatments evaluated werechitin enriched oil formulation of *L. lecanii*Vl 8 (NBAIR isolate), Chitin enriched oil formulation of *L. saksenae*(KAU isolate), Spore suspension of *L.lecanii* Vl 8 (NBAIR isolate), Spore suspension of *L. saksenae* (KAU isolate), Thiamethoxam 25 WDG 2g/10L and Untreated check.

Fig:37. Experimental plot- Spraying of biopesticides

Analysis of data (Table131) revealed that, after the first spraying, three days after treatment, chitin enriched oil formulation 10 ml/L of *L. saksenae* and its spore suspension 10^7 spores mL^{-1}were equally effective in managing pod bugs with a mean population of 0.5 bugs per plot. The corresponding population in *L. lecanii* treated plot was 2.5 with oil formulation and 1.0 in spore suspension treatment, which were on par with thiamethoxam treatment. The population in untreated plot was 1.5 bugs per plot. Though all the treatment were found to be ineffective after 3rd day of third spraying, on the 7th day *L. saksenae*oilformulationwas the superior treatment for pod bugs where the bugs were totally absent. The corresponding population in *L. lecanii* treatment was 1.25 with oil formulation and 1.0with spore suspension, the former being on par with that of untreated control.

Table 131. Effect of improved formulations of *Lecanicillium* spp. in the management of *Riptortus pedestris* in cowpea

Treatments	Population of podbug/ plot						
	Pre Count	First spray		Second spray		Third spray	
		3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
T1- Chitin enriched oil formulation of *L.lecanii* Vl8 (NBAIR isolate)	2.5 (1.71)	2.5^{a} (1.71)	2 (1.56)	1.5^{a} (1.40)	1.5 (1.34)	1.25 (1.31)	1.25^{ab} (1.27)
T2- Chitin enriched oil formulation of *L.saksenae* (KAU isolate)	1.25 (1.31)	0.5^{c} (0.96)	1.25 (1.31)	1.25^{a} (1.31)	0.75 (1.05)	0.5 (0.96)	0^{c} (0.70)
T3- Spore suspension of *L.lecanii* Vl8 (NBAIR isolate)	1.25 (1.31)	1.0^{bc} (1.22)	1.5 (1.36)	1.5^{a} (1.40)	1.25 (1.27)	1.25 (1.25)	1.0^{ab} (1.18)
T4- Spore suspension of *L.saksenae* (KAU isolate)	2 (1.56)	0.5^{c} (0.96)	0.5 (0.96)	1^{a} (1.22)	0 (0.70)	0.5 (0.96)	0.5^{bc} (0.96)
T5-Thiamethoxam 25 WDG 2gm/10L	1.25 (1.31)	1^{bc} (1.22)	1.0 (1.22)	0.5^{b} (0.96)	0.75 (1.05)	0.75 (1.05)	0.75^{ab} (1.09)
T6- Untreated check	1.5 (1.34)	1.5^{b} (1.40)	1.5 (1.36)	1.5^{a} (1.40)	1.5 (1.40)	1.25 (1.31)	1.25^{a} (1.31)

CD (0.05%)	NS	(0.29)	NS	(9.30)	NS	NS	(0.32)
CV	18.01	15.78	20.50	0.18	26.70	24.96	19.72

DAS – Days after spraying; Figures in parantheses are square root transformed values

Table 132. Natural enemy population after treatment with *Lecanicillium* spp and their formulations

Treatments	Population of natural enemies/plot						
	Pre Count	First spray		Second spray		Third spray	
		3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
T1- Chitin enriched oil formulation of *L.lecanii* Vl8 (NBAIR isolate)	1.00 (1.18)	1.5 (1.40)	1.5 (1.40)	1.75 (1.31)	3.5 (1.99)	4.5 (2.11)	6.00 (2.44)
T2- Chitin enriched oil formulation of *L.saksenae* (KAU isolate)	1.00 (1.18)	1.75 (1.49)	1.75 (1.49)	2.00 (1.39)	3.25 (1.93)	4.00 (1.99)	6.00 (2.44)
T3- Spore suspension of *L.lecanii* Vl8(NBAIR isolate)	1.50 (1.40)	1.5 (1.40)	1.75 (1.49)	2.25 (1.49)	3.25 (1.93)	4.5 (2.11)	5.75 (2.39)
T4- Spore suspension of *L.saksenae* (KAU isolate)	1.00 (1.18)	1.75 (1.47)	2.00 (1.58)	2.25 (1.49)	3.25 (1.92)	4.25 (2.05)	6.5 (2.54)
T5-Thiamethoxam 25 WDG 2gm/10L	0.5 (0.96)	0.75 (1.05)	1.00 (1.18)	1.75 (1.31)	2.75 (1.79)	4.00 (1.98)	5.75 (2.39)
T6- Untreated check	1.25 (1.31)	1.5 (1.40)	1.5 (1.38)	1.75 (1.31)	2.75 (1.70)	4.00 (1.99)	5.75 (2.39)
CD@ 5%	NS	NS	NS	NS	NS	NS	NS
CV	23.70	20.99	17.40	15.53	16.82	8.70	5.40

Natural enemy population (Table133) assessed over the experimental period revealed that treatment with biopesticides did not have any adverse effect on their population. The increase in population observed at the end of the experiment may be attributed to the population of pollinator cum predators (vasps)

Table 133. Yield data of plots treated with *Lecanicillium* spp. and their formulations

Treatments	Yield/plot (kg)	Yield increase %
T1- Chitin enriched oil formulation of *L.lecanii* Vl8 (NBAIR isolate)	30.08	3.36
T2- Chitin enriched oil formulation of *L.saksenae*(KAUisolate)	31.12	6.94

T3- Spore suspension of *L.lecanii* Vl8(NBAIR isolate)	29.02	0.27
T4- Spore suspension of *L.saksenae* (KAU isolate)	30.70	5.39
T5-Thiamethoxam 25 WDG 2gm/10L	30.56	5.01
T6- Untreated check	29.10	-
CD (0.05)	NS	

The yield data recorded throughout the harvesting period also confirmed the superiority of oil based *L .saksenae* in managing *R. pedestris*. Except for *L. lecanii* spore suspension, there was increase in yield varying from 0.27 % to 3.36 %.

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

5.3.1 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 2020 to May 2020 as per the technical programme given below. The incidence of pod bug was too low in the experimental plot. The experiment is being repeated.

Design: RBD Variety: Anaswara

Treatments: 4 Replications: 5

Treatments:

T1: *Beauveria bassiana* (NBAIR strain) 10^8 spores/ml at 10 days interval

T2: *Metarhizium anisopliae* (NBAIR strain) 10^8 spores/ml at 10 days interval

T3: Malathion 500 g a.i ha^{-1} at 10 days interval

T4: Untreated control

Fig:38. Experimental plot for evaluation of entomopathogenic fungi against pod bug

6. Biological Control Chickpea Pests

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

6.1.1 MPKV, Pune:

The experiment was laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. The chickpea*var*. "Phule Vijay" is sown on 14.12.2020 in 3 x 3 m plot size with 30 x 10 cm spacing in Randomized Block Design with five treatments replicated four times. Two applications of sprays were given on 19.2.2021 and 5.3.2021 at fourteen days interval. The treatment details are as follow. **Table 134.**

T1: *Beauveria bassiana* @ 1×10^8 conidia /gm @ 5 g /l at 14 day interval, at pod initiation stage, 2 sprays
T2: *Bacillus thuriengiensis* @ 1 Kg/ha at 14 day interval, at pod initiation stage, 2 sprays
T3: Spinosad 45 SC @ 150ml/ha - 2 sprays
*T4:*Spray of *Ha*NPV (1.5×10^{12} POBs/ha) twice during the peak flowering and at pod initiation stage at 14 days interval
T5:Untreated control

Observation:

Number of larvae/ m row length before spray and 7 and 14 days after spray

Table 135.

Treatment	Larval count / sq.mt					Pooled mean Larval count / sq.mt	Pod damage %	Yield q/ha
	Pre count	First spray		Second spray				
		Post count (7DAS)	Post count (14 DAS)	Post count (7 DAS)	Post Count (14 DAS)			
T_1:*Beauveria bassiana* @ 1×10^8 conidia /gm @ 5 gm/l	1.08[a] (1.27) *	1.25[b] (1.30)	1.58[b] (1.44)	1.08[b] (1.25)	1.33[b] (1.35)	1.31[b] (1.34)	9.58[c] (17.96) **	14.05[b]
T_2:*Bacillus thuriengiensis* @ 1 Kg/ha @ 2g/L	1.33[a] (1.40)	0.75[a] (1.12)	0.92[a] (1.19)	0.50[a] (0.99)	0.58[a] (1.04)	0.68[a] (1.09)	5.33[a] (13.30)	15.97[a]
T_3:Spinosad 45 SC @ 150ml/ha@ 0.3 ml/L	0.92[a] (1.11)	0.33[a] (0.90)	0.50[a] (0.98)	0.25[a] (0.86)	0.41[a] (0.95)	0.37[a] (0.93)	4.27[a] (12.82)	16.28[a]

T_4:Spray of *Ha*NPV (1.5 × 10^{12} POBs/ha) @1ml/L	0.92[a] (1.16)	1.08 [b] (1.25)	1.41 [b] (1.38)	0.83 [b] (1.15)	1.08 [b] (1.25)	1.10 [b] (1.26)	7.11 [b] (15.40)	14.35 [b]
T_5 :Untreated control	1.00[a] (1.18)	1.83 [c] (1.74)	2.16 [c] (1.63)	2.50 [c] (1.75)	2.92 [c] (1.84)	2.35 [c] (1.68)	12.75 [d] (20.88)	9.52 [c]
SE ±	0.16	0.10	0.08	0.07	0.04	0.07	0.81	0.32
CD at 5%	NS	0.31	0.23	0.21	0.14	0.20	2.50	0.96
CV (%)	27.18	15.96	11.37	11.31	6.86	10.88	10.11	6.57

Total and damaged pods at harvest.

Pod yield will be recorded on whole plot basis.

Results:The data regarding larval count, pod damage and grain yield q/ha are presented in Table.134 It is revealed that, the gram pod borer, *Helicoverpa armigera* incidence was low during this year.

In pre count, larval population was ranged from 0.92 to 1.33 larvae / Sq. mt. The pooled mean of larval count after applications of two sprays was ranged from 0.37 to 2.35 larvae / Sq. mt. The lowest larval population 0.37 larvae/ Sq. m was observed in spinosad 45 SC @ 150ml/ha@ 0.3 ml/L which is significantly superior over rest of the treatments and on par with *Bacillus thuriengiensis* @ 1 Kg/ha @ 2g/L with (0.68) larvae / Sq. m. The lowest pod damage (4.27 %) was recorded in spinosad 45 SC @ 150ml/ha@ 0.3 ml/L, which was on par with *Bacillus thuriengiensis* @ 1 Kg/ha @ 2g/L (5.33 %). Similarly, highest grain yield 16.28 q/ha was recorded in treatment with spinosad 45 SC, which was on par with *Bacillus thuriengiensis* treatment(15.97 q/ha). The lowest grain yield was observed in untreated control (9.52 q/ha).

Table.135 Effect of biocontrol agents against *Helicoverpa armigera* (Hubner) in chickpea

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

6.1.2 MPUAT Udaipur:

Design: Randomized Block Design

Replications: 5

Treatments: 5

Treatment details:

T1:*Beauveria bassiana*@ 1x10^8 conidia /gm @ 5 gm/l at 7 days interval, at pod initiation stage, 2 sprays

T2:*Bacillus thuriengiensis*@ 1 Kg/ha at 7 days interval, at pod initiation stage, 2 sprays

T3: Quinalphos 25 EC @ 250g a.i/ha, at pod initiation stage, 2 sprays

T4: Spray of HaNPV (1.5 × 10^{12} POBS/ha) twice during the peak flowering and at pod initiation stage at 15 days interval

T5: Untreated control

Observations:

Number of larvae/m. row length before spray and 3, 7, 10 and 15 days after spray

Total and damaged pods at harvest.
Record natural enemies from 5 plants in each plot.
Pod yield were recorded on whole plot basis.

Table 136. Effect of biocontrol agents against *Helicoverpa armigera* (Hubner) in chickpea

S. No.	Treatments	Larval count (Mean number/plant)					Pod damage (%)	Grain Yield (q/ha)
		PTP	3 DAS	7 DAS	10 DAS	15 DAS		
1.	*B. bassiana*@ 1x108 conidia /gm @ 5 gm/l	3.4	3.5	3.4	2.8	3.2	13.88	12.90
2.	*Bt.*@ 1 Kg/ha	3.8	3.6	3.7	2.9	3.3	14.67	12.10
3.	Quinalphos25 EC @ 250g a.i/ha	4.0	3.0	2.5	1.9	2.1	9.37	16.40
4.	HaNPV (1.5 × 10^{12} POBS/ha)	3.7	3.8	3.2	2.6	3.0	11.62	15.10
5.	Untreated control	4.1	4.4	5.1	5.8	6.2	21.38	10.70

PTP: Pretreatment population

Results: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 3.4 to 4.1 larvae per plant which was statistically non-significant. The maximum reduction was recorded in quinalphos 25 EC @ 250g a.i/ha treatment (1.9 larvae per plant) and the minimum reduction was observed in*Bt.* @ 1 Kg/ha (2.9 larvae per plant) at ten days after spray;whereas, the untreated control recorded least reduction in larval population (5.8 larvae per plant). Minimum per cent pod damage was recorded in treatment ofquinalphos 25 EC @ 250g a.i/ha(9.37%) and maximum wasin*Bt.* @ 1 Kg/ha (14.67%).

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

6.2.1 PAU Ludhiana: The experiment (chickpea variety PBG 7) was sown at Entomological Research Farm, Punjab Agricultural University, Ludhiana on 18.11.2020 in a randomized block design There were four treatments with six replications.

T1: BIPM 1 Package
Seed bio-priming *Trichoderma harzianum*@ 10g/kg of seeds
Erection of bird perches @ 8/acre
Spray of HaNPV strain (1.5x10^{12} POBs/ha) @ 500 ml/ha twice at 15 days interval, first spray starting from pod initiation stage
Raising marigold as trap crop.
Use of pheromone traps @ 1 trap per plot.
T2: BIPM 2 Package
Seed bio-priming *T. harzianum*@ 10g/kg of seeds

Erection of bird perches @ 8/acre

Sprays of *Bacillus thuringiensis*@ 2 kg/ha twice at 15 days interval, first spray starting from pod initiation stage

Raising marigold as trap crop

Use of pheromone traps @ 1 trap per plot.

T3: Chemical insecticide (recommended)

T4: Untreated control

Results: All the treatments were significantly better than untreated control in reducing the pod damage. Minimum percent pod damage (2.90%) was recorded in BIPM 2 module followed by BIPM 1 module (5.95%). However, chemical control (chlorantraniliprole 18.5 SC) recorded significantly lowest pod damage (1.03%). The yield was also significantly better in all treatments as compared to control (Table 137). Maximum yield (18.83 q/ha) was recorded in chlorantariliprole 18.5 SC and it was not significantly different from BIPM 2 (18.02 q/ha). The lowest yield was recorded in untreated control (12.98 q/ha).

Table 137. Evaluation of BIPM modules for the management of *Helicovera armigera* in chickpea (2020-2021)

Treatments	Mean larval population /5 plants	Per cent pod damage	Yield (q/ha)
BIPM 1	1.33 b (1.48)	5.95c (14.11)	15.27 b
BIPM 2	0.83 b (1.34)	2.90b (9.80)	18.02 a
Chlorantraniliprole18.5 SC @ 125 ml/ha	0.16 a (1.06)	1.03a (5.81)	18.83 a
Untreated control	2.50 c (1.86)	11.21d (19.55)	12.98 c
CD (p=0.05)	0.26	(0.27)	0.47
CV (%)	14.58	11.79	2.32

6.2.2 TNAU Coimbatore: Two BIPM modules were evaluated for the management of *Helicoverpa armigera* Table 138.

Farmer's Name	:	Mr. Palanisamy
Place and District	:	Vellamadai, Coimbatore
Geographical coordinates	:	11.1516° N, 76.9843° E
variety	:	Local chickpea
D/S	:	10.11.20
Treatments	:	4
Replications	:	6

T1 :BIPM module -1

Erection of bird perches @8/ac

Spray of HaNPV strain ($1.5x10^{12}$ POBS/ha) @ 500ml/ha twice during the early pod formation stage at 15 days interval

Use of pheromone traps @ 1 trap per plot.

T2 :BIPM module -2

Erection of bird perches @8/ac

Spray of *Bacillus thuriengiensis* @ 2 Kg/ha at 7 day interval, at pod initiation stage, 2 sprays twice during the early pod formation stage at 15 days interval **Table 139.**

Treatments	Number of larvae/meter row*				Number of larvae/ meter row*			Pod damage %**	Yield Kg/acre *	% increaseover control	CB ratio
	First spraying				Second spraying						
	Pre treatment	3DAS	7DAS	14DAS	3DAS	7DAS	14 DAS				
T1 BIPM (HaNPV)@500 ml/ha+ Bird perches@8/acre +Pheromone Traps@1/plot	4.33 (2.06)	4.00 (2.10)[bc]	3.33 (1.91)[b]	4.17 (2.13)[a]	3.17 (1.86)[b]	2.33 (1.59)[a]	4.83 (2.16)[a]	13.41 (21.44)[b]	434 (20.83)[b]	21.91	2.34
T2 BIPM (Bt)@2kg/ha + Bird perches@8/acre +Pheromone Traps@1/plot	4.17 (2.03)	2.33 (1.66)[ab]	2.17 (1.57)[ab]	5.17 (2.37)[a]	3.50 (1.96)[b]	3.17 (1.87)[b]	5.33 (2.21)[a]	14.17 (22.04)[b]	445 (21.09)[b]	25.00	2.42
T3 Chemical (farmer practice)	4.50 (2.09)	1.33 (1.31)[a]	1.17 (1.25)[a]	3.83 (2.05)[a]	1.33 (1.27)[a]	1.17 (1.23)[a]	3.17 (1.68)[a]	8.38 (16.78)[a]	512 (22.62)[a]	43.82	3.27
T4- Control	4.67 (2.15)	5.67 (2.46)[c]	6.17 (2.57)[c]	8.50 (2.99)[b]	10.17 (3.23)[c]	11.33 (3.43)[b]	11.20 (3.34)[c]	20.42 (26.79)[c]	356 (18.86)[c]	-	-
SEd	NS	0.211	0.210	0.180	0.269	0.257	0.318	1.143	0.143	-	-
CD(P=0.05)	NS	0.444	0.440	0.379	0.565	0.540	0.668	2.402	0.301	-	-

Use of pheromone traps @ 1 trap per plot.

T3: Chemical insecticides

T4: Untreated control

Result: A field trial was conducted to evaluate two BIPM modules on *Helicoverpa armigera* on chickpea in a farmer's field at Vellamadai, Coimbatore District. In addition to bird perches@8/acre and pheromone traps@1/plot, two sprayings of HaNPV and *Bt* were given in BIPM module 1 and 2 respectively. A minimum number of larvae (1.33Nos./meter row) were seen in insecticide treatment on 3rd Day after first spraying (DAFS), which was statistically on par with BIPM module 2 (2.33Nos.). Similar trend was observed on 7 DAFS also. BIPM modules and insecticide treatment were found to be statistically similar in their effect on 14 DAFS. The population of larvae after second spraying also showed the same trend as that of population of larvae after first spraying. Pod damage was less in insecticide treatment (8.38%) when compared to the BIPM module 1 (13.41%) and BIPM module 2 (14.17%). There was 43.82 per cent increase in the yield in insecticide treatment followed by BIPM module 1 (21.91%) and BIPM module 2 (25.00%) (Table140).

Table .140 Effect of BIPM modules on *Helicoverpa armigera* on chickpea

DAS – Days After Spraying

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

Means followed by a common letter (s) in a column are not significantly different

Values are mean of six replications

6.3 Large Scale Demonstration of *Ha*NPV Kalaburgi strain against chickpea pod borer during 2020-21

6.3.1 UAS Raichur:

Crop: Chickpea

Variety: JJ-11

Date of Sowing: 18-11-2020

Experimental location: Seed Production Unit, MARS, Raichur

Area: 10 hectare

Treatments details has been given below: **Table 140.**

T_1:	HaNPV @ 100 LE/acre (8 ha)	Date of Spray: 23-01-2021 and 03-02-2021
T_2 :	Farmers Practice (1.75 ha)	Emamectin benzoate 5 SG @ 0.2 g/lit Date of Spray: 28-01-2021
T_3 :	Untreated control (0.25 ha)	--

Observations were taken on number of larvae per plant, pod damage (%) and grain yield (q/ha).

Results: One day before spray, larval population ranged from 3.32 to 3.48 per plant among treatments. Seven days after treatment imposition lowest number of larva per plant (0.58) was noticed in farmers practice followed by HaNPV (1.06 larvae/plant).

The lowest pod damage (6.38%) and highest grain yield (14.18 q/ha) was observed in farmers practice followed by HaNPV (12.46 % pod damage and 12.44 q/ha grain yield). Untreated control recorded 10.24 q/ha grain yield (Table 141).

Table 141. Large Scale Demonstration of *Ha* NPV Kalaburgi strain against chickpea pod borer during 2020-21

Sl. No.	Particulars	Pod borer, *H armigera* No. of larvae per plant *			Pod damage (%) #	Grain Yield (q/ha)
		1 DBS	7 DAS	10 DAS		
T_1	HaNPV @ 100 LE/acre	3.48 (1.99)	1.82 (1.52)	1.44 (1.39)	12.46 (20.67)	12.44
T_2	Farmers Practice	3.32 (1.95)	1.06 (1.25)	0.58 (1.04)	6.38 (14.63)	14.18
T_3	Untreated control	3.38 (1.97)	2.86 (1.83)	2.58 (1.75)	18.38 (25.39)	10.24
S Em±		0.09	0.05	0.04	0.61	0.53
CD (P=0.05)		NS	0.16	0.12	1.84	1.61

*Figures in parentheses are square root transformed values

#Figures in parentheses are arcsine transformed values

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 chickpea pod borer

Impact of intercrops and border crops on the natural enemies abundance

Table 142.

Number of treatments : 12	Number of replications : 3
Design : RBD	Plot size: 4.5 x 4.5 m^2

Treatment details:

Table 143.

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 + Coraider (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)

Results: Significantly lower *Helicoverpa* larvae and consequent pod damage was observed in all the intercrops as compared to sole chickpea. Among the different intercrops – linseed and coriander was the best, recording lowest number of *Helicoverpa* larvae per five plants (5.33 and 5.67 Chickpea + Linseed + mustard and Chickpea + Linseed + napier respectively), and significantly lowest pod damage (11.87%) was observed in chickpea + linseed + napier. Significantly highest no. of larvae and pod damage was observed in sole chickpea (16.33 larvae per five plants) with no border crops proving the effect of border crops. Among the two border crops – napier was observed to be significantly superior to mustard in enhancing the percent parasitization by *Campoletischloridae*. Percent parasitization by *C. chloridae*was highest in coriander (15.33%), followed by linseed (11.67%) and fenugreek (10.67%). Napier as border crop also proved good in distracting parrots, and the damage by parrots were almost nil.

The trial is in progress, harvested on 26.04.2021 and yet to be threshed. Hence, the data on grain yield and C:B ratio shall be furnished later on.

Table 144. *Helicoverpa* larvae population, pod damage and percent parasitization by *Campoletis chloridae* during post-winter months

Treatments	As on 7.04.2021		As on 27.04.2021		Pod Damage (%)
	Larvae /5 plants	Parasitization (%)	Larvae /5 plants	Parasitization (%)	
T1	2.67	10.33 (18.73)	5.67	11.67 (19.94)	11.87 (19.99)
T2	2.67	13.00 (21.12)	6.33	15.33 (23.04)	16.06 (23.62)
T3	3.67	8.33 (16.77)	7.00	10.67 (19.05)	22.60 (28.37)
T4	3.33	7.33 (15.70)	7.67	9.33 (17.78)	17.07 (24.36)
T5	2.67	6.67 (14.95)	5.33	7.33 (15.70)	13.30 (21.36)
T6	3.67	7.67 (16.06)	5.67	8.33 (16.77)	18.40 (25.38)
T7	5.33	6.33 (14.56)	6.67	6.33 (14.56)	24.26 (29.38)
T8	6.00	5.00 (12.87)	9.00	5.67 (13.72)	20.09 (26.56)
T9	7.67	2.33 (8.74)	16.33	2.67 (9.36)	54.11 (47.34)
T10	4.33	4.67 (12.46)	7.67	5.67 (13.75)	32.97 (34.93)
T11	5.00	4.00 (11.47)	12.67	4.67 (12.46)	38.99 (38.61)
T12	6.00	1.33 (6.53)	10.33	0.00 (0.00)	36.62 (37.21)
C.D. at 5%	1.698	(1.722)	1.595	(1.256)	(4.41)


Gram Pod borer, *Helicoverpa armigera*


Coccinellid beetles on border crop Napier


Coccinellid grub and pupae on intercrops

Coccinellid adult on intercrop

Campoletis chloridae adult

Fig:39.

6.4.2 ICAR-NCIPM:

Experiment initiated in 2020

Evaluation of Biointensive Integrated Pest Management against pod borer in chickpea in Bundelkhand region (ICAR-NCIPM)

Justification

Due to covid-19 pandemic and covid infection to PI and disruption of train connectivity,only one experiment (6.2) ‘Evaluation of Biointensive Integrated Pest Management against pod borer in chickpea in Bundelkhand region was initiated at farmers field in village Chokari (25°35'15.4"N 79°13'00.5"E) of district Jhansi with the help of district KVK during *Rabi* 2020in five acres in farmers participatory mode.Following BIPM module was applied.

BIPM MODULE

1. Deep summer ploughing and field sanitation
2. Timely sowing in the first fortnight of October
3. Selection of tolerant/resistant variety (JG14)
4. Seed Treatment with *T. harzianum* (NCIPM-TH1) 10 g/kg seed
5. Intercropping with mustard
6. Installation of pheromone trap for monitoring 5/ha
7. Erection of bird perches 20/ha
8. Need based application of botanical neem Azadirachtin 1500 ppm @5 ml/litre and biopesticides *Bacillus thuringiensis krustaki* (2×10^8cfu per ml).

In farmers practice (FP) fields'farmers used insecticides without recommendations based up on the advice of pesticides dealers 1-2 spray against chickpea pod borer.

Results

Larval population of pod borer was recorded at weekly interval starting from 46th standard meteorological week (SMW) i.e. 15-20 days after sowing. Moth catch in pheromone trap was observed during 48thSMW 2±0.5 and continuedup to 14th SMW with 70±21 moths per trap.Initially there was no infestation of pod borer up to 49 SMW. Larval population start appearing in 50 SMW in BIPM whereas in FP it was first appeared in 49 SMW at vegetative stage of crop growth.Maximum larval population 0.5/meter row was recorded in BIPM during flowering stage i.e. 5-6 SMW and thereafter population was maintainedbetween 0- 0.3/ meter row up to crop maturity withthe application of Neem, *Bt* and NPV.In FP fieldlarval population was significantly higher compared to BIPM and reached upto 2.0/ meter row. In BIPM pod damage was maximum during 7th SMW i.e. 8±2% and8th SMW with 6 ±1.6% damage. Thereafter damage was remained between 0 to 2±1.2%. In FP pod damage was significantly higher than BIPM and reached upto17% during 12thSMW.Average yield in BIPM field was between 15.80 q/ha with B:C ratio 2.90 whereas, 13.10 q/ha yield was recorded in FP fields with B:C ratio of 2.43.

In BIPM fields wilt incidence was 8.0% and 5.0% due to *Fusarium* spp. and *Sclerotium rolfsii* respectively. Whereas, in FP fields incidences of *Fusarium* spp. and *S. rolfsii* were 18.0% and 11.0% respectively. Incidence of *Ascochyta rabiei* was similar in both the BIPM and FP fields. No disease incidences of stem rot (*Sclerotinia sclerotium*) and root knot nematode (*Meloidogyne incognita*) were found.

Over all larval population in BIPM fields was significantly low (ranged from 0.3-0.5 L/m row)compared to FP fields (range 0.2-2.0 L/m row). Use of pheromone traps, installation of bird perches and foliar spray of *B. thuringiensis* and neem were found effective against pod borer resulted in >20 per cent increase in seed yield of chickpea. Similarly, seed treatment with T. *harzianum* provided satisfactory management of wilt (*Fusarium oxysporum*) and collar rot (*Sclerotium rolfsii*).

Farmers' field schools were organized in different villages to promote the use of biological control agents for pest management in chickpea and seed treatment by *T. harzianum* was also demonstrated.

Economic analysis **Table 145.**

Variable	BIPM	FP
Cost(Rs/ha)	26500	26200
Yield (Q/ha)	15.80	13.10
Gross Income (Rs/ha)	77025	63862.50
Net Income (Rs/ha)	50525	37662.50
BC Ratio	2.90	2.43

Price of chickpea (Rs/qt) was 4875/qt

Fig:40.

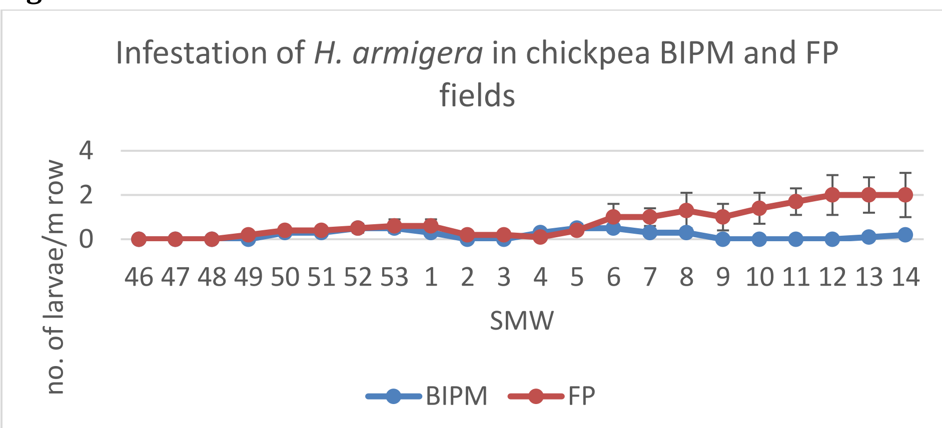


Fig:41.

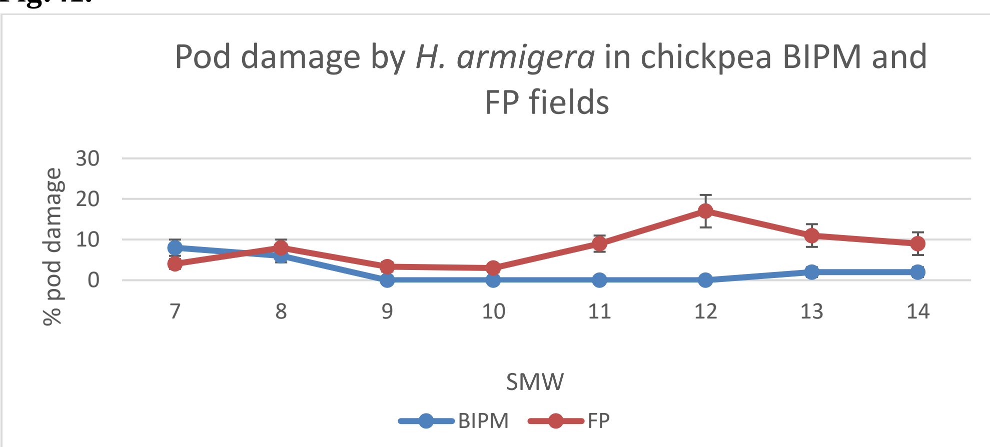


Fig:42.

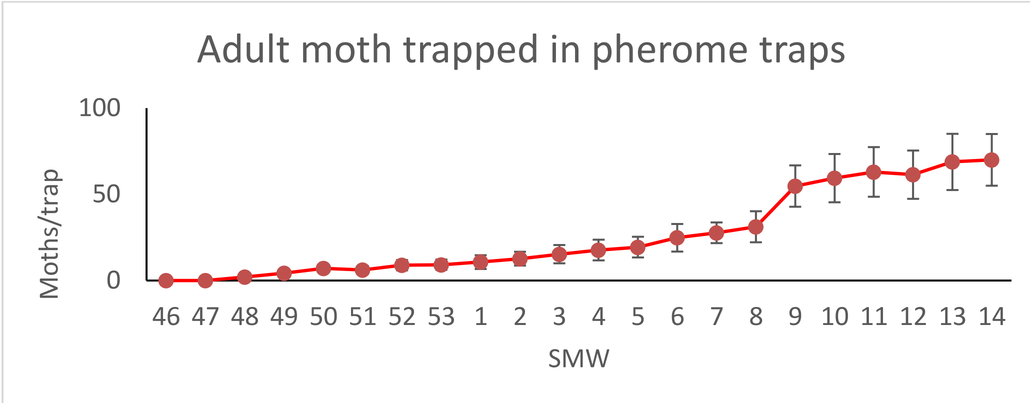


Figure 1: trapped adult (male)

Figure 2: T-shaped wooden

Fig:43.

7. Biological Control Pigeonpea Pests

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

7.1.1 PDKV,Akola:

Experimental details:

Date of sowing: 29.06.2020

Table 146.

Variety	:	PKV Tara
Treatments	:	Three T1: Biocontrol 3 sprays - NBAII BtG4 2% @ 2.0 ml/lt - at pre flowering, post Flowering and pod formation stage.

		T2: Chemical control 1st Spray – Thiodicarb 75 WP @ 625 ml/ha 2nd spray – Chlorantraniliprole 18.5 SC @ 150 ml 3rd spray - Monocrotophos 36 SL @ 625 ml T3: Control
Replications	:	8 replications Each block was divided into 8 equal sized units, each unit was considered as replication (each unit = one replication)
Area	:	T1 – 2000 m^2 T2 – 2000 m^2 T3 – 2000 m^2
Observations	:	Pod borer complex (*Helicoverpa*, Plume moth, podfly) Per cent pod damage Grain yield (kg/ha)

Results

The data in Table 1 revealed significant differences among the treatments. The data on number of *Helicoverpa* larvae per plant is the mean of three observations, each after 3 sprays and it was found that significantly less larvae of 0.44 per plant was recorded in treatment T2 which was significantly superior treatment, followed by 1.22 larvae per plant in treatment T1, both were significantly superior over untreated control which recorded 4.47 larvae per plant. The population of tur plume moth was also significantly less in Treatment T2 which was followed by treatment T1 recording 0.13 and 0.44 larvae per plant, respectively. The untreated control recorded 0.97 larvae per plant.

The mean observation of 3 sprays on pod damage revealed that significantly minimum damage was recorded in insecticidal treatment (T2) with 3.05 % pod damage due to lepidopteran pod borers and was significantly superior to rest of the treatments. It was followed by Bt treatment (T1) with 3.70 % pod damage and was significantly superior over untreated control (11.30 %). The data on pod borer damage at harvest also revealed significant differences among the treatments, recording significantly minimum damage of 12.50 % in insecticidal treatment (T2), followed by treatment T1 with Bt sprays recording 13.38 % pod damage and both the treatments were at par with each other and significantly superior to untreated control that has recorded significantly maximum pod damage of 27.25 %.

The grain damage due to pod fly was recorded by split opening the pods at harvest and it was found that treatment T2 was significantly superior with 24.11 % grain damage followed by Bt treatment (T1) with 24.81 % grain damage and both the treatments were significantly superior over untreated control which recorded maximum per cent grain damage 31.62%.

The data on yield revealed significant differences among the treatments, treatment T2 receiving insecticidal application recorded significantly maximum yield of 16.68 quintals per hectare followed by Bt treatment (T1) recording 16.08 Q/ha, both being at par with each other and significantly superior over untreated control which recorded 10.50 Q/ha.

Table 147. Effect of different treatments on pod borers, pod damage and yield of pigeonpea

Treatments	Number of larvae/plant		Mean pod damage (%)	Per cent damage at harvest	Grain damage %	Yield Q/ha
	H. armigera	TPM				
T1- Bt	1.22 (1.31)*	0.44 (0.97)*	3.70 (11.09)**	13.38 (21.45)**	24.81 (29.87)**	16.08
T2	0.44 (0.97)	0.13 (0.79)	3.05 (10.06)	12.50 (20.70)	24.11 (29.41)	16.68
T3	4.47 (2.23)	0.97 (1.21)	11.30 (19.65)	27.25 (31.47)	31.62 (34.21)	10.50
SE(m)	0.07	0.04	0.25	0.76	1.04	0.45
CD at 5 %	0.20	0.13	0.75	2.30	3.15	1.37
CV	12.39	12.27	5.14	8.74	9.44	8.83

Note: * Figures in parentheses are square root transformation values

**Figures in parentheses are Arcsin transformation values

Commercial Crops

8. Cotton

8.1.Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton (MPKV, Pune, PJTSAU, Rajendranagar, UAS, Raichur)

8.1.1. MPKV, Pune

The experiment was laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. *Bt*cotton var- ACH199- BG-II from Ajeet Seeds Pvt. Ltd., was sown on 9.7.2020 having plot size of 4.5 x 4.5 m with 90 x 90 cm spacing in Randomized Block Design with six treatments replicated four times. Three sprays of biopesticides and chemical insecticide were given at fortnightly interval on 8.10.2020, 26/10/2020 and 12/11/2020.

The following treatments were used for the experiment

T1: *Metarhizium anisopliae*(1x 10^8conidia /g) @ 5 g/litre

T2: *Lecanicillum lecanii*(1 x 10^8conidia /g) @ 5 g/litre

T3: *Beauveria bassiana*(1 x 10^8conidia /g) @ 5 g/litre

T4: Azadiractin 1500 ppm @ 2ml/ suspension

T5: Imidachloprid 17.8 SL @ 0.2 ml/ suspension (Standard chemical check)

T6: Untreated control

Observation:The observations recorded on 5 plants per plot from each treatment before treatment as pre-count and post counts observation were taken 10 days after each spray.

Recorded sucking pests population (aphids, jassids, thrips, white flies) on 3 leaves (terminal shoots)/ plant

Seed cotton yield per plot will be recorded and converted into q/ha.

Results:The pooled data of sucking pest population was presented in Table 148, It is revealed from the data that the amongst the biopesticides, *Lecanicillium lecanii*(1 x 10^8conidia /g) @ 5 g/litre recorded lowest population of sucking pests *viz.*, aphids (4.80), jassids (2.90), thrips (2.40) and white flies (1.72) on 3 leaves per plant compared to the untreated control which recorded aphids (38.1), jassids (13.26), thrips (30.66), and white flies (10.57) on 3 leaves per plant. Chemical treatment recorded lowest population of all sucking pests and significantly superior over rest of the treatments. The *L. lecanii*(1 x 10^8conidia/g) @ 5 g/litre recorded seed cotton yield of 15.20 q/ha which is at par with Imidachloprid 17.8 % SL (17.00 q/ha). Whereas, untreated control recorded lowest seed cotton yield of 6.04q/ha.

Table 148. Effect of bioagent against sucking pests in *Bt*cotton

Treatment	Av. population / 3 leaves / plant								Yield q/ha
	Aphids		Jassids		Thrips		White flies		
	Pre-count	Post count	Pre-count	Post count	Pre-count	Post count	Pre-count	Post count	
T1: *M. anisopliae* (1x 10^8 conidia /g) @ 5 g/lit.	23.34 ^{a} (4.88)	6.80^c (2.70)	7.70 ^{a} (2.86)	3.30 ^{b} (1.95)	13.20 ^{a} (3.70)	3.10 ^{c} (1.90)	4.05 ^{a} (2.13)	2.10^c (1.61)	14.77 ^{a}
T2: *L. lecanii* (1 x 10^8 conidia /g) @ 5 g/lit.	22.96 ^{a} (4.84)	4.80 ^{b} (2.30)	7.80 ^{a} (2.88)	2.90 ^{a} (1.84)	12.96 ^{a} (3.67)	2.40 ^{b} (1.70)	4.10 ^{a} (2.14)	1.72 ^{b} (1.49)	15.20 ^{a}
T3: *B. bassiana* (1 x 10^8 conidia /g) @ 5 g/lit.	24.22 ^{a} (4.97)	11.06 ^{e} (3.40)	8.14 (2.94)	4.49 ^{b} (2.23)	12.88 ^{a} (3.66)	4.97 ^{e} (2.34)	4.15 ^{a} (2.16)	3.38 ^{d} (1.97)	13.39 ^{b}
T4:Azadirachtin 1500 ppm @ 2 ml/lit	23.46 ^{a} (4.89)	8.40^d (2.98)	8.40 ^{a} (2.98)	4.20 ^{b} (2.17)	13.30 ^{a} (3.72)	4.26 ^{d} (2.18)	3.74 ^{a} (2.06)	2.23^c (1.65)	13.81 ^{b}
T5: Imidachloprid 17.8 % SL @ 0.2 ml/lit	23.10 ^{a} (4.86)	3.06 ^{a} (1.89)	8.30 ^{a} (2.97)	1.68 ^{a} (1.47)	12.70 ^{a} (3.63)	1.60 ^{a} (1.45)	4.32 ^{a} (2.19)	1.09 ^{a} (1.26)	17.00 ^{a}
T6: Untreated control	20.30 ^{a} (4.56)	38.1^f (6.21)	8.20 ^{a} (2.95)	13.26^c (3.71)	12.80 ^{a} (3.65)	30.66 ^{f} (5.58)	4.28 ^{a} (2.19)	10.57 ^{e} (3.33)	6.04 ^{c}
SE ±	0.07	0.08	0.05	0.13	0.06	0.04	0.06	0.04	0.71
CD at 5%	NS	0.23	NS	0.38	NS	0.13	NS	0.11	2.13
CV (%)	2.63	4.42	3.62	11.37	3.25	3.36	6.60	4.23	10.59

(DAS- Days after spray *Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values)

8.1.2. PJTSAU

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

Treatments: Six

T1: *Metarhizium anisopliae*(1x10^8 conidia/g) @ 5 g/l

T2: *Lecanicillium lecanii* (1x10^8 conidia/g) @ 5 g/l

T3: *Beauveria bassiana* (1x10^8 conidia/g) @ 5 g/ l

T4: Azadirachtin 1500ppm @ 2 ml/lit

T5: Acetamiprid 20% SP - 0.2g/litre

T6: Control

Design : RBD

Replications : Four

Plot Size : 8x5 m

Variety : Local Bt Hybrid

Season : *Vanakalam* 2020-21

Location : ARI Research plots, Rajendranagar

The first spray will be given on occurrence of the pest and rest based on abundance of the pest. The cloth screen will be used to avoid drift into neighboring plots.

Average number of sucking pest population / 3 leaves,*viz.,* Aphids, leafhoppers, whiteflies and thrips will be counted and recorded.

Number of whitefly adults from 3 leaves (top, middle and lower canopy) of 5 randomly selected plants in each plot will be recorded before spray, 3 and 7 days after spray.

Cadavers without apparent sporulation along with leaves will be brought in the laboratory and incubated under optimal condition. After 5 days cadavers were observed for signs of fungal infection and sporulation.

The population of other sucking pests will also be recorded.

Yield (q/ha) to be recorded.

Results

Three sprays of the treatments were carried out and results revealed that *Lecanicillium lecanii* @ 5g/litre and Neem oil 1500 ppm @ 5ml/l and the chemical check (Acetamiprid) recorded recorded lesser sucking pest population at 3rd and 7th day count after each of the three sprays ranging from 0.67 to 0.95/leaf afterfirst spray. Rest of the treatments recorded hopper populations from 1.94-3.00/leaf after the first day count. Untreated control recorded 3.78 hoppers/leaf. At 7 days after spray, *L.lecanii* and Neem oil recorded minimum hopper population (2.68 and 3.25/leaf) compared to control (5.55/leaf). After the second spray, 3.0 hoppers/leaf were recorded in the *L.lecanii* and the Neem oil treatment, and 4.00/leaf in the Acetamiprid treatment.Rest of the treatments recorded higher population (4.6-5.10/leaf). Control plot recorded maximum no.of 5.50 hoppers/leaf at the 3rd day after spray. At 7 DAS after the second spray *L.lecanii* and Neem oil recorded minimum population of hoppers (1.90) while Acetamiprid recorded 2.97/leaf which was on par with

M.anisopliae and *B.bassiana* treatments (3.0 and 3.9 hoppers/leaf). At 3 day count after third spray, 3.48-3.73/leaf of hoppers were recorded in *L.lecanii*, Neem oil and Acetamiprid. Rest of the treatments like *Metarhizium* and *Beauveria* recorded higher hopper numbers after the sprays.

Yield data recorded was less due to poor crop growth due to water stagnation in the fields for a week due to continuous heavy rains in September and October. However, yield was higher in L.lecanii, Neem oil 1500 ppm and Acetamirpid treated plots and ranged from 4.12 to 4.41 q/acre, while the other registered lesser yields (2.81 to 4. q/acre). (Tables 149 and 7). Population of aphids was least in Acetamiprid treated plots while in all other treatments it ranged from 0.48-1.03/leaf at 3day count after the first spray. At the 7th day count, all treatments recorded no population of aphids. At 3 days after the second spray, the biological treatments recorded higher populations of aphids (2.18-2.98/leaf) much higher than the Acetamiprid treated plots (0.53/leaf). Control plot recorded highest no.of aphids (5.16/leaf).

Table 149. Population of Leafhoppers, *Amrasca biguttula biguttula* (mean no./ leaf)

Treatment	Population of leafhoppers									Yield (q/acre)
	First spray			Second spray			Third spray			
	Pre count	3 day count	7 day count	Pre count	3 day count	7 day count	Pre count	3 day count	7 day count	
T1 *M.anisopliae* (1X 10^8) CFU/ml	3.53 (1.84)	3.00 (1.66)^{ab}	4.63 (2.11)^{ab}	13.25 (3.63)	5.10 (2.25)^{bc}	3.0 (1.67)^{ab}	5.35 (2.31)	4.25 (2.04)^{b}	2.2 (1.47)	4.00^{a}
T2 *L.lecanii* (1X 10^8)CFU/ml	1.87 (1.36)	0.67 (0.81)^{a}	2.68 (1.63)^{a}	13.53 (3.64)	3.00 (1.72)^{a}	1.90 (1.36)^{a}	9.56 (2.88)	3.55(1.88)^{a}	1.65(1.25)	4.19^{a}
T3 *B.bassiana* (1X 10^8)CFU/ml	1.30 (1.02)	1.94 (1.25)^{ab}	4.25 (2.04)^{ab}	12.48(3.05)	4.6 (2.14)^{bc}	3.9 (1.97)^{bc}	5.18 (2.27)	4.25 (2.04)^{b}	2.1(1.45)	2.97^{b}
T4 Azadirachtin 1500 ppm	2.40 (1.53)	0.95 (0.98)^{a}	3.25 (1.75)^{a}	13.51 (3.61)	3.00 (1.72)^{a}	1.90 (1.36)^{a}	5.31 (2.30)	3.48(1.84)^{a}	1.15(1.04)	4.12^{a}
T5 Acetamiprid 20% SP	3.70 (1.91)	0.95 (0.98)^{a}	4.63 (2.11)^{ab}	13.53(3.64)	4.00(1.97)^{ab}	2.97(1.71)^{ab}	6.08 (2.46)	3.73(1.91)^{a}	1.83(1.22)	4.41^{a}
T6 Untreated Control	4.07 (2.00)	3.78 (1.94)^{b}	5.55 (2.35)^{b}	14.9 (3.86)	5.50(2.33)^{c}	5.33(2.30)^{c}	4.49 (2.11)	5.97(2.44)^{c}	2.03(1.41)	2.81^{b}

CD at 1%	NS	0.94	0.49	NS	0.32	0.6	NS	0.43	NS	0.57
CV	22.98	25.25	17.09	12.85	10.42	16.31	23.81	10.63	19.60	10.15

Table 150. Population of aphids, Aphis gossypii (mean no./ leaf)

Treatment	Population of aphids (no/leaf)					
	First spray			Second spray		
	Pre count	3 day count	7 day count	Pre count	3 day count	7 day count
T1 *M.anisopliae* (1X 10^8)CFU/ml	2.50 (1.55)	0.91 (1.19)^c	0 (0.71)	2.55 (1.59)	2.98 (1.86) ^{bc}	0 (0.71)
T2 *L.lecanii*(1X 10^8)CFU/ml	2.17 (1.52)	0.48 (0.97)^b	0 (0.71)	2.75 (1.64)	2.18 (1.54)^{ab}	0.75 (0.99)
T3 *B.bassiana*(1X 10^8)CFU/ml	2.47 (1.48)	1.03 (1.24)^c	0.16 (0.81)	2.88 (1.69)	2.8 (1.79)^{bc}	1.25 (1.22)
T4 Azadirachtin 1500 ppm	2.13 (1.57)	0.52 (0.98) ^{b}	0.2 (0.82)	2.78 (1.66)	2.85 (1.82)^{bc}	1.45 (1.27)
T5 Acetamiprid 20% SP	2.60 (1.50)	0 (0.71) ^{a}	0 (0.71)	2.55 (1.57)	0.53 (0.93)^a	1.8 (1.49)
T6 Untreated Control	2.40 (1.51)	1.03 (1.24)^c	0.12 (0.78)	3.10 (1.75)	5.16 (2.33)^c	3.13 (1.88)
CD at 1%	NS	0.27	NS	NS	0.69	NS
CV	8.49	12.26	13.73	9.61	26.95	15.34

8.1.3. UAS, Raichur

Crop: Cotton
Soil: Deep cotton soil
FYM: 10 t/ha
Hybrid: KCH-14K59 BG II (Jadoo)
Fertilizers: 150:75:75 NPK kg/ha
Irrigation: Drip irrigation
Experimental details
a): Design: Randomized Block Design (RBD)
b) No. of treatments: eight
c) No. of replications: Three
d) Plot size 9.0 x 6.0 m
e) Spacing: 90 x 60 cm
f) Date of Sowing: 20-06-2020
g) Target pests: sucking pests

f) Date of treatments imposition: 11-08-2020, 27-08-2020,12-09-2020 and 27-09- 2020
g) Method of application and equipment: Knapsack sprayer with hollow cone nozzle
h) Quantity of water used for dilution: 500 litres/ha

Treatments

T1: *Beauveria bassiana* (ICAR- NBAIR-Bb-5a) @ 1×10^8 @ 5 gm/l
T2: *Lecanicillium leccani* (ICAR-NBAIR-VL-8) @ 1×10^8 @ 5 gm/l
T3: *Lecanicillium leccani* (ICAR-NBAIR-VL-15) @ 1×10^8 @ 5 gm/l
T4: *Metarhizium* anisopliae (ICAR-NBAIR-Ma 4) @ 1×10^8 @ 5 gm/l
T5: *Isaria fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l
T6 : Azadirachtin 1500ppm @ 2 ml/lit
T7 : Fipronil 5 SC @ 1 ml/lit
T8: Untreated control

Observation:

In each treatment five plants were randomly selected and from each plant top, middle and bottom leaves were observed to record the number of leafhoppers, thrips and aphids population and later expressed as number per plant at a day before spray, seven and ten days after each spray and subjected for square root transformation and analyzed statistically.

At each picking (Total 3 pickings) total seed cotton yield was recorded in each treatment converted to quintals per hectare.

Results:

Leafhopper population ranged from 10.68 to 11.56 per plant a day before spray. Seven days after spray lowest leafhopper population of 6.08 per plant was noticed in *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l which was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l which recorded 6.54 per leafhopper per plant while chemical treatment fipronil 5 SC recorded 4.88 leafhopper per plant while untreated control recorded 11.24 leafhopper per plant. Among the biocontrol agents, *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l recorded highest reduction of leafhopper population over control (49.15%) and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l which recorded 45.38 per cent. Lowest thrips of 2.04 per plant was noticed in *B. bassiana* (ICAR-NBAIR-Bb-5a) 1×10^8 @ 5gm/l and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l and *I. fumosorosea* (ICAR-NBAIR strain) 1×10^8 @ 5gm/l which recorded 2.84 and 2.78 thrips per plant, respectively. Reduction of thrips population over control was highest in *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l (50.32 %) and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l and *I. fumosorosea* (ICAR-NBAIR strain) 1×10^8@ 5gm/l which recorded 46.48 and 47.33 per cent, respectively. Aphid population ranged from 8.12 to 8.98 per plant at one day before spray. On seven days after spray, lowest aphid population of 4.74 per plant was noticed in *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l and *I. fumosorosea* (ICAR-NBAIR strain)) 1×10^8 @ 5gm/l which recorded 4.86 and 4.92 aphids per plant, respectively. Per cent reduction of aphid population was highest in *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l (57.23 %) and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l and *I. fumosorosea* (ICAR-NBAIR strain)) 1×10^8 @ 5gm/l which recorded 53.25 and 56.14 per cent, respectively. Highest seed cotton yield of 27.58 q/ha was noticed in *B. assiana* (ICAR-NBAIR-Bb-5a) 1×10^8 @ 5gm/l and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l and *I. fumosorosea* (ICAR-NBAIR strain)) 1×10^8 @ 5gm/l which recorded 25.84 and 26.16 q/ha, respectively (Table 151).

Table 151. Evaluation of entompthogenic fungi against sucking insect pests of cotton during 2020-21

Sl. No.	Treatment Details	Dosage (g/l)	No. of leafhoppers/plant				No. of thrips/plant				No. of aphids/plant				Seed cotton yield (q/ha)
			IDBS	7 DAS	10 DAS	ROC (%)	IDBS	7 DAS	10 DAS	ROC (%)	IDBS	7 DAS	10 DAS	ROC (%)	
T_1	*Beauveria bassiana* (ICAR-NBAIR-Bb-5a)	1×10^8 @ 5gm/l	11.56 (3.47)	6.08 (2.57)	5.26 (2.40)	49.15 (44.51)	4.18 (2.16)	2.62 (1.77)	2.04 (1.59)	50.32 (45.18)	8.12 (2.94)	4.74 (2.29)	2.36 (1.69)	57.23 (49.16)	27.58
T_2	*Lecanicilliumleccani* (ICAR-NBAIR-VL-8)	1×10^8 @ 5gm/l	11.08 (3.40)	6.82 (2.71)	5.72 (2.49)	43.77 (41.42)	4.86 (2.32)	3.04 (1.88)	2.62 (1.77)	39.66 (39.03)	8.56 (3.01)	5.18 (2.38)	3.08 (1.89)	50.24 (45.14)	25.72
T_3	*Lecanicilliumleccani* (ICAR-NBAIR-VL-15)	1×10^8 @ 5gm/l	10.94 (3.38)	6.54 (2.65)	5.64 (2.48)	45.38 (42.35)	4.52 (2.24)	2.84 (1.83)	2.18 (1.64)	46.48 (42.98)	8.98 (3.08)	4.92 (2.33)	2.84 (1.83)	53.25 (46.87)	25.84
T_4	*Metarhizium*anisopliae (ICAR-NBAIR-Ma 4)	1×10^8 @ 5gm/l	11.06 (3.40)	8.32 (2.97)	7.06 (2.75)	31.03 (33.85)	4.34 (2.20)	3.98 (2.12)	3.06 (1.89)	24.95 (29.96)	8.34 (2.97)	6.08 (2.57)	3.48 (1.99)	42.41 (40.63)	23.58
T_5	*Isariafumosorosea* (ICAR-NBAIR strain)	1×10^8 @ 5gm/l	10.84 (3.37)	7.84 (2.89)	6.12 (2.57)	37.40 (37.70)	4.62 (2.26)	2.78 (1.81)	2.16 (1.63)	47.33 (43.47)	8.16 (2.94)	4.86 (2.29)	2.72 (1.79)	56.14 (48.53)	26.16
T_6	Azadirachtin 1500ppm	2 ml/lit	11.32 (3.44)	9.36 (3.14)	7.94 (2.91)	22.42 (28.26)	4.36 (2.20)	3.14 (1.91)	2.96 (1.86)	34.97 (36.25)	8.52 (3.00)	4.18 (2.16)	3.92 (2.10)	51.20 (45.69)	23.28
T_7	Fipronil 5 SC	1 ml/lit	10.68 (3.34)	4.88 (2.32)	2.42 (1.71)	67.26 (55.10)	4.58 (2.25)	1.94 (1.56)	1.02 (1.23)	68.44 (55.82)	8.48 (3.00)	5.56 (2.46)	4.26 (2.18)	40.84 (39.72)	29.46

T_8	Untreated control	-	10.92 (3.38)	11.24 (3.43)	11.06 (3.40)	0.00 (0.00)	4.74 (2.29)	4.82 (2.31)	4.56 (2.25)	0.00 (0.00)	8.36 (2.98)	8.44 (2.99)	8.16 (2.94)	0.0 0 (0.0 0)	20.78
S Em±			0.68	0.03	0.02	-	0.18	0.04	0.03	-	0.13	0.02	0.04	-	0.38
CD (P=0.05)			NS	0.11	0.07	-	NS	0.12	0.10	-	NS	0.07	0.12	-	1.16

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

8.2.Biointensive management of pink bollworm in *Bt* cotton (PJTSAU, Hyderabad, TNAU, Coimbatore)

8.2.1. PJTSAU, Hyderabad

Treatment details :

Three treatments

Each treatment consisting of 200 sq.m., and the total plot size is 800 sq.m. including isolation distance

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

The following inputs to be provided for PBW.

Erection of pheromone traps (Funnel type) @ 15/acre

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

Application of azadirachtin 1500 ppm at ETL

Need based chemical insecticide based on label claim/university recommendation.

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

T3: Control

Totally 5 quadrants will be made and each quadrant will serve as replication.

Replications : Five (quadrats)
No.of modules : Three
Module Size : 200 Sq. mt
Variety : Local Bt Hybrid
Season : *Kharif*, 2020-21
Location : ARI Farm, Rajendranagar

Observations:

No. of healthy open bolls and infested open bolls (at least 100 balls were observed @ five observations/plot) along with number of pink bollworm larvae.

About 20 green bolls from 20 random plants may be 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 (at least 20-50 eggs will collected in each observation) were observed.

Yields at harvest were recorded.

Results

Results revealed that BIPM package plots recorded higher nos. of good opened bolls per plant(0.47), least no.of bad opened bolls (1.57/plant) and was on par with farmers practices (0.39/plant).More no.of parasitized larvae/plant (6.07/plant) and boll infestation (46.23%) and yield of 3.99a/acre were recorded in the BIPM plots. Farmers practices recorded 0.23 good bolls/plant, 0.39% bad opened bolls/plant, lesser no.of parasitized larvae/plant (0.67) and least infestation by boll dissection (32.22%). Yield in farmers plot was 4.76 q/acre, while control plot recorded least yield (1.23 q/acre) and maximum boll infestation 69.09%. (Table 152 .BIPM package was found to be on par with Farmers practices in recording lesser boll infestation and higher yield than control plots.

Table 152. Bio-intensive management of Pink Bollworm in *Bt* cotton

Treatment	No.of good opened bolls (no./plant)	No.of Bad opened bolls (no./plant)	No.of rosette flowers (no./plant)	No.of green bolls (no./plant)	N.ofparasitised larvae (no./plant)	Infestation (%) by Boll dissection	Yield (q/acre)
BIPM	0.47 (0.96)[a]	1.57 (1.39)[a]	0.7	6.26 (2.11)	6.07 (2.56)[a]	46.23 (39.76)[a]	3.99[a]
FP	0.23 (0.81)[b]	0.39 (0.93)[a]	0.92	5.3 (2.24)	0.67 (1.06)[b]	32.22 (34.56)[a]	4.76[a]
Control	0.15 (0.78)[c]	1.78 (1.43)[c]	0.75	4.07 (1.90)	2.5 (1.79)[c]	69.09 (59.40)[b]	1.23[b]
CV (%)	14.42	14.23	26.25	12.99	7.65	14.67	15.27
CD 1%	0.13	0.42	NS	NS	0.25	13.83	0.87

Fig:44. Pheromone trap catch in BIPM plots

8.2.2. TNAU, Coimbatore

Biointensive management of pink bollworm on *Bt* cotton

Table 153.

Location	Maththireddipalayam
Geographical coordinates	11.251521° N, 77.152139° E
Variety	Boll guard II
D/S	19.06.20

Results:In the field trial conducted in a farmer's field at Mathireddypalayam, Annur Block, Coimbatore Dt., rosette flowers due to pink boll worm was 1.25 per cent in BIPM plots while it was 3.00 per cent in the control plot on 110 Days After Sowing (DAS). Green boll damage due to pink boll worm was 8.90 per cent in BIPM plots while it was 13.00 per cent in the control plot on 110 DAS. Observations on bad open bolls were taken on 130, 140 and 150DAS. There was 14.61 per cent reduction in the bad open bolls in BIPM module whereas 40.00 per cent reduction in bad open bolls was observed in insecticides treated plots. The yield was maximum in insecticide sprayed plots (1976Kg/ha) followed by 1684Kg/ha and 1416Kg/ha in BIPM and control plots respectively. The CB ratios were 1:2.19 and 1:2.13 for BIPM and insecticide treatments respectively (Table 154).

Table 154. Bio-intensive management in Pink bollworm on Bt cotton

Treatments	Rosette flowers % * 110DAS	Green boll damage % * 110DAS	Bad open bolls % *			Mean Bad open bolls%	% decrease from control	Yield Kg/ha**	% increase over control	CB ratio
			130DAS	140DAS	150DAS					
T1: *Trichogrammatoidea bactrae*@2cc/ac+ pheromone traps	1.25 (5.84)[a]	8.9 (3.22)[b]	24 (29.28)[b]	27 (31.19)[b]	30 (33.16)[b]	27.00	14.61	1683.77 (41.03)[b]	18.88	2.13
T2:Insecticides spray	0.75 (3.88)[a]	6.8 (2.74)[a]	19 (25.69)[a]	21 (27.16)[a]	26 (30.61)[a]	22.00	40.00	1976.15 (44.45)[a]	39.52	2.19
T3: Control	3.00 (9.73)[b]	13.0 (3.71)[c]	32 (34.35)[c]	36 (36.82)[c]	33 (35.02)[c]	33.66	-	1416.39 (37.59)[c]	-	1.57
SEd	1.106	0.201	0.997	0.793	0.699	-	-	0.201	-	-
CD(P=0.05)	3.386	0.395	2.992	2.429	2.140	-	-	0.435	-	-

DAS – Days After Sowing

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

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

Values are mean of eight replications

8.2.3 PDKV, Akola:

"Management of pink bollworm by using *Trichogrmmatoideabactrae* on *Bt* cotton"

Experimental Details:

Date of Sowing: 29.06.2020

Table 155.

Variety		Ajeet 155
Layout	:	Randomised Block design
Plot size- Area	:	T1 – 3888 m^2 T2 – 3888 m^2 T3 – 3888 m^2
Treatments	:	T1: Standard practice of plant protection till 55[th] day or appearance of PBW. Erection of pheromone traps (Funnel type). 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. 1[st] spray – Triazophos 40 EC @ 20 ml/10 Lt 2[nd] spray – Spinosad 45 SC @ 2.2 ml/10 Lt 3[rd] spray – B-cyfluthrin 2.5 %@10 ml/10 Lt 4[th] spray – Fenpropathrin 10 EC @ 10 ml/10 Lt T3: Control
Replications	:	8
Methodology and 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.

For sucking pest management – Spraying of Imidacloprid 17.8 SL @ 2 ml/ 10 Lt and Acetamiprid 20 SP@ 2 g/10 Lt were undertaken as blanket spray.

Results

The data on number of rosette flowers, presented in Table 156 revealed that there were significant differences among the treatments as significantly minimum infestation of 0.19 rossette flowers was recorded in insecticidal treatment followed by 0.25 flowers per 10 plants in *T. bactrae* treatment, both being significantly superior to untreated control.

The data on green boll damage was also recorded to be significant and both Treatments T2 and T1 with 4.58 and 5.42 % green boll damage were found at par with each other and significantly superior to untreated control that has recorded maximum green boll damage (15.42 %).

The data recorded on per cent bad open bolls at picking revealed that significantk minimum bad open bolls were recorded in treatment T2 with 20.13 % bad open bolls, followed by treatment T1 with 21.38%, both the treatments being at par with each other and significantly superior over untreated control which has recorded 42.81 % bad open bolls. The data on yield of seed cotton revealed that the treatment T2 recorded significantly maximum yield of 1302.73 Kg/ha seed cotton, followed by treatment T1 recording 1257.46 Kg/ha seed cotton. Both these treatments were significantly superior over untreated control that has recorded minimum yield of 671.81 Kg/ha seed cotton.

Table 156. Effect of different treatments on incidence of Pink bollworm (2020-21)

Treatments	Number of Rosette Flowers/plant	Green boll damage (%)	bad open bolls (%)	Seed Cotton Yield Kg/ha
T1-*Trichogrammatoidea bactrae*	0.25 (0.86)*	5.42 (13.46)**	21.38 (27.54)**	1257.46
T2- recommended insecticides	0.19 (0.82)	4.58 (12.36)	20.13 (26.65)	1302.73
T3- Untreated control	0.72 (1.10)	15.42 (23.12)	42.81 (40.87)	671.81
F Test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.05	1.88	0.71	28.73
CD at 5 %	0.16	5.63	2.15	87.17
CV	16.31	34.01	6.34	7.54

Note: Figures in parentheses are$\sqrt{(x+0.5)}$, (*) and Arc sin (**) transformation values

9. Sugarcane

9.1.Field efficacy of EPN strains against white grubs in sugarcane (MPKV, Pune).

2019-20

In efficacy studies of EPN, *H. indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation) recorded clump mortality of 11.41 % and white grub reduction over control was 54.72 % with cane yield of 141.00 Mt/ha as against 9.18%, 63.57 % and 160.30 Mt/ha, respectively in chemical check (Fipronil 40% + imidacloprid 40 WG @ 0.4 g /L). Whereas, untreated control recorded clump mortality of 25.20 % and cane yield of 114.00 Mt/ha.

2020-21

The lowest mean clump mortality of 7.08 % by white grub was recorded in T_{5-} chemical treatment with Fipronil 40% + imidacloprid 40 WG @ 0.4 g /L, while it was 8.53% in case of EPN treatment *H. indica* WP. Highest white grub reduction (70.64%) was recorded in chemical treatment (T_5) followed by EPN treatment *H. indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation) with 64.63 %. The untreated control recorded clump mortality of 24.12 %. However, harvesting of sugarcane crop is awaited and hence this trial is in progress.

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

2019-20

In studies on dose application of EPN strain, T_1- *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) treatments recorded clump mortality of 7.09 % and 8.79 %, while white grub reduction over control was (72.78 % and 66.25%) and yield of (146.83 Mt/ha and 144.57 Mt/ha), respectively. The chemical check (Fipronil40% + imidacloprid 40 WG @ 0.4 g /L) treatment, however, recorded lowest clump mortality of 6.29 % and white grub reduction over control was 75.85 % and cane yield of 157.17 Mt/ha. In untreated control plots, the clump mortality was maximum (26.05 %) with lowest cane yield of 110.17 mt./ha.

2020-21:

Lowest mean clump mortality of 6.15 % was recorded in chemical treatment with Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L followed by 7.85% in *H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation) and 8.13% inT_6 - *H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation) treatments. The highest white grub reduction (79.59 %) was recorded in chemical treatment. Amongst EPN strains, highest white grub reduction (69.64 %) and (68.56 %) was recorded in *H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation and Commercial formulation), respectively. However, harvesting of sugarcane crop is awaited and hence this trial is in progress.

Year 2019-20:

The experiment was laid out on the farmers' field at Dogargaon village of Haveli Tahasil of Pune district. Planting of Sugarcane var. Co. 86032 was done on 15.07.2019 having plot size of 8 x 5 m with spacing 90 x 60 cm in Randomized Block Design with six treatments replicated four times. Two applications of EPN strains and insecticide were given on 9.9.2019 and 14.10.2019. Harvesting of sugarcane is completed on 28.10.2020.

Year 2020-21 :

The experiment was laid out on the farmers' field at Lonikand village of Haveli Tahasil of Pune district. The planting of sugarcane variety Co. 86032 was done on 14.07.2020 with 90 x 60 cm spacing in plot size of 8 x 5 m in Randomized Block Design having six treatments replicated four times. Two applications of *H. indica* and insecticide were given on 7.9.2020 and 9.10.2020.

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.

Results (2019-20):

Clump Mortality/15 clumps / plot due to white Grub: The data on efficacy of EPN strains against white grubs in sugarcane are presented in Table 157 It is seen from Table 157 that, pre count clump mortality due to white grub was ranged from 3.32 to 5.12/ 15 clumps in plot. The 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 clump mortality/15 clumps / plot due to white grub: Clump mortalityat 30 and 60 days after first and second applicationswas 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 with T_3 : *S. carpocapsae* @ $1.0x10^5$/ m^2 (NBAIR WP formulation) and recorded 14.30 % clump mortality, where as in untreated control clump mortality was 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 applications: 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 - *H. bacteriophora* @ $1.0x10^5$/ m^2 and T_3 - *S. carpocapsae* @ $1.0x10^5$/ m^2 (49.12 and 43.25 %), respectively.

Cane Yield (Mt/ha): The cane yield was ranged from114.00 to 160.30 Mt/ha. The highest cane yield 160.30 Mt/ha was recorded in chemical treatment T_5 (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L)) which was at par with all the treatments except untreated control (114.00 Mt/ha). The chemical treatment was at par withall the EPN treatments, T_1 - *H. indica* @ $1.0x10^5$/ m^2 which recorded 141.00 Mt/ha followed by T_2 - *H. bacteriophora* @ $1.0x10^5$/ m^2 with 139.38 Mt/ha. after that T_4 - *S.abbasi* @ $1.0x10^5$/ m^2 with 139.31 Mt/ha and T_2 - *H. bacteriophora* @ $1.0x10^5$/ m^2 which recorded 139.13 Mt/ha

Results (2020-21):

Clump Mortality/15 clumps in plot due to white Grub: The data on efficacy of EPN strains against white grubs in sugarcane is presented in Table 158. It is seen from Table 158 that, pre count clump mortality due to white grub varied from 3.33 to 6.66 / 15 clumps in plot and no significant differences were observed amongst the treatments. In post count observations at 30 and 60 days after first and second applications significant differences amongst all the treatments were recorded except at 30 days after first application.

Mean clump mortality/15 clumps in plot due to white grub: Clump mortality oftwo applications are pooled and mean clump mortality is work out. Mean clump mortality ranged from 7.08 to 24.12 %. Lowest clump mortality (7.08 %) was recorded in T_5 -

chemical control (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L) treatment which is at par with all EPN strains except *S. abbasi* @ 1.0x10^5/ m^2 (NBAIR WP formulation) and recording 13.00 % clump mortality as against untreated control recorded (24.12 %). Amongst EPN, the promising treatment with T_1 - *H. indica* @ 1.0x10^5/ m^2 followed by T_2 - *H. bacteriophora* @ 1.0x10^5/ m^2 (NBAIR WP formulation) and T_3- *S. carpocapsae* @ 1.0x10^5/ m^2 (NBAIR WP formulation) recorded clump mortality of 8.53 % , 10.11 and 11.30 %, respectively.

White grubper cent reduction over control after two application: Highest (70.64%) white grub reduction was recorded in T_5 - chemical control treatment (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L). The next best treatments are T_1 - *H. indica* @ 1.0x10^5/ m^2 (64.63 %), T_2 -*H. bacteriophora* @ 1.0x10^5/ m^2 (58.08), T_3 *S. carpocapsae* @ 1.0x10^5/ m^2 (53.15) and T_4- *S. abbasi* @ 1.0x10^5/ m^2 (46.10 %).

Table 157. Efficacy of EPN strains against white grubs in sugarcane (Year 2019-20)

Tr.. No	Treatment	Pre-count	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.	Cane Yield Mt./ha.
			Post count 30 DAA 1st appln.	Post count 60 DAA 1st appln.	Post count 30 DAA 2nd appln.	Post count 60 DAA 2nd appln.			
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	141.00 [a]
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	139.38 [a]
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	139.13 [a]
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 [b] (20.50)	50.19	139.31 [a]
T_5	Chemical control (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/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	160.30 [a]
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)	-	114.00 [b]
SE ±		2.90	1.94	0.68	0.99	0.93	1.23	-	7.76
CD at 5%		NS	NS	2.04	2.99	2.81	3.49	-	23.38
CV (%)		55.62	25.88	6.40	8.69	6.92	11.42	-	11.17

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

Table 158. Efficacy of EPN strains against white grubs in sugarcane (Year 2020-21)

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 appln.	Post count 60 DAA 1st appln.	Post count 30 DAA 2nd appln.	Post count 60 DAA 2nd appln.		
T_1	*H. indica* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	5.00[a] (11.25)*	5.00[a] (11.94)	6.66[a] (14.66)	8.45[a] (16.71)	14.04[a] (20.19)	8.53[a] (15.95)	64.63
T_2	*H. bacteriophora* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	3.33[a] (7.50)	5.00[a] (11.94)	8.33[a] (16.57)	10.24[a] (18.46)	16.89 (23.98)	10.11[a] (17.74)	58.08
T_3	*S. carpocapsae* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	3.45[a] (7.61)	6.66[a] (14.96)	6.66[a] (14.96)	13.33[b] (21.41)	18.56[a] (22.57)	11.30[a] (18.47)	53.15
T_4	*S. abbasi* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	6.66[a] (15.01)	6.78[a] (15.09)	10.00[b] (18.59)	13.57[b] (21.61)	21.65[b] (26.40)	13.00[b] (20.32)	46.10
T_5	Chemical control (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L)	5.00[a] (11.25)	5.00[a] (11.94)	5.00[a] (11.94)	6.66[a] (14.96)	11.66[a] (18.19)	7.08[a] (14.25)	70.64
T6	Untreated control	5.00[a] (11.25)	11.88[a] (19.80)	19.51[c] (26.19)	25.34[c] (30.11)	40.00[c] (36.19)	24.12[c] (28.17)	-
SE ±		4.17	2.26	1.40	1.20	1.51	1.64	-
CD at 5%		NS	NS	4.22	3.63	4.58	4.65	-
CV (%)		78.45	31.61	16.37	11.73	12.33	17.18	-

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

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

Year 2019-20 :The experiment was laid out on the farmers field at Dogargaon village of Haveli Tahasil of Pune district. The planting of sugarcane variety Co. 86032 was done on 15.07.2019, having plot size of 8 x 5 m with spacing 90 x 60 cm in Randomized Block Design having eight treatments replicated thrice. Two applications of *H. indica* and insecticide were given on 9.9.2019 and 14.10.2019. Harvesting of sugarcane is completed on 25.10.2020.

Year 2020-21:

The experiment was laid out on the farmers field at Lonikand village of Haveli Tahasil of Pune district. The planting of sugarcane variety Co. 86032 was done on 14.07.2020having plot size of 8 x 5 m with spacing 90 x 60 cm in Randomized Block Design having eight treatments replicated thrice. Two applications of *H. indica*and insecticide were given on 7.9.2020 and 9.10.2020.

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

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.

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 159. It is seen from Table 159 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 showed the significant differences among the treatments except at 30 days after first application.

Mean clump mortality/15 clumps plot due to white grub: For comparison of 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 (75.85 %) was recorded 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.
Cane Yield (Mt/ha): The cane yield was ranged from110.17 to 157.17 Mt/ha.The highest cane yield 157.17 Mt/ha was recorded in T_7 treatment - Chemical control (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L) which was 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), T_2 -*H. indica* @ 2.0 x 10^5/ m^2(NBAIR WP formulation) and T_5 - *H. indica* @ 2.0. x 10^5/ m^2 (Commercial WP formulation), and recorded cane yield of 146.83, 144.57 140.17 and 138.83 Mt/ha, respectively.

Results (2020-21):

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 160. It is seen from Table 160 that pre count clump mortality due to white grub is ranged from 2.22 to 6.66/ 15 clumps in plot. In case of post count observation at 30 and 60 days after first and second applications, significant differences among treatments were recorded except at 30 days after first application.

Mean clump mortality/15 clumps plot due to white grub: Clump mortality of two applications are pooled and mean clump mortality was work out. Mean clump mortality was ranged from 6.15to 25.86 %. Lowest clump mortality was recorded (6.15 %) in T_7- chemical control (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L) which is at par with T_3 - *H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation) with 7.85 % mortality and T_6 - *H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation) with 8.13 % mortality.

White grubper cent reduction over control after two applications: Highest white grub reduction over control was recorded (79.59 %) in T_7 - Chemical control (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L) and the next best treatment is T_3 - *H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation) with 69.64 % reduction followed by T_6 - *H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation) with 68.56 per cent reduction in grubs.

Table 159. 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.)	Cane yield (Mt./ha)
		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	130.10^{b}
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	140.17 ^{a}
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	146.83 ^{a}
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	129.33 ^{a}
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	138.83 ^{a}
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	144.57 ^{a}
T_7	Chemical control(Fipronil 40% + imidacloprid 40 WG @ 0.4 g/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	157.17 ^{a}
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)	-	110.17 ^{c}
SE ±		3.61	3.04	0.94	0.77	0.65	1.44	-	6.14
CD at 5%		NS	NS	2.85	2.34	1.96	4.09	-	18.63
CV (%)		63.08	39.75	8.19	5.80	4.37	14.01	-	7.83

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

Table 160. Efficacy of EPN strains against white grubs in sugarcane (Year 2020-21)

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)	4.44^a (10.93) *	8.88^a (17.11)	11.58^b (19.71)	13.33^b (21.41)	14.65 ^{b} (22.5)	12.11^b (20.18)	53.17
T_2	*H. indica* @ 2.0 x 10^5/ m^2 (NBAIR WP formulation)	6.66^a (14.96)	6.66^a (14.96)	11.11^b (19.26)	11.27^b (19.44)	14.28 (22.2)	10.83^b (18.97)	58.12
T_3	*H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation)	4.44^a (10.93)	4.44 ^{a} (10.93)	6.66 ^{a} (14.96)	6.66^a (14.96)	13.65^a (21.68)	7.85^a (15.63)	69.64
T_4	*H. indica* @ 1.0 x10^5/ m^2 (Commercial WP formulation)	4.44^a (10.93)	9.2 ^{a} (17.37)	13.33^b (21.41)	13.96^c (21.94)	16.91^b (24.24)	13.35^b (21.24)	48.37
T_5	*H. indica* @ 2.0. x10^5/ m^2 (Commercial WP formulation)	4.44^a (10.93)	8.88^a (17.11)	11.42^b (19.52)	13.33^b (21.41)	14.65 ^{b} (22.5)	12.07^b (20.13)	53.33
T_6	*H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation)	6.66^a (14.96)	4.44^a (10.93)	6.98^a (15.32)	7.14 ^{a} (15.5)	13.96 ^{a} (21.94)	8.13 ^{a} (15.92)	68.56
T_7	Chemical control(Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L)	2.22 ^{a} (6.9)	2.22 ^{a} (6.9)	4.44^a (10.93)	6.66^a (14.96)	11.27 ^{a} (19.44)	6.15^a (13.06)	79.59
T_8	Untreated Control	2.22 ^{a} (6.9)	13.65^a (21.68)	22.69^c (28.42)	24.9^d (29.91)	42.22 ^{c} (40.52)	25.86 ^{c} (30.13)	-
SE ±		3.19	3.01	1.61	0.84	0.99	1.02	-
CD at 5%		NS	NS	4.89	2.25	3.00	3.01	-
CV (%)		50.51	35.68	14.92	7.32	7.02	10.54	-

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

9.2. Large scale demonstration of *Trichogramma* species against sugarcane borer (MPKV, Pune, OUAT, Bhuvaneswar)

9.2.1. MPKV, Pune

Early shoot borer (ESB), *Chilo infuscatellus* (Snellan) is the key pest of sugarcane in Maharashtra state. The ESB infestation crosses ETL level of 15 % deadhearts in *Suru* sugarcane crop only and in *Adsali* and Pre-seasonal planting seasons, ESB infestation is always below ETL. Hence, release of *Trichogramma* spp. was done in March, 2020 in the in farmers' field at Manjri, Fursungi, Ohawalwadi, Lonikand, Dogargaon villages in Haveli Tahasil in Pune district.

However, due to Pandemic Covid-19 situation and lockdown periodduring April and May, 2020, it was not possible to release the *Trichogramma* spp. in sugarcane fields and trial is vitiated during the year 2020-21.

In Maharashtra , farmers are undertaking sugarcane plantation in three season *viz., Suru* planting – (15th December to 15th February), *Adsali* planting (15th July to 15th August) and *Pre-seasonl* planting (15th October to 30th November).

Early shoot borer (ESB), *Chilo infuscatellus* (Snellan) is the key pest of sugarcane in Maharashtra state. The infestation of ESB is found only in *Suru* sugarcane plantation which crosses ETL level of 15 % deadhearts. Other borers are of minor importance in the state. Hence, the demonstration with release of parasitoids for management of ESB in *Suru* Season is conducted. During 2020 -21, the release of *Trichogramma* spp. was done in March, 2020 in the in farmers' field at Manjri, Fursungi, Ohawalwadi, Lonikand, Dogargaon villages in Haveli Tahasil in Pune district.

However, due to Pandemic Covid-19 situation and lockdown period during April and May, 2020, it was not possible to release the *Trichogramma* spp. in sugarcane field and trial is vitiated.

9.2.2: OUAT, Bhbaneswar

Large scale demonstration of *Trichogramma spp.* against sugarcane borers.

Area covered: 5ha of sugarcane

Variety :(SABITA)

Location: Aonlamada& ranipada of Nayagarh District.

No. of beneficiaries: 8

Treatments

T1: Release of *Trichogramma chilonis* (temperature tolerant strain-HTTS) @ 50,000/ha at 10 days interval starting from 45 days after sowing against early shoot borer (ESB). Eight(8) releases were made from Feb. to June 2020. Release of *T. japonicum* was made against top shoot borer (TSB) and internode borer(IB) at 10 days interval starting from Aug.2020. Eight releases of *T. japonicum* were made(BIPM package)

T2: Farmers practice (spraying of insecticides like chlorantraniliprole 18.5 SC or Fipronil 5% SC or Chlorpyriphos 50% + cypermethrin 5% basing on appearance of DH%.

T3: Untreated control

Replications: 8

Plot size: 10x10m

Results: The crop was sown in last week of January 2020. Release of *T. chilonis* and *T. japonicum* were done as per treatment schedule and compared with farmers practice and untreated control. Maximum infestation due to ESB, and TSB in BIPM package were 10.4%and 1.94% as against 10.7% and 2.18% in FP indicating comparable level of infestation. But, much higher levels of infestation due to ESB (11.5%) and TSB (3.46%) were recorded in untreated control. Highest cane yield (75.04 t/ha)and B: C ratio (1.72) were recorded in BIPM package which is comparable to FP(72.60/ha). Lowest yield (60.47 t/ha) and B: C ratio (1.38) were noted in untreated control (Table 161).

Table 161. Effect of *Trichogramma* spp. against borer pests of sugarcane (Sabita)

Treatments	Early shoot borer(%)		Top shoot borer(%)		Yield (t/ha)	B:C ratio
	Pre release	Post release	Pre release	Post release		
Release of *T. chilonis* @ 50,000/ha at 10 days interval after 45 DAP & *T. japonicum* 5-6 months after planting	10.4	6.3(2.51)	1.94	0.83	75.04	1.72
Farmers' practice (Pesticide application)	10.7	5.9(2.43)	2.18	0.80	72.60	1.63
Untreated control	9.8	11.5(3.39)	2.14	3.46	60.47	1.38
S.E. (m) ±	-	0.19	-	0.15	1.79	
C.D(p=0.05)	NS	0.58	NS	0.46	5.43	

Figures in the parentheses are square root transformation values

9.2.3. UAS, Raichur

Large Scale Demonstration of *Trichogramma chilonis* (TTS) against sugarcane early shoot borer during 2020-21 **Table 162.**

1.	Crop	Sugarcane
2.	Year	2020-21
3.	Variety	CO- 86032
4.	Month of Sowing	January, 2020
5.	Date of harvest	February, 2021
6.	Experimental Location	Kadalur
7.	Area	10 ha
8.	Treatments Details	
	T_1 : Releases of *T. chilonis* (HTTS)	@ 2,50,000/ha at 10 days intervals 5 releases from 45 days old crop.
	Date of releases :	27-02-2020, 10-03-2020, 21-03-2020, 02-04-2020 and 14-04-2020
	T_2 : Farmers' practice	Spray of Chlorantriniliprole 18.5 SC @ 0.25 ml/lit Date of Spray 10-03-2020
	T_3 : Untreated control	-

9.	Observations	Pre-release infestation, i.e., per cent dead hearts due to ESB and Post-release count of per cent dead hearts at fortnight interval from initiation of parasitoid release up to 4 months. Total cane yield was recorded and expressed as ton per hectare (Plate 11).
10.	Results:	Before treatment imposition dead hearts ranged from 17.50 to 18.75 per cent. Two months after treatment imposition minimum of 1.25 per cent dead hearts were noticed in farmers practice which was followed by release of *T. chilonis* (TTS) recorded 1.85 per cent while untreated control recorded 6.50 per cent dead hearts. The highest cane yield of 138.25 t/ha was recorded in farmers practice and it was followed by *T. chilonis* (TTS) release plot 138.25 t/ha while untreated control recorded 123.14 t/ha

Table 163. Large Scale demonstration of *Trichogramma chilonis* (TTS) against sugarcane early shoot borer during 2020-21

Sl. No.	Particulars	Dead hearts (%)* Before release	Dead hearts (%)* After final release	Cane yield (t/ha)
T_1	Releases of *T. chilonis* (TTS)	17.50 (24.73)	1.85 (7.82)	132.80
T_2	Farmers' practice	18.25 (25.29)	1.25 (6.42)	138.25
T_3	Untreated control	18.75 (25.66)	6.50 (14.77)	123.14
S Em$\pm$		0.25	0.18	1.18
CD (P=0.05)		NS	0.56	3.55

*Figures in parentheses are square root transformed values

#Figures in parentheses are arcsine transformed values

9.3. Large scale demonstrations of proven biocontrol technologies against sugarcane stalk borer, *Chilo auricilius* (PAU, Ludhiana)

Large scale demonstrations on the effectiveness of *T. chilonis* against stalk borer, *Chilo auricilius*were carried out over an area of 5010 acres in collaboration with Krishi Vigyan Kendras (KVKs), Regional Station (Gurdaspur) and 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 10-12 times from July to October at 10 days interval @ 50,000/ha and was compared with untreated control. Tricho-cards each having approximately 500 parasitized eggs were cut into 40 strips and were stapled uniformly per acre to the underside of the sugarcane leaves. The incidence of stalk borer in released fields (2.84 %) was comparatively less than untreated control (6.60 %). The yield was also relatively more in released fields (818 q/ha) and as against untreated control (760 q/ha) with higher additional returns (Rs. 16730/- per ha;). 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 56.91 per cent.

Table 164. Large-scale demonstrations using *T. chilonis* against *Chilo auricilius* in sugarcane during 2020

Demonstrations	Mean incidence of *C. auricilius* (%)		Per cent reduction over control
	Biocontrol*	Untreated control	
PAU in collaboration with four sugarcane mills of Punjab (4)	2.96	6.77	56.28
PAU Ludhiana	2.37	5.90	59.83
Overall Mean	2.84[a]	6.60[b]	56.91

*10-12 releases of *T. chilonis* @ 50,000 per ha at 10 days interval during July to October

Table 165. Cost Benefit analysis (2020)

Treatments	Yield (q/ha)	Additional yield over control (q/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)
T. chilonis @ 50,000 per ha	818.0	58.0	17980.00	1250.00	16730.00
Untreated control	760.0	-	-	-	-

Price of sugarcane: Rs. 310/- per quintal during 2020; * includes tricho-card cost

9.4. Efficacy of *Aschersonia placenta* for the management of whitefly in sugarcane ecosystem (ICAR-SBI)

Two types of media were used for assessment of colony growth of *A. placenta*. In the first set, fifteen semisynthetic commercially available standard media were studied while in the second test eight economic media developed from locally available jaggery/molasses were assessed with YpSs Agar as the standard. The economic media consisted of 3% Molasses Agar 10% Jaggery with Agar with or without any amendments or adjustment of pH, 10% and 15% SBI media. Colony growth was observed on 7,14 and 21 days post inoculation. Based on the observations on 7th,14th and 21st days post inoculation, though Oat Meal Agar was the best for radial growth followed by Dextrose Peptone Agar, it could be concluded that the fungus *A. placenta* could grow and sporulate on all the 15 standard media indicating its versatility.On the economic media , two media based on Jaggery, developed at ICAR-SBI proved superior to other jaggery or molasses- based media for colony growth.

Field experiment

A preliminary trial at Perani, Viluppuram district(TN) in a severely affected field with a single application of *A. placenta* against *Aleurolobus barodensis* @1x1012/ha was found to effectively reduce the population.

Mass production of entomopathogenic fungi

i)*A. placenta*

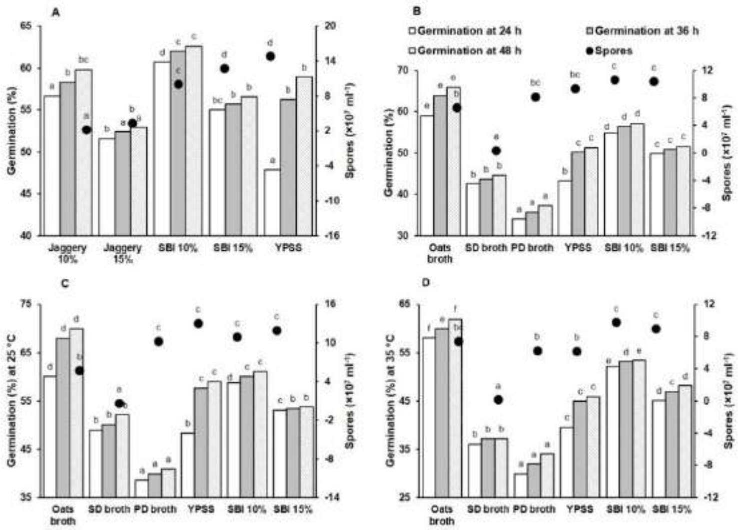


Fig:45. Sporulation and germination of *A. placenta* during liquid fermentation on different media **Table 166.**

Media	Sporulation of *B. bassiana (X* 10 ^{7}/ML)
Jag-10% WITHOUT PH	6.60±2.01BC
JAG -10% WITH PH	7.40±0.87BC
JAG-15% WITHOUT PH	7.60±0.72BC
JAG-15% WITH PH	8.10±0.89 C
SBI-10%	15.00±1.51D
SBI 15%	16.60±2.11D
OATS	5.20 ±1.06B
YPSS	17.33 ±0.61D
PD BROTH	27.17±1.91E
SD BROTH	2.52±0.11 A

Mass production of *B. bassiana* on economic media

In the comparison of 10% and 15% jaggery with or without yeast or peptone, the media were significantly less efficient than the standards YpSs and PDB in spore production of *A. placenta*(Fig.1A). While addition of yeast increased sporulation of *A. placenta*, peptone promoted viability of spores. Comparison of the new media evolved, *i.e*., SBI-10% and 15% with jaggery solutions of 10% and 15% showed significant differences favouring the former two(Fig.1-B). Germination rates of the spores from the SBI media showed superiority of the SBI media.

Comparison of pooled data of experiments with all the standard media at 25˚C as well as 30˚ C showed the significantly better performance of SBI media over OB and SDB and comparable performance with YpSs and PDB(Fig.1C).Though spore production was slightly lesser at 30˚C than at 25˚C, the change was dependent on media (Fig. 1-C and D) but considering both sporulation and germination of spores,SBI-10% was better choice with high initial vigour of fungus and exudates among all media tested, for large scale cultivation of *A.placenta* that can be recommended.

B.bassiana

The spore production of *B.bassiana* was found to be highest in PD broth followed by YpSs medium which was on par with SBI medium at two different concentrations(Table 167).

B.brongniartii

Table 167. Mass production of *B.brongniartii*on economic media

Media	*B.brongniartii* (x 10^7/ml)
Jag-10% WITHOUT PH	2.27±0.47AB
JAG -10% WITH PH	2.63 ±0.37BC
JAG-15% WITHOUT PH	1.17 ±0.44A
JAG-15% WITH PH	1.39 ±0.39A
SBI-10%	6.27 ±1.03D
SBI 15%	7.47 ±1.15E
SD BROTH	1.32 ±0.40A
OATS	3.58 ±0.53C

The spore production of *B. brongniartii* was found to the highest in SBI medium at both concentrations ranging between 6.27 and 7.47 x 10^7/ml at 10 and 15% concentrations respectively(Table 168).

9.5 Efficacy of entomopathogenic fungi for the management of white grub in sugarcane ecosystem (ICAR-SBI)

Field evaluation of EPF against *H. serrata*

Table 168. Field evaluation of EPF against *H. serrata* in sugarcane

Treatment	% grub reduction of *H. serrata* in sugarcane	
	First trial	Second trial
B.bassiana	26.67	13.6
B.bassiana+L	47.70	45.2
B.brongniartii	29.6	36.4
B.brongniartii+L	37.5	49.1
M.anisopliae	65.0	58.4
M.anisopliae+L	80.0	72.2

B.ba+B.br+M.a	71.43	59.4
Lesenta	72.22	78.9
control	15	4.7

In the two field experiments conducted ,all treatments resulted in better control of H.serrata. However, application of *M. anisopliae* led to effective reduction of white grub(*H. serrata*) population in sugarcane. In both trials *M. anisopliae* either alone or in combination with Lesenta resulted in 58.4 to 80% grub reduction post application.

Biological Control of Oilseeds

10.Biological Control Groundnut Pests

10.1.Evaluation of locally isolated potential entomopathogenic fungi, *Metarhizium rileyi (KK-Nr-1)* against groundnut leaf miner and tobacco caterpillar in ground nut ecosystem (UAS, Raichur)

1.Crop: Groundnut
2.Soil: Deep cotton soil
3.FYM: 10t/ha
4.Variety : G852
5.Fertilizers : 100:50:50 NPK kg/ha
6.Irrigation: Drip Irrigation
7. Experimental details
a) Design: RBD
b) No. of treatments: 7
c) No. of replications: 3
d) Plot size 6.00 m x 6.00 m
e) Spacing: 60.0 cm x 30.0 cm
f) Date of Sowing: 30/06/2020
g) Target pests: Leaf miner and Defoliator
8.Date of treatments imposition: Date of treatments imposition
9.Method of application and equipment: Knapsack sprayer with hollow cone nozzle

Plate 11

10.Quantity of water used for dilution: 500 litres/ha
Treatment Details:
T1: *Metarhizium rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L)
T2: *Metarhizium rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) @ 5.0 g/l
T3: *Beauveria bassiana* 1×10^8 spores/g (ICAR-NBAIR-Bb-5a) @ 5.0 g/l
T4: *Metarhizium anisopliae* 1×10^8 spores/g (ICAR-NBAIR-Ma 4) @ 5.0 g/l
T5: BtG4 2% (ICAR-NBAIR) @ 2.0 ml/lt
T6: Emamectin benzoate 5 SG @ 0.2 gm/lit
T7: Untreated control
Observations:
Number of active miner per 20 leaflet -Leaf miner
Number of larvae per mrl - *Spodoptera*
Pod and Halumyield (Plate 12).

Results:

One day before spray leafminer population ranged from 12.18 to 13.62 active mines per 20 leaflets and it was statistically non-significant. Seven days after spray, lowest of 4.16 active mines per 20 leaflets was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) which was at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) which recorded 4. 62 active mines per 20 leaflets and similar trend were noticed at ten days after treatment imposition. Among the biocontrol agents highest per cent reduction of leafminer over control was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) which recorded 74.29 per cent and it was at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS-Dharwad) which recorded 70.81 per cent. Similarly, the defoliator, *Spodoptera* population ranged from 3.34 to 3.86 per meter row length among the treatments at one day before treatment imposition. On seven days lowest of 1.72 larvae per meter row length was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) which was at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) which recorded 1.88 larvae per meter row length and similar trend was noticed on ten days after spray. The highest per cent reduction of defoliator was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) (61.08 %) and at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) (57.84%). Among the biocontrol agents highest pod and halum yield of 21.35 q/ha and 30.92 q/ha was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) which was at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) which recorded 20.81 q/ha and 30.16 q/ha pod and halum yield (Table 169)

Table 169. Evaluation of locally isolated potential entomopathogenic fungi, *Metarhizium rileyi (KK-Nr-1)* against groundnut leaf minerand tobacco caterpillar in ground nut ecosystem during 2020-21.

Sl. No.	Treatment Details	Dosage (g/l)	Leafminer (Active mines/20 leaflets)			ROC (%)	Defoliator (No. of larvae/ mrl)			ROC (%)	Yield (q/ha)	
			IDBS	7 DAS	10 DAS		IDBS	7 DAS	10 DAS		Pod	Halum
T_1	*Metarhizium rileyi* (KK-Nr-1)	1×10^8 @ 5gm/l	12.58 (3.62)	4.16 (2.16)	2.34 (1.69)	74.29 (59.53)	3.68 (2.04)	1.72 (1.49)	1.16 (1.29)	61.08 (51.40)	21.35	30.92
T_2	*Metarhizium rileyi* (UAS-Dharwad)	1×10^8 @ 5gm/l	13.62 (3.76)	4.62 (2.26)	2.76 (1.81)	70.81 (57.30)	3.72 (2.05)	1.88 (1.54)	1.24 (1.32)	57.84 (49.51)	20.81	30.16
T_3	*Beauveria bassiana*	1×10^8 @ 5gm/l	12.18 (3.56)	5.68 (2.49)	3.42 (1.98)	64.00 (53.13)	3.58 (2.02)	1.94 (1.56)	1.38 (1.37)	55.14 (47.95)	20.16	30.08

	(ICAR-NBAIR-Bb-5a)										
T_4	*Metarhizium anisopliae* (ICAR-NBAIR-Ma 4)	1×10^8 @ 5gm/l	13.06 (3.68)	7.32 (2.80)	4.18 (2.16)	54.51 (47.59)	3.86 (2.09)	2.08 (1.61)	1.96 (1.57)	45.41 (42.36)	18.50	28.23
T_5	BtG4 2% (ICAR-NBAIR)	2.0 ml/lt	12.42 (3.59)	8.46 (2.99)	4.56 (2.25)	48.50 (44.14)	3.34 (1.96)	2.76 (1.81)	2.28 (1.67)	31.89 (34.38)	17.25	27.55
T_6	Emamectinbenzoate 5 SG	0.2 g/lt	13.48 (3.74)	2.68 (1.78)	1.04 (1.24)	85.28 (67.44)	3.76 (2.06)	1.12 (1.27)	0.46 (0.98)	78.65 (62.48)	25.61	32.96
T_7	Untreated control	-	12.68 (3.63)	12.76 (3.64)	12.52 (3.61)	0.00 (0.00)	3.64 (2.03)	3.72 (2.05)	3.68 (2.04)	0.00 (0.00)	15.50	20.23
S Em±			0.41	0.06	0.03	-	0.38	0.05	0.02	-	0.51	0.43
CD (P=0.05)			NS	0.19	0.10	-	NS	0.16	0.07	-	1.54	1.29

*Figures in parentheses are square root transformed values

#Figures in parentheses are arcsine transformed values

11. Biological Control Mustard Pests

11.1.Frontline demonstration on biological control of insect pests of mustard (CAU, Pasighat)

Technical programme

Year of start: 2020-21

Location: Farmers field, YagrungTodeng village, East Siang district, Arunachal Pradesh

Crop and Variety: Mustard, PM-29

Area: 4 ha

Treatments: 02

Plot size: 02 ha

Treatment details:

Treatment 1: BIPM Module: Spraying of Neem oil 1500 ppm @ 2 ml/L and *Lecanicillium lecanii* NBAIR 1×10^8 spores/g @ 5g/lit and application of *Beauveria bassiana*/*Metarhizium anisopliae* @0.05% and Bt 2% for defoliators*.

Treatment 2: Farmers' practice(Untreated control/Natural control as farmers of this region were not interested to apply any sort of management practices against mustard aphids).

Observations

Aphids: Aphid population/plant were recorded from ten randomly selected plants at weekly interval .

Incidence of defoliators were very low

Natural enemies– Coccinellids and syrphid flies were recorded at 15 days interval.

Yield (seeds): q/ha

Table 170. Efficacy of BIPM module against insect pests of mustard

Treatments	Aphids/twig	Natural enemies/twig	Yield (q/ha)
BIPM Module	25.12	4.11	9.36
Farmers practice	41.92	5.47	6.44
't' value	3.05*	1.85*	7.02*
Table $t_{0.05}$	2.78	2.77	2.26

*Significant at $t_{0.0.5}$

Results:

The data on the efficacy of BIPM module in reducing the pest population in comparison to farmers practice is presented in Table No.170 . The plots treated with farmers' practices recorded highest aphid population (41.92/plant), followed by the BIPM module (25.12 aphids/plant) treated plots. Although, the farmers practice recorded the highest number of natural enemies (coccinellid beetles and syrphid flies) *i.e.* 5.47 per plant, it was found statistically at par with those recorded in BIPM module (4.11/plant). Highest yield (9.36 q/ha) was recorded in the BIPM module treated plots followed by the plots treated with farmers practices (6.44 q/ha).

A field day was organized at farmer's field, YagrungTodeng village on 19th Dec 2020 to popularize this technology Around 30 farmers including 25 women farmers participated the programme. The farmers were exposed to the ecofriendly management practices to control mustard aphids.

Fig:46. Mustard aphids

Fig:47. Coccinellid grub and adult beetles

Fig:48. FLD on 'Biological Control of Insect Pests of Mustard' at farmers field, Yagrung Todeng, East Siang, Arunachal Pradesh

11. 2.Field evaluation of bio-pesticides against mustard aphid (UBKV, Pundibari)

Technical programme

Agro-climatic zone: Terai zone

Season: Rabi, 2020-21

Plot size: 5x 4 m

Layout: RBD

Replication: Three

Treatment details:

T1- *Beauveria bassiana*NBAIR Bb-5a (1 × 10^8spores/g) @ 5g/lit

T2-*Metarhizium anisopliae*NBAIR Ma-4 (1×10^8spores/g) @ 5 g /lit

T3- *Lecanicillium lecanii* NBAIR VI-8 (1×10^8spores/g) @ 5g/lit

T4- Azadirachtin 3000ppm @ 2.5 ml/lit

T5- Imidacloprid 17.8 SL @ 0.4ml/lit.

T6- Control

Spray schedule: Two sprays at 15 days interval (First: 13.01.2021 & Second: 29.01.2021)

Results:

It was observed that all the treatments were superior over control. Imidacloprid 17.8 SL @0.4 ml/lit treated plots showed the lowest number of aphid per shoot after first and second spray (8.33 and 1.67 aphid per shoot respectively). Among the selected bio-pesticides, Azadirachtin 3000 ppm @ 2.5 ml/lit treated plots showed the lowest number of aphid per shoot followed by *Beauveria bassiana* .

The highest yield was recorded from Imidacloprid 17.8 SL treated plots (12 q/ha) followed by Azadirachtin 3000 ppm treated plots (9.17 q/ha) and *Beauveria bassiana* (7.5 q/ha). *Metarhizium anisopliae* treated plots recorded low yield (6.33 q/ha).

Table 171. Evaluation of bio-efficacy of some bio-pesticides against mustard aphid

Treatment	Population of mustard aphid/ shoot								Yield of yellow sarson (B-9) (Qt./ha)	Percent yield increase over Control (%)
	First spray				Second spray					
	PT	3DAS	7DAS	14DAS	PT	3DAS	7DAS	14DAS		
T1- *Beauveria bassiana*NBAIR Bb-5a (1 × 10^8spores/g) @ 5g/lit	23.33 (4.82)	20.67 (4.54)	16.67 (4.08)	17.33 (4.16)	17.33 (4.16)	13.33 (3.65)	13.00 (3.60)	11.00 (3.31)	7.50 (2.74)	25.00
T2-*Metarhizium anisopliae*NBAIR Ma-4 (1×10^8 spores/g) @ 5 g /lit	25.33 (5.03)	22.00 (4.69)	20.00 (4.47)	19.00 (4.35)	19.00 (4.35)	17.67 (4.20)	16.00 (4.00)	13.33 (3.65)	6.83 (2.61)	13.89
T3- *Lecanicillium lecanii* NBAIR VI-8 (1×10^8 spores/g) @ 5g/lit	23.00 (4.79)	21.67 (4.65)	19.00 (4.36)	18.33 (4.28)	18.33 (4.28)	16.33 (4.04)	15.33 (3.91)	14.33 (3.78)	7.17 (2.67)	19.44
T4- Azadirachtin 3000ppm @ 2.5 ml/lit	19.67 (4.40)	15.67 (3.95)	11.00 (3.29)	13.67 (3.69)	13.67 (3.69)	12.33 (3.51)	11.67 (3.41)	9.00 (3.00)	9.17 (3.03)	52.78
T5- Imidacloprid 17.8 SL @ 0.4ml/lit.	20.00 (4.46)	4.67 (2.10)	2.00 (1.38)	8.33 (2.85)	8.33 (2.85)	4.00 (1.93)	2.00 (1.38)	1.67 (1.24)	12.00 (3.45)	100.00
T6- Control	19.33 (4.37)	28.67 (5.35)	37.33 (6.08)	38.67 (6.22)	38.67 (6.22)	38.00 (6.15)	37.67 (6.12)	42.67 (6.53)	6.00 (2.44)	
SEm (±)		0.13	0.24	0.13	0.13	0.23	0.17	0.17	0.12	-
CD (at 5%)	N.S.	0.41	0.75	0.42	0.42	0.74	0.55	0.55	0.39	-
CV (%)		5.47	10.75	5.56	5.56	10.57	8.33	8.33	7.83	-

PT- Pre-treatment DAS- Days after spray * Figures in the parenthesis are square root transformed values.

Fruit crops

12. Banana

12.1 Bio-efficacy of entomopathogens against Banana fruit and leaf scarring beetles, *Nodostoma subcostatum*

Experimental details:

Location: Farmers' field, Rupahi, Nagaon

Target pests: Banana fruit and leaf scarring beetles, *Nodostoma subcostatum*

Plot size: 1000 m^2

Variety: Cavendish (CV-Jahaji)

Replication: 4 RBD

Plot size: 7m x7.5 m

Date of planting: 1-year ratoon crop

Fertilizer dose: 110:33:330 g N: P: K/ plant

Treatment:6

Treatment details:

T1: Four sprays of Neem product (Azadiractin, 1500 ppm) @ 5ml/lit

T2: Four-time filling of Leaf axil with *Beauveria bassiana* (AAU Culture @ 10^8 spores),5 ml /lit

T3: Four spray of *Beauveria bassiana* (AAU Culture) @ 10^8spore) 5 ml /lit

T4: Bunch covering with plastic bags.

T5: Sprays Cholropyrifos20EC @ 2.5 ml/lit

T6: Untreated control

Observations: The presence of the mean number of scarring beetle on randomly selected plants (5 nos) were recorded at 3, 7 and 10 days after treatments. The Per cent infested fingers per bunch were recorded. Entomopathogenic fungi, neem formulation and Chloropyriphos 20 EC were applied thrice at 15 days interval.

Table 172. Bioefficacy of entomopathogen against *Nodostoma subcostatum* (Beetles/plant)

Treatments	Pre-treatment count	Post treatment count *				Reduction over control (%)	Fruit damage (%)
		Ist spray	IInd spray	IIIrd spray	Mean number of beetle/ plant		
T1: Neem product (Azadiractin) @ 5ml/lt	12.72	13.55	11.40	9.15	11.37^{d}	19.93	13.90
T2:Leaf axil with *Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	13.11	12.80	10.80	8.60	10.73^{c}	24.44	12.20
T3:*Beauveria bassiana*(AAU Culture) @ 10^8 spore / ml	12.86	13.40	12.40	9.00	11.60^{d}	18.31	13.10

T4:Bunch covering with plastic bags	12.77	11.80	10.55	6.80	9.72^{b}	31.55	9.55
T5:Cholropyrifos20Ec @ 2.5 ml/l	13.01	11.30	9.80	4.80	8.63^{a}	39.23	7.53
T6:Untreated control	12.76	13.45	14.10	15.05	14.20^{e}		17.90
CV %		3.17	4.04	5.62	2.83		
CD =0.05	NS	0.61	0.70	0.75	0.47		NS

Mean of three observations

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

Results: Among the treatments, covering the bunches with the perforated plastic bagwas effective in reducing the beetle population (9.72/plant) with a 31.55 per cent reduction over control. Among the entomopathogens leaf axil filling of *Beauveria bassiana* (AAU Culture) recorded 10.73/plant followed by spraying of *B. bassiana* that effected 18.31 per cent reduction over control. Chloropyriphos 20 EC @ 2.5ml /lit was effective over the neem and entomopathogens in suppressing the beetle population (8.63/plant) with a 39.23 % reduction over control. The highest number of beetles (14.20/plant) was recorded in the untreated control plot. There was no significant difference among the treatment on per cent fruit damage mean fruit damage.

Plate 4: View of Experimental plot of Banana

Fig:49.

13. Papaya

13.1 Monitoring and record of the incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts

13.1.1 AAU, Anand

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

Year of start: 2010-11

Methodology:

The survey was conducted in randomly selected villages of Anand district to record the infestation of papaya mealybug,*Paracoccusmarginatus*.

The percentage of plants infested with mealybug was assessed by observing 25 randomly selected plants and the intensity of damage was determined.

Observations recorded:
Crop plants infested
Non-hosts crop and weeds infested
Chemical pesticides if any used with dose
Existing natural enemies in 25 randomly selected plants
Results:
During the survey, trace incidence (<1%) of papaya mealybug was noticed in three orchards (Table 173). The parasitoid *Acerophagus papaya* was noticed parasitizing mealybug.

Table 173. Survey and surveillance of papaya mealybug, *Paracoccus marginatus*

Sr. No.	Date of survey	Farmer's name and location	Crop plants infested	Non-hosts crop and weeds infested	Chemical pesticides or if any used	Existing natural enemies in 25 randomly selected plants	Infestation (%)
1.	26.10.2020	Mohmmedbhai U. Vohra Sandeshar Ta- Anand Dist- Anand	-	-	-	-	0
2.	26.10.2020	Jesanghbhai G. Parmar Sandeshar Ta- Anand Dist- Anand	Papaya	-	-	*A. papayae*	< 1% (Trace incidence)
3.	26.10.2020	AtulbhaiRamjibhai Patel Sandeshar Ta- Anand Dist- Anand	-	-	-	-	0
4.	27.11.2020	RasikbhaiMangalbhaiTalpada Bhavanipura Ta- Petlad Dist- Anand	-	-	Deltamethrin	-	0
5.	27.11.2020	ShaileshbhaiVaghjibhai Patel Dhundhakuva Ta- Borsad Dist- Anand	-	-	-	-	0
6.	27.11.2020	GajendrabhaiBhikhabhai Patel Dhundhakuva Ta- Borsad Dist- Anand	Papaya	-	-	*A. papayae*	< 1% (Trace incidence)
7.	7.1.2021	HarshadbhaiGordhanbhai Patel	-	-	Azadirachtin 1500 ppm	-	0

		Bhavanipura Ta- Petlad Dist- Anand					
8.	7.1.2021	NavganBharwad Bhavanipura Ta- Petlad Dist- Anand	-	-	-	-	0
9.	4.8.2020	Rajeshbhai D. Patel, Dungri Dist. Valsad	Papaya	-	Imidacloprid Fipronil Buprofezin	-	< 1% (Trace incidence)
10.	4.8.2020	Dilipbhai N. Patel, Vasan Dist. Valsad	-	-	-	-	-

14. Mango

14.1 Large scale demonstration on bio-intensive management of mango hopper

14.1.1 AAU, Anand

Objectives:

To demonstrate the bio-intensive pest management (BIPM) strategies for the management of mango hopper

To create awareness and to train the farmers on BIPM strategies in mango for the management of mango hopper **Table 174.**

	Year of commencement	:	2020-21
	Location	:	Farmers' fields Location 1: Ganghor, Dist. Navsari Location 2: Talala, Dist. SasanGir
	Crop &variety	:	Mango, Kesar
	Area	:	5 ha
	Treatments	:	02
	Repetitions	:	10
	Design	:	Large plot sampling CRD
	Spacing	:	10 x 10 m
	Plot size	:	2.5 ha for each treatment
	Treatments		
T_1	BIPM module		One spray of *Metarhizium anisopliae* NBAIR Ma-4 1% WP (2 × 10^8CFU/ g) @ 50 g/ 10 litre of water on tree trunk during October Three sprays of *Metarhizium anisopliae* NBAIR Ma-4 1% WP (2 × 10^8CFU/ g) @ 50 g/ 10 litre of water on foliage during flowering at fifteen days interval with the initiation of pest
T_2	Chemical module/ Farmers' practice		-

	Methodology & observations recorded	A total of ten trees were selected randomly in each treatment. Each tree served as one repetition. Number of hoppers/twig During off-season spray, no of hoppers/tree around the trunk region were counted by using the sweep net method. Two observations were recorded onthe5th and 10th day after spray. During the flowering season, ten twigs-panicles (approx. 15 cm length) from each tree were observed and the number of hoppers per twig was recorded. Two observations were recorded onthe5th and 10th day after spray.

Table 175. Efficacy of different modules on mango hopper population

Modules	Off-season population (mango hoppers /sweep)		Flowering period population (mango hoppers/ panicle)	
	Ganghor, Dist. Navsari	Talala, Dist. SasanGir	Ganghor, Dist. Navsari	Talala, Dist. SasanGir
BIPM Module	2.90	3.60	3.43	2.94
Chemical Module/ Farmers practice	6.40	5.30	7.13	4.67
't'value	8.42*	7.46*	7.94*	3.51*
Table $t_{0.05}$	2.78	2.78	2.78	2.78

* Significant at $t_{0.0.5}$

Results:

The data of the efficacy of the BIPM module in two locations in reducing the mango hopper infestation in comparison to farmers practiceis presented in Table No 175. The population of mango hopper was comparatively low at Talala, SasanGir district, as compared to Ganghor, Navsari district.

At Ganghor, Navsari district during the off-season, the population of mango hoppers was significantly high in farmers' practice (6.40/sweep) than in the BIPM module (2.90/sweep). A similar trend followed intheflowering period. The BIPM module comprising *Metarhizium anisopliae* waswas effective in reducing the hopper population. The BIPM module recorded the significantly lowest mango hopper population of 3.43/panicle as compared to 7.13/panicle in farmers practice.

At Talala, Dist. SasanGir during the off-season the BIPM module recorded the lowest population (3.60/sweep) as compared to farmers' practice (5.30/sweep). During the flowering period, the BIPM module recorded the significantly lowest mango hopper population (2.94/panicle) than farmers' practice (4.67/panicle).

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

14.2.1 DRYSRHU, AMBAJIPETA, A.P

Experimental Details

A mango orchards having about 50- 100 trees were selected for imposing the treatment.

Treatmentdetails **Table 176.**

Treatment	Dose	Source/ Strain name
T1- *Beauveria bassiana*	5 ml/l	ICAR- NBAIR (Strain NBAIR Bb5a)
T2- *Metarhizium anisopliae*	5 ml/l	ICAR- NBAIR (Strain NBAIR Ma4)
T3- *Verticillium lecanii*	5 ml/l	ICAR- NBAIR (Strain NBAIR VL15)
T4- Azadirachtin 10000 ppm	5 ml/l	Commercial
T5- Fipronil 5SC	2 ml/l	Commercial
T6- Untreated Control	-	-

Replications: 4

Location :Bavajipeta village , Gokavaram Mandal, East Godavari district

Frequency of spray: Weekly (a total of three/ four sprays) (with the incidence of thrips first generation)

Observations: Population of thrips (nymphs and adults) was done by counting a single tap of shoot or panicle on a whitepaper on 10 panicles per tree at a standing height of the tree on a day before spray and 7th, 14th and 21st day after spray.

The spraying experiment was carried out in a mango garden (variety Totapuri) aged 7-10 years in Bavajipeta village of GokavaramMandal in East Godavari district. The first spray was done on 08.02.2021 and subsequent sprays were given at weekly interval. Data on surviving thrips population was transformed into $\sqrt{x+0.5}$ values before subjecting to an analysis of variance.

The results in Table 176 reveals that after the second and third spray, Fipronil and Azadirachtin 10000 ppm treated trees had no thrips. The biopesticides *Metarhizium anisopliae* and *Beauveria bassiana* also recorded low thrips population *i.e.*, 0.20,0.06 and 0.40, 0.16 thrips per tree, respectively after second and third sprays. Among the bio-pesticide treatments, *Lecanicillium lecanii* had a higher load ofthrips(0.80 thrips/tree). In the untreated control block, the maximum population of mango thrips ranged from 4.26 to 15.25.

Table 177. Field evaluation of biopesticide formulations against mango thrips

S.No.	Treatments	Dosage	The average number of thrips per 10 inflorescences per tree 7 days after spray			
			Pre count*	1st spray	2nd spray	3rd spray

1	T_1- *Beauveria bassiana* (NBAIR Strain Bb5a)	5 ml/l	2.86 (2.08)	1.62 (1.43)	0.40 (0.98)	0.16 (0.81)
2	T_2- *Metarhizium anisopliae* (NBAIR Strain Ma4)	5 ml/l	3.10 (2.35)	1.21 (1.40)	0.20 (0.82)	0.06 (0.75)
3	T_3- *Lecanicillium lecanii* (NBAIR StrainVL15)	5 ml/l	2.26 (1.73)	1.52 (1.29)	1.44 (1.37)	0.80 (1.12)
4	T_4- Azadirachtin 10000 ppm	5 ml/l	4.32 (2.78)	2.86 (1.81)	0.00 (0.71)	0.00 (0.71)
5	T_5- Fipronil	2 ml/l	4.22 (2.67)	2.88 (1.82)	0.00 (0.71)	0.00 (0.71)
6	T_6- Untreated control	-	4.26 (2.13)	9.05 (3.07)	11.85 (3.50)	15.25 (3.97)
	SEm	-	-	0.10	0.08	0.06
	CD (5%)	-	-	0.29	0.23	0.17

*Fig in parenthesis are √x+0.5 transformed values.

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

14.3.1 CISH, Lucknow

Table 178.

Variety	:	Dashehari
No. of trees		10 trees per treatment
Layout	:	Randomized Block Design
Treatments	:	T1: Mango intercropped with maize T2: Mango intercropped with mustard T3: Mango intercropped with Coriander T4: Mango as sole.
Replications	:	Each tree to serve as replication
Methodology for imposing treatments		Crops were sown during December or January, and these crops came flowering during the second fortnight of February and it was synchronised with panicle emergence and flowering of mango
Methodology and observations	:	Observation will be taken at different intervals after application; Status of a major pest of mango and Natural enemies, if any.

Results

An experiment was conducted in 30 years old mango orchard of the institute. Dashehari variety was evaluated at 10 tree /treatment in a Randomized Block Design. Four treatments viz., intercropping maize with mango, intercropping mustard with mango, intercropping coriander with mango and one sole crop mango as control treatment were evaluated. The intercrops were sown in the first week of January because of their flowering synchronization with panicle emergence ith mango. The experimental field was fenced to avoid grazing by wild animals, primarily blue bull often roaming in the orchards.

None of the treatments had an impact on suppressing insectpests. Isolation distances were to be maintained to see the effects of the treatment. The faunal diversity, comprised an array of pollinators, natural enemies in all the three respective intercrops *viz*., maize, mustard and coriander (Table 179). Thus, enrichment of pollinators and natural enemies rendered prospective ecosystem services in the mango orchard in present experimentation.

Table 179. Habitat manipulation for conservation of bio-agents for management of mango insect Pests at CISH Lucknow

Treatments	Occurrence of pollinators, natural enemies and insect pests		
	Pollinators	Natural Enemies	Insect Pests
Mango intercropped with maize	Bumble bees, ***Chrysopid*, **Megachilus* spp., ** *Apis mellifera*	**Coccinellids, Syrphids, Spiders, *Praying Mantis, Ants *Telenomus* spp., *Trichogramma* spp, **Cotesia*sp	Stem borer, Armyworm Chafer beetle, Grasshopper, Earwigs, Leaf cutter bee (*Megachile anthracina*)
Mango intercropped with Mustard	***Honeybees (*Apis mellifera*, *Apis cerana*, *Apis dorsata* * Bumble bees	**Coccinella spp., Syrphids fly Carpenter bee, Yellow banded wasp, Short horned grasshopper,	Mustard saw fly, Green Stink bug, Blister beetle, *Pieris brasscae*, *Bagrada cruciferarum*
Mango intercropped with Coriander	*Apisflorea*, ***Apis mellifera*, *Trigona* sp, *Musca domestica Episyrphus balteatus*	***Menochilus sexmaculatus*, *Camponotus* sp., Unknown sp., ***Chrysoperla carnea*	*Raphilopalpa foevicolis*, *Dysdercus koenghii*, *Oxycarenus laetus*, *Plutella xylostella*,
Mango Sole crop	***Apis mellifera*, Bumble bees	*Camponotus* sp., *Coccinellids	*Blister beetle, Chafer beetle

*** High population
** Moderate population
* Stray population

14.4 Field evaluation of microbial biocontrol agents for the management of mango thrips

14.4.1CISH-Lucknow

Table 180.

Variety	:	Dashehari
No. of trees		5 trees per treatment
Layout	:	Randomized Block Design.

Treatments	:	T1: *Beauveria bassiana* (NBAIR culture) @1x10^8 spores/g @ 5g/lit T2: *Beauveria bassiana*(CISH culture) @1x10^8 spores/g @ 5g/lit T3: *Metarhizium anisopliae* (NBAIR culture) @1x10^8 spores/g @ 5g/lit T4: Azadirachtin 1500 ppm @ 2ml/lt T5: Imidacloprid 0.005% (CISH POP) T6: Untreated control

Replications: Each tree to serve as replication

Methodology for imposing treatment: Soil Application and spray

Observations: Observations were taken at different intervals after application; No of thrips/tree, percent damage of fruits, Natural enemies, if any

Results:

Microbial bioagents *viz*., *Beauveria bassiana* and *Metarhizium anisopliae* formulations were evaluated for their bio-efficacy against mango thrips. A significant difference was found between the treatments at 7, 14 and 21 days after the spray. Among the bio-pesticides, a low incidence of thrips was observed in *B. bassiana* (CISH formulation) which registered 7.00 thrips/ panicle at 7 days after spraying. The efficacy of *B. bassiana* (NBAIR formulation) and *M. anisopliae* (NBAIR formulation) was at par (Table 181). It was observed that 14 days after treatment *B.bassiana* (CISH formulation) exhibited better than that of NBAIR formulation in suppressing thrips;albeit in subsequent observation after 21 days of treatments both the formulations of *B.bassiana* of CISH and NBAIR were at par.

Table 181. Field evaluation of microbial biocontrol agents for the management of mango thrips

Treatments	Pre count	7 DAS	14 DAS	21 DAS
Beauveria bassiana (NBAIR culture) @1x10^8 spores/g @ 5g/lit	15.20 (4.40)	7.60 ^{ab} (3.26)	6.20 ^{ab} (2.99)	4.40 ^{a} (2.10)
Beauveria bassiana (CISH culture) @1x10^8 spores/g @ 5g/lit	14.00 (4.24)	7.00 ^{ab} (3.15)	4.33 ^{a} (3.29)	3.80. ^{a} (2.45)
Metarhizium anisopliae(NBAIR culture) @1x10^8 spores/g @ 5g/lit	16.00 (4.50)	7.60 ^{ab} (3.26)	6.60 ^{ab} (3.06)	5.40 ^{ab} (2.82)
Azadirachtin 1500 ppm @ 2ml/lt	13.40 (4.16)	5.80 ^{ab} (2.91)	8.80 ^{ab} (3.47)	10.40 ^{c} (1.13)
Imidacloprid 0.005% (CISH POP)	15.80 (4.47)	2.20 ^{a} (1.98)	5.24 ^{ab} (2.79)	6.95 ^{ab} (3.14)
Untreated control	14.07 (4.25)	21.20^{c} (5.10)	12.76. ^{c} (4.07)	12.80 ^{c} (4.08)
LSD (0.05%)	-	4.78	4..99	6.75

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 test.

14.5 Bioefficacy of entomopathogenic fungi formulations in suppression of mango tortricid borers (CISH-Lucknow).

Table 182.

Variety	Dashehari
No. of trees	5 trees per treatment
Layout	Randomized Block Design.
Treatments	T1: *Beauveria bassiana* (CISH culture) @1x10^8 spores/g @ 5g/lit T2: *Metarhizium anisopliae*(NBAIR culture) @1x10^8 spores/g @5g/lit T3: *Beauveria bassiana* (NBAIR culture) @1x10^8 spores/g @5g/lit T4: Dimethoate 30% EC 2 ml/lit (CISH POP) T5: Untreated control
Replications	Each tree to serve as replication
Methodology and observations	Observation will be taken at different intervals after application; mean damage by fruit borer, Natural enemies, if any

Result:

Bioefficacy of entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* formulations were tested against mango fruit borer. A significant difference was found between the treatments at 7, 14 and 21 days after the spray. All the entomopathogenic fungi reduced the fruit borer incidence significantly table 183. Onbioefficacy of *B.bassiana* did not differ significantly and was at par with *M.anisopliae*in reducing the fruit borer infestation at 7 and 14 days intervals. The native bioagent of *B.bassiana* (CISH formulation) after 21 days of treatment recorded better efficacy over NBAIR formulation.

Table 183. Bio-efficacy of entomopathogenic fungi against mango fruit borer

Treatments	Mean number of fruits damaged by fruit borer			
	Before spray	7 DAS	14 DAS	21 DAS
Beauveria bassiana (CISH) 1×10^8 @5g/lit	17.00 (4.62)	6.00^{a} (2.95)	7.60^{ab} (3.26)	4.80^{a} (2.69)
Beauveria bassiana (NBAIR) 1×108 @ 5g/lit	18.20 (4.77)	8.20^{a} (3,33)	6.00^{ab} (2.95)	7.00^{ab} (3.15)
Metarhizium anisopliae (NBAIR) 1×10^8 @5g/lit	16.40 (4.55)	7.00^{a} (3.15)	9.00^{ab} (3.50)	6.20^{a} (2.99)
Dimethoate 30EC 2ml/l	15.80 (4.47)	5..40^{a} (2.82)	3.40^{a} (2.34)	3,40^{a} (2.34)
Untreated control	15.60 (4.44)	26.40^{b} (5.64)	15.80^{b} (4.47)	11.00^{b} (3.82)

LSD (0.01)	9.65	6.87	4.65	3.74

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 test.

15. Guava

15.1 Biological control of guava mealybug using entomopathogens

15.1.1 SKUAST, Jammu

Number of treatments: 5
Number of replications: 5
Design: RBD
Five trees per replication

Treatment details **Table 184.**

T1	*B. bassiana* (NBAIR-Bb-5a) @ 5 g/L
T2	*Metarhizium anisopliae*(NBAIR-Ma-4) @ 5 g/L
T3	*Lecanicillium lecanii*(NBAIR-VI-22) @ 5 g/L
T4	Azadirachtin 10000 ppm @ 1 ml/L
T5	Untreated Control

Observations to be recorded- Pre and post spray mealy bug counts

Table 185. Percent reduction in Mealy bug nymphs and adults

Treatments	Pre-spray count	Post spray count (mean no. per leaf)		Percent Reduction at 7 DAS	Fruit yield (kg/tree)
		3 DAS	7 DAS		
T1	25.4	20.7	13.4	47.19 (43.37)	5.467
T2	21.2	16.9	10.7	49.51 (44.67)	6.050
T3	21.6	18.6	13.6	36.87 (37.37)	4.067
T4	23.4	19.8	12.9	45.06 (42.14)	5.417
T5	23.7	24.1	26.8	-	0.883
CD at 5%	N.S.	3.48	3.10	(1.99)	0.174

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

Results -

Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, along with Azadirachtin 10000 ppm were assessed against Guava mealybug. The highest percent reduction in the mealybug population was recorded in *M. anisopliae* spray (49.51% reduction) that was at par with that of *B. Bassiana* spray (47.19%) at 7 DAS. At 3 DAS also mealybug population was significantly lowest in *M. anisopliae* spray (16.9 mealybug nymphs or adults per leaf). Significantly highest mealybug and scales population was recorded in the untreated control.

Fig:50. Guava mealy bug

15.2 Development of biocontrol based IPM module for the management of guava fruit borere.

15.2.1 CISH, Lucknow

Table 186.

Variety	:	Allahabad safeda
No. of trees		5 trees per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: *Beauveria bassiana*(CISH culture) @1x10^8 spores/g-5g/lit T2: *Metarhizium anisopliae* (NBAIR culture) @1x10^8 spores/g-5g/lit T3: *Beauveria bassiana* (NBAIR culture) @1x10^8 spores/g-5g/lit T4: Neem oil @ 3ml/lt T5: Dimethoate 30% EC 2 ml/lit (CISH POP) T6: Untreated control
Replications	:	Each tree to serve as replication
Methodology for imposing treatments		Spray
Methodology and observations	:	Observation will be taken at different intervals after application; percent damage by fruit borer, Natural enemies, if any

Results:

The present experiment was initiated during 2020-21 in institute campus Block II. To assess the management measures for guava fruit borer, three fungal bioagents, one indigenous plant products and one synthetic chemical insecticide were tested in randomized block design considering 5 trees/ treatment having each tree served as a replicate against this pest, by administering their spray in the experimental field. The per cent infestation of the fruits was recorded.

Observations revealed that all three bioagents and neem oil were at parin reducing the infestation. Chemical pesticide dimethoate caused the highest reduction in fruit damage.(Table 187).

Table 187. Bio-efficacy of bioagents for the development of IPM module for guava fruit borer

Treatments	Percent infestation		
	23.10.2020	31.10.2020	12.11.2020

Beauveria bassiana (NBAIR culture) @1x108 spores/g-5g/lit	11.8	5.88^{ab}	2.88^{b}
Metarhizium anisopliae (NBAIR culture) @1x10^8 spores/g-5g/lit	3.56	3.48^{abc}	2.96^{b}
Beauveria bassiana(CISH culture) @1x10^8 spores/g-5g/lit	5.6	3.02^{bc}	0.8^{b}
Neem oil @ 3ml/lt	10.96	4.06^{abc}	3.94^{b}
Dimethoate 30% EC 2 ml/lit (CISH POP)	8.06	0^{c}	0^{b}
Untreated control	25.54	8.66^{a}	9.38^{a}
F	NS	2.713	3.404
CD (0.05)	NS	5.209	5.293

15.3 Biological control of root-knot nematode in guava

15.3.1 UAHS, SHIVAMOGGA

Objective: To study bioagents against root-knot Nematode in Guava
Location: Shivamogga
Year of start: 2020-21
Methodology:

The efficacy of biocontrol agents against root-knot Nematodewas recorded. The bioagents such as *Purpureocilliumlilacinum, Trichoderma harzianum, Pseudomonas fluorescens,* were used for the management of root-knot nematodes in guava, the bioagents were mixed with the FYM and three times applied to the guavaplants at three months interval, the nematode populations and percent reduction in nematode populations were recorded.

Expirement details:

Table 188. Effect of different bio agents on the number of plant-parasitic nematodes (PPN) associated with guava,

Variety	Lucknow 49
No of trees	5 trees per treatment
Lay out	Randomized block design
	T_1 :*Purpureocillium lilacinum*(UAHS-15) @ 1 x 10^{8}Cfu/ g @ - 30g/ plant multiplied in 3kg of FYM
	T_2 : *Trichoderma harzianum*(UAHS-3) @ 1 x 10^{8}Cfu/ g- 30g/ plant multiplied in 3kg of FYM
	T_3 : *Pseudomonas fluorescens* @ (UAHS-56) 1 x 10^{8}Cfu/ g- 30g/ plant multiplied in 3kg of FYM
	T_4 : *P. lilacinum+ P. fluorescens + T. harzianum* @ 1 x 10 8 Cfu/g – 10g each/plant multiplied in 3kg of FYM
	T_5 : Carbofuran 10 G @ 25g per plant
	T_6 : Non-treated trees (check)
Replications	Each tree to serve as replication

Table 189. Effect of different bio agents on the number of plant-parasitic nematodes (PPN) associated with guava,

Treatments	No. of plant parasitic nematodes / kg of soil			
	I *	II*	III*	Per cent reduction
T_1: *Purpureocillium lilacinum* (UAHS-15) @ 1 x 10^8Cfu/ g @ - 30g/ plant multiplied in 3kg of FYM	888.5	608.25	90.00	80.55 (71.44)
T_2 : *Trichoderma harzianum* (UAHS-3) @ 1 x 10^8Cfu/ g- 30g/ plant multiplied in 3kg of FYM	871.25	548.75	276.75	68.22 (55.68)
T_3 : *Pseudomonas fluorescens* @ (UAHS-56) 1 x 10^8Cfu/ g- 30g/ plant multiplied in 3kg of FYM	785.75	603.0	288.25	63.31 (52.71)
T_4 : *P. lilacinum+ P. fluorescens + T. harzianum* @ 1 x 10 8 Cfu/g – 10g each/plant multiplied in 3kg of FYM	726.5	542.25	81.25	88.81 (70.45)
T_5 : Carbofuran 10 G @ 25g per plant	852.25	575.0	96.25	88.70 (70.35)
T_6 : Non-treated trees (check)	851.25	848.75	842.25	1.06 (5.90)
SEM±	10.25	8.32	9.81	0.26
CD@5%	31.46	25.91	29.43	0.35

Result: The PPN population was estimated after the application of bioagents there was a significant reduction in the PPN after the application of bioagents the maximum reduction of PPN was observed in the treatment T4 treated with consortia of *P. lilacinum+ P. fluorescens + T. harzianum*@ 1 x 10^8Cfu/ g- 10g each/ plant multiplied in 3kg of FYM it was on par with the treatment T5 treated with Carbofuran 10 G @ 25g per plant the minimum population of PPN was recorded in the treatment T6 untreated control.

The consortial application of*P. lilacinum+ P. fluorescens + T. harzianum*@ 1 x 10^8Cfu/ g- 10g each/ plant multiplied in 3kg of FYM three times per year helps in maximum reduction of PPN population in guava so it can be effectively used for the management of PPN in guava.

15.4 Evaluation of entompthogenic fungi, *Beauveria bassiana* (ICAR-NBAIR-Bb-5a) against mealy bug in guava ecosystem

15.4.1UAS, Raichur

Table 190.

	Crop	Guava
	Year	2020-21
	Variety	Lucknow 49
	Age of the orchard	Three years old

	Experimental Location	Horticulture Orchard, UAS, Raichur
	No of plants per treatment	10
	Replication	3
	Treatments Details	
	T_1	*Beauveria bassiana* (ICAR- NBAIR-Bb-5a) @ 1×10^8 @ 5 gm/l
	T_2	*Lecanicillium leccani* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-8) @ 5.0 g/l
	T_3	*Lecanicillium leccani* @ 1×10^8 @ 5gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l
	T_4	*Metarhizium anisopliae* @ 1×10^8 @ 5gm/l (ICAR-NBAIR-Ma 4)@ 5.0 g/l
	T_5	*Isaria fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l
	T_6	Azadirachtin 1500ppm @ 2 ml/lit
	T_7	Buprofeizn 25 SC @ 1 ml/lit
	T_8	Untreated control
	Date of spray	13-12-2020, 21-12-2020 and 03-01-2021

Observation: To record the infestation of mealy bugs top growing shoots and young fruits were selected in each plant and numbers of mealybug crawlers were recorded one day before, seven and ten days after each spray and per cent reduction over control was worked out. Total fruit yield (Ten pickings) was computed and expressed as a ton per ha.

Results

The number of mealybug crawlers a day before spray ranged from 18.84 to 20.52 per plant which was statistically non - significant. Ten days after spray, the lowest mealybug crawlers of 4.17 per plant was noticed in *B. bassiana* (ICAR- NBAIR-Bb-5a) @ 1×10^8 @ 5 gm/l and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l (4.26 crawlers/plant). The highest per cent reduction in mealy bug population over control was noticed in *B. bassiana* (ICAR- NBAIR-Bb-5a) @ 1×10^8 @ 5 gm/l (80.94%) and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l which recorded 79.79 per cent. Among the biocontrol agents, *B. bassiana* (ICAR- NBAIR-Bb-5a) @ 1×10^8 @ 5 gm/l recorded the highest fruit yield of 18.56 t/ha and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l which recorded 18.13 t/ha. Untreated control recorded the lowest fruit yield of 14.04 t/ha (Table 191).

Table 191. Evaluation of entompthogenic fungi, *Beauveria bassiana* (ICAR-NBAIR-Bb-5a) against mealy bug in guava during 2020-21

Sl. No.	Treatment Details	Dosage (g/l)	Number of mealybug crawlers per plant							ROC (%)	Fruit yield (q/ha)
			I Spray			II Spray		III Spray			
			IDBS	7 DAS	10 DAS	7 DAS	10 DAS	7 DAS	10 DAS		
T_1	*Beauveria bassiana* (ICAR-NBAIR-Bb-5a)	1×10^8 @ 5gm/l	20.52 (4.58)	9.02 (3.09)	4.17 (2.16)	3.56 (2.01)	2.51 (1.73)	1.93 (1.56)	1.48 (1.41)	80.94 (64.11)	18.56
T_2	*Lecanicillium leccani* (ICAR-NBAIR-VL-8)	1×10^8 @ 5gm/l	19.18 (4.44)	11.36 (3.44)	6.34 (2.62)	5.21 (2.39)	4.82 (2.31)	4.01 (2.12)	3.56 (2.01)	70.32 (56.99)	16.08
T_3	*Lecanicillium leccani* (ICAR-NBAIR-VL-15)	1×10^8 @ 5gm/l	19.84 (4.51)	10.18 (3.27)	6.16 (2.58)	5.18 (2.38)	4.76 (2.29)	3.96 (2.11)	3.28 (1.94)	71.82 (57.93)	16.19
T_4	*Metarhizium anisopliae* (ICAR-NBAIR-Ma 4)	1×10^8 @ 5gm/l	20.08 (4.54)	14.54 (3.88)	11.35 (3.44)	10.97 (3.39)	9.56 (3.17)	9.34 (3.14)	7.43 (2.82)	46.87 (43.20)	15.54
T_5	*Isaria fumosorosea* (ICAR-NBAIR strain)	1×10^8 @ 5gm/l	20.34 (4.57)	9.78 (3.21)	4.26 (2.18)	3.74 (2.06)	2.68 (1.78)	2.01 (1.58)	1.56 (1.44)	79.79 (63.29)	18.13
T_6	Azadirachtin 1500ppm	2 ml/lit	19.62 (4.49)	7.56 (2.84)	3.98 (2.12)	3.32 (1.95)	2.34 (1.69)	1.78 (1.51)	1.33 (1.35)	82.92 (65.59)	19.08
T_7	Buprofeizn 25 SC	1 ml/lit	18.84 (4.40)	5.32 (2.41)	3.16 (1.91)	2.72 (1.79)	2.08 (1.61)	1.03 (1.24)	0.51 (1.00)	87.54 (69.33)	21.56
T_8	Untreated control	-	19.11 (4.43)	19.53 (4.48)	20.14 (4.54)	20.45 (4.58)	19.87 (4.51)	19.51 (4.47)	19.43 (4.46)	0.00 (0.00)	14.04
S Em±			0.58	0.08	0.03	0.05	0.07	0.03	0.06	0.46	0.53
CD (P=0.05)			NS	0.25	0.11	0.16	0.21	0.10	0.18	1.38	1.61

*Figures in parentheses are square root transformed values,

#Figures in parentheses are arcsine transformed values

16. Biological Control Apple Pests

16.1 Exp 3.Management of apple root borer using *Metarhizium anisopliae*

16.1.1 Dr YS PUHF, Solan

A large scale demonstration on the management of apple root borer, *Dorystheneshugelii* by using *Metarhizium anisopliae* was laid in apple (cv Royal Delicious) in 13 orchards in Shimla, Sirmaur and Kinnaur districts covering an area of 5h (Table 192). *Metarhizium anisopliae*(10^8 conidia/g) was applied @ 30g/ tree basin mixed in well rotten farm yard manure (FYM) during July- August 2020 i.e. at the time of egg hatching and emergence of new/young grubs. Chemical treatment comprising of chlorpyriphos (0.06%) was also applied maintained for comparison.

Table 192. Details of the locations where the demonstrations were laid:

SN	Location	Number of orchards
1	Urni, district Kinnaur	2
2	Pooh, district Kinnaur	2
3	Sangla, district Kinnaur	1
3	Jubbal, district Shimla	2
4	Rohru, district Shimla	2
5	Nankhadi (Rampur), district Shimla	3
6	Rajgarh, district Sirmaur	1
	Total	13

The observations on the grub mortality and feedback from the farmers were collected during November 2020 at the time of basin preparation. *Metarhizium anisopliae* treatment resulted in 68.6 to 83.1 per cent mortality of the apple root borer grubs in different orchards, while in chlorpyriphos (0.06%) treated plants the grub mortality was 79.4 to 87.3 per cent.

16.2 Exp.4 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), *Steinernemmafeltiae,Heterorhabditis bacteriophora* (each at 2500 and 5000IJs/gallery) and azadirachtin (2ml/L of 1500ppm; 10ml/gallery) in comparison with chlorpyriphos (0.04%) as chemical control and water as untreated control were evaluated against leopard moth, *Zeuzera multistrigata* in apple (cv Royal Delicious). The experiment was laid at Temperate Horticultural Research Station, Kotkhai in a randomised block design with five replications. In each case, 10ml treatment suspension was injected into the live insect gallery with the help of a syringe (without a needle). After treatment, the gallery holes were 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. The results (Table 193) reveal that chlorpyriphos (0.04%) was the most effective resulting in 100 per cent mortality of the pest. Among the different biocontrol agents evaluated, *Heterorhabditis bacteriophora* (5000IJs/gallery) was the most effective resulting in 80 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 50 per cent pest mortality; in control no pest mortality was recorded.

Table 193. Evaluation of some biocontrol agents against leopard moth, *Zeuzera multistrigata* in apple

SN	Treatment	Mortality (%)
1	*Beauveria bassiana* (5g/L of 10^8 conidia/g; 10ml/gallery)	33.3 (32.1)
2	*Metarhizium anisopliae*(5g/L of 10^8 conidia/g; 10ml/gallery	40 (36.1)
3	*Steinernemma feltiae* (2500IJs/gallery)	50 (45.0)
4	*Steinernemma feltiae* (5000IJs/gallery)	66.7 (57.8)
5	*Heterorhabditis bacteriophora* (2500IJs/gallery)	50 (45.0)
6	*Heterorhabditis bacteriophora* (5000IJs/gallery)	80 (71.9)
7	Azadirachtin (2ml/L of 1500ppm; 10ml/gallery)	66.7 (57.7)
8	Chlorpyriphos (0.04%; 10ml/gallery)	100 (90.0)
9	Control (water, 10ml/Gallery	0.0 (0.0)
	CD (0.05)	(15.9)

Figures in parentheses are arc sine transformed values

16.3 Field evaluation of some bio pesticides against green apple aphid, *Aphis pomi* and mites infesting apple in Kashmir.

16.3.1 SKUAST (Srinagar)

Bioefficacy of commercial azadirachtin and commercial entomo pathogenic fungus *Lecanicillium lecanii* along with University recommended chemicals wereevaluated against sap-sucking pests infesting apple (var. Red delicious) in the University campus, Shalimar during June- July 2020. Treatments for green apple aphid, *Aphis pomi* and mites were given in two different plots. Three sprays of azadirachtin and entomo fungus were provided weekly by using a foot sprayer. Data before spray and, one day- three days and seven days after each spray was recorded against each pest. Only one application of Dimethoate 30 EC @ 1.0 ml^{-1} of water and Fenazaquin 10 EC @ 0.4ml^{-1}was provided. Data on aphids were recorded per 5 terminal shoots^{-}plant from randomly selected 10 plants. Data on two-spotted spider mite, *Tetranychus urticae* and European red spider mite, *Panonychus ulmi* was recorded from 5 top leaves^{-}plant from randomly selected 10 plants. The experiment was replicated thrice.

The average population of the aphid-terminal shoot after 3 sprays of azadirachtin and *L. lecanii* was found minimum (6.77^{-shoot}) in the case of T5 which received sprays of Azadirachtin 1500 ppm @ 5.0 ml^{-1} followed by *Lecanicillium lecanii*($1x10^8$ CFU/ml) @ 5.0 $ml^{-1}$and was statistically superior to all the bio pesticides used (Plate 1, Fig. 1). However, one spray of Dimethoate 30 EC @ 1.0 ml^{-1} of water recorded the least number of aphids (3.06/ shoot).Population of aphid after every spray tended to increase on the 3rd and 7th day but declined on the 1st day after the application. The difference in the cumulative mean population of aphids was found statistically significant when compared with one way ANOVA (F= 531.28**; d.f.= 6(24); p= <0.001).Per cent reduction in aphid population over pretreatment (F= 55.90**; d.f.=5(20); p= <0.001) and control (F= 179.54**; d.f.= 5(20); p= <0.001) were found statistically significant among all the treatments when data was analyzed through one way ANOVA.Per cent reduction over controlwas found to be highest in the order of Dimethoate 30 EC > T5 > T3 > T2 > T1 (Table 1).

The number of two-spotted spider mite, *Tetranychus urticae* ranged from 19.8 to 28.8^{-leaf}, before treatment during June' 2020. After treatment, the number of mites declined from 4.41 to 10.94. One treatment of Fenazaquin 10 EC @ 0.4ml^{-1} recorded the lowest cumulative population (4.4 1) whereas three sprays of Nimbecidine 300 ppm@ 5.0 ml^{-1} showed an average of 10.94 mites (Plate 1, Fig. 2) Next to Fenazaquin, T3 and T5 were found more effective and statistically on par. The difference in cumulative mean aphid population when compared for treatments was found statistically significant (F= 201.17**; d.f.= 6(24); p= <0.001) when analyzed through one way ANOVA. In response to every spray, mites were also found first to decline a day after spray but picked up on the 3rd and 7th day after spray. Comparison of treatments indicated per cent reduction in mites over pretreatment (F= 63.41**; d.f.= 6(24); p= <0.001) and over control (F= 63.80**; d.f.= 6(24); p= <0.001) as statistically significant. Although Fenazaquin 10 EC @ 0.4ml^{-1} showed maximum reduction in mite population over control (87.58), T5 was found to be the next effective treatment with an 80.12 per cent reduction in mite over control (Table 2).

The average number of European red mite, *Panonychus urticae* ranged from 11.8 to 26.4^{-leaf} of apple during June' 2020 and was found to be statistically different before treatment (F= 6.18**; d.f.= 6(24); p= <0.001). After treatment, cumulative mean population of motile stages of ERM was found to be least in case of treatment with one spray of Fenazaquin 10 EC @ 0.4ml^{-1} and maximum in plants treated with Nimbecidine 300 ppm @ 5.0 ml^{-1}. Treatments T3 and T5 resulted in containing the population up to 5.25 and 5.92 respectively (Plate 1, Fig.2) and were found to be statistically identical. The cumulative mean population of ERM was found to be statistically significant among the treatments (F= 61.76**; d.f.= 6(24); p= <0.001) when data were compared using one way ANOVA. The pattern of population rise and fall after every spray was identical as in the case of two-spotted spider mite (Table 3). Difference in per cent reduction in mite population over pretreatment (F= 19.05**; d.f.= 4(20); p= <0.001)) and over control (F=

27.94**; d.f.= 4(20); p= <0.001) was found statistically significant. Maximum reduction over control was obtained by Fenazaquin 10 EC (85.76) followed by Azadirachtin 10000 ppm @ 2.0 ml^{-1}(72.79),T5 (69.34), T2 (60.48) and T1 (58.31).

Table 194. Effect of botanicals and entomopathog on the population of green apple aphid, *Aphis pomi* on apple in Srinagar, Kashmir during 2020

Treatments	No. of aphids/shoot after 1st spray				No. of aphids/shoot after 2nd spray			No. of aphids/shoot after 3rd spray			Cumulative mean pop. / shoot	% reduction over pre-treatment	% reduction over control
	1 DBS	1 DAS	3 DAS	7 DAS	1 DAS	3 DAS	7 DAS	1 DAS	3 DAS	7 DAS			
Nimbicidine 300ppm @ 5.0 ml^{-l} (T1)	36.8 (6.04)^{b}	23.8 (4.86)^{e}	26.4 (5.12)^{e}	28.6 (5.33)^{e}	19.6 (4.39)^{c}	23.00 (4.77)^{d}	25.4 (5.02)^{d}	13.0 (3.59)^{e}	18.6 (4.30)^{d}	21.4 (4.62)^{e}	22.2 (4.70)^{e}	38.61 (38.34)^{a}	50.94 (45.54)^{a}
Azadirachtin 1500 ppm@ 5.0 ml^{-1} (T2)	25.6 (5.04)^{a}	114 (3.34)^{d}	14.60 (3.80)^{d}	21.4 (4.60)^{d}	9.40 (3.04)^{b}	11.8 (3.41)^{c}	15.6 (3.94)^{c}	7.6 (2.75)^{c}	11.8 (3.42)^{c}	14.2 (3.76)^{c}	13.08 (3.61)^{c}	48.27 (44.00)^{b}	71.23 (57.57)^{c}
Azadirachtin 10000 ppm @ 2.0 ml^{-l} (T3)	39.00 (6.19)^{b}	7.2 (2.67)^{c}	9.4 (3.06)^{c}	12.4 (3.51)^{c}	3.2 (1.77)^{ab}	6.6 (2.56)^{b}	9.6 (3.09)^{b}	1.8 (1.31)^{a}	6.2 (2.47)^{a}	12.2 (3.48)^{b}	7.62 (2.75)^{b}	79.23 (63.04)^{d}	83.16 (65.79)^{d}
L. lecanii($1x10^{8}$ CFU/ml) @ $5ml^{-l}$ (T4)	45.4 (6.73)^{c}	21.0 (4.56)^{e}	24.4 (4.92)^{e}	28.0 (5.28)^{e}	9.6 (3.09)^{b}	12.4 (3.51)^{c}	16.4 (4.04)^{c}	10.0 (3.15)^{d}	11.4 (3.36)^{c}	16.6 (4.06)^{d}	16.64 (4.07)^{d}	63.01 (52.57)^{c}	63.15 (52.65)^{b}
T5 (T2+T4)	28.2 (5.29)^{a}	3.2 (1.77)^{b}	5.6 (2.36)^{b}	9.2 (3.02)^{b}	2.2 (1.45)^{a}	6.00 (2.44)^{b}	11.2 (3.34)^{b}	4.0 (1.97)^{b}	8.00 (2.81)^{b}	11.6 (3.39)^{b}	6.77 (2.59)^{b}	75.39 (60.36)^{d}	85.10 (67.31)^{e}
Dimethoate 30 EC @ 1.0 ml^{-l} (T6)	31.4 (5.59)^{ab}	1.4 (1.16)^{a}	2.2 (1.45)^{a}	3.4 (1.83)^{a}	1.4 (1.16)^{a}	1.6 (1.24)^{a}	2.00 (1.37)^{a}	3.4 (1.83)^{b}	5.4 (2.32)^{a}	6.8 (2.60)^{a}	3.06 (1.75)^{a}	90.09 (71.68)^{e}	93.22 (74.91)^{f}
Untreated control (T7)	44.2 (6.63)^{c}	45.6 (6.74)^{f}	44.4 (6.64)^{f}	45.8 (6.76)^{f}	42.6 (6.51)^{d}	43.2 (6.56)^{e}	47.8 (6.91)^{e}	45.6 (6.74)^{f}	45.4 (6.73)^{e}	49.4 (7.01)^{f}	45.4 (6.73)^{f}	-	-
CD (0.05)	0.38	0.36	0.37	0.17	0.40	0.18	0.28	0.28	0.30	0.26	0.17	4.05	1.94
CV(%)	13.10	51.58	43.73	36.51	59.02	47.27	41.11	56.23	39.89	32.59	41.47	21.82	16.68

Each observation represents mean of 5 replications; Figures in parentheses except last two columns which are asin transformations are $\sqrt{n}$; similar superscripts in a column indicate values statistically on par

Table 195. Effect of botanicals and entomopathogen on the population of Two spotted spider mite, *Tetranychus urticae* on apple in Srinagar, Kashmir during 2020

Treatments	No. of mites/leaf after 1st spray				No. of mites /leaf after 2nd spray			No. of mites/leaf after 3rd spray			Cumulative mean pop. / leaf	% reduction over pre treatment	% reduction over control
	1 DBS	1 DAS	3 DAS	7 DAS	1 DAS	3 DAS	7 DAS	1 DAS	3 DAS	7 DAS			
Nimbicidine 300ppm @ 5.0 ml^{-l} (T1)	19.8 (4.4)^{a}	13.4 (3.64)^{b}	17.00 (4.11)^{b}	21.6 (4.64)^{d}	15.2 (3.89)^{c}	18.2 (4.26)^{d}	17.00 (4.11)^{d}	12.6 (3.54)^{c}	17.0 (4.12)^{bc}	21.8 (4.66)^{d}	10.94 (3.30)^{c}	44.19 (41.64)^{a}	69.16 (56.29)^{a}
Azadirachtin 1500 ppm @ 5.0 ml^{-l}(T2)	23.00 (4.77)^{b}	14.00 (3.73)^{bc}	18.00 (4.23)^{bc}	23.4 (4.83)^{e}	14.2 (3.74)^{c}	17.6 (4.18)^{d}	20.8 (4.55)^{e}	8.0 (2.82)^{ab}	13.8 (3.71)^{b}	16.8 (4.09)^{c}	10.49 (3.23)^{c}	53.24 (46.88)^{b}	70.50 (57.12)^{a}
Azadirachtin 10000 ppm @ 2.0 ml^{-l}(T3)	27.8 (5.26)^{bc}	11.8 (3.43)^{b}	14.4 (3.79)^{b}	17.4 (4.17)^{b}	9.8 (3.12)^{b}	10.4 (3.22)^{ab}	12.8 (3.57)^{c}	6.0 (2.43)^{a}	8.6 (2.92)^{a}	12.8 (3.56)^{b}	7.68 (2.77)^{b}	72.00 (58.08)^{d}	78.33 (62.28)^{c}
L. lecanii(1x10^{8} CFU/ml) @ 5ml/l (T4)	26.4 (5.11)^{b}	12.4 (3.50)^{b}	16.00 (3.99)^{b}	19.00 (4.35)^{bc}	9.6 (3.09)^{b}	13.0 (3.60)^{c}	6.8 (2.59)^{a}	10.0 (3.15)^{b}	12.6 (3.54)^{b}	16.6 (4.06)^{c}	8.46 (2.90)^{c}	67.17 (55.10)^{c}	76.12 (60.79)^{b}
T5 (T2+T4)	28.8 (5.34)^{bc}	13.4 (3.65)^{b}	15.0 (3.87)^{b}	16.8 (4.09)^{b}	6.2 (2.44)^{a}	8.8 (2.91)^{a}	11.0 (3.29)^{b}	5.6 (2.30)^{a}	8.0 (2.78)^{a}	10.8 (3.27)^{a}	7.11 (2.66)^{b}	75.09 (60.06)^{d}	80.12 (63.54)^{c}
Fenazaquin 10 EC @ 0.4ml^{-l}	26.0 (5.09)^{b}	1.4 (1.16)^{a}	3.4 (1.83)^{a}	4.6 (2.14)^{a}	5.4 (2.31)^{a}	6.8 (2.61)^{a}	7.4 (2.71)^{a}	8.6 (2.92)^{ab}	9.2 (3.03)^{a}	9.6 (3.09)^{a}	4.41 (2.10)^{a}	82.86 (65.56)^{e}	87.58 (69.38)^{d}
Untreated control (T7)	24.8 (4.96)^{b}	27.2 (5.20)^{d}	30.2 (5.48)^{d}	33.00 (5.73)^{f}	34.6 (5.87)^{d}	37.4 (6.11)^{e}	39.4 (6.27)^{f}	41.8 (6.46)^{d}	43.6 (6.60)^{d}	45.6 (6.75)^{e}	21.59 (4.64)^{d}	--	--
CD (0.05)	0.43	0.28	0.27	0.22	0.33	0.33	0.27	0.31	0.26	0.19	0.13	2.69	1.45
CV(%)	19.01	54.89	46.84	42.41	70.50	61.90	65.43	92.03	73.80	61.32	57.46	47.32	16.99

Each observation represents mean of 5 replications; Figures in parentheses except last two columns which are asintransformationare √n; similar superscripts in a column indicate values are statistically on par

Table 196. Effect of botanicals and entomopathogen on the population of European red mite, *Panonychus ulmi* on apple in Srinagar, Kashmir during 2020

Treatments	No. of mites/leaf after 1st spray				No. of mites /leaf after 2nd spray			No. of mites/leaf after 3rd spray			Cumulative mean pop. / leaf	% reduction over pre treatment	% reduction over control
	1 DBS	1 DAS	3 DAS	7 DAS	1 DAS	3 DAS	7 DAS	1 DAS	3 DAS	7 DAS			
Nimbicidine 300ppm @ 5.0 ml^{-l}(T1)	17.2 (4.13)^{ab}	11.6 (3.36)^{c}	13.8 (3.68)	16.00 (3.97)^{bc}	8.6 (2.91)^{bc}	10.8 (3.27)^{c}	13.4 (3.65)^{d}	7.6 (2.75)^{c}	12.00 (3.45)^{c}	16.2 (4.02)^{d}	8.06 (2.83)^{c}	52.88 (46.65)^{a}	58.31 (49.84)^{a}
Azadirachtin 1500 ppm @ 5.0 ml^{-l}(T2)	16.6 (4.06)^{a}	5.6 (2.35)^{b}	11.4 (3.37)	13.4 (3.65)^{b}	5.8 (2.39)^{b}	14.2 (3.72)^{d}	18.00 (4.21)^{e}	9.6 (3.08)^{c}	11.8 (3.41)^{c}	14.6 (3.80)^{c}	7.68 (2.76)^{c}	53.28 (46.89)^{a}	60.48 (51.09)^{a}
Azadirachtin 10000 ppm @ 2.0 ml^{-l}(T3)	19.00 (4.34)^{ab}	6.00 (2.43)^{b}	7.2 (2.67)	11.6 (3.40)^{b}	2.4 (1.54)^{a}	6.4 (2.52)^{b}	10.4 (3.22)^{c}	4.00 (1.98)^{a}	7.8 (2.78)^{b}	13.00 (3.60)^{c}	5.25 (2.29)^{b}	71.71 (57.94)^{b}	72.79 (58.58)^{bc}
L. lecanii(1x10^{8} CFU/ml) @ 5ml^{-l}(T4)	14.00 (3.71)^{a}	6.2 (2.48)^{b}	9.2 (3.03)	11.8 (3.43)^{b}	7.2 (2.67)^{bc}	9.4 (3.06)^{c}	12.2 (3.48)^{c}	6.4 (2.52)^{ab}	10.6 (3.24)^{c}	14.8 (3.84)^{cd}	6.57 (2.56)^{bc}	49.93 (44.97)^{a}	66.07 (54.38)^{b}
T5 (T2+T4)	16.4 (3.98)^{a}	6.4 (2.50)^{b}	15.00 (3.87)	16.8 (4.09)	3.2 (1.77)^{a}	5.2 (2.26)^{b}	7.4 (2.71)^{b}	5.6 (2.30)^{a}	8.00 (2.78)^{b}	10.8 (3.27)^{b}	5.92 (2.43)^{b}	59.64 (50.74)^{ab}	69.34 (56.43)^{b}
Fenazaquin 10 EC @ 0.4ml^{-l}	26.4 (5.13)^{b}	1.4 (1.16)^{a}	2.6 (1.6)	2.6 (1.60)^{a}	3.2 (1.77)^{a}	3.8 (1.94)^{a}	3.8 (1.94)^{a}	4.6 (2.13)^{a}	4.8 (2.18)^{a}	5.8 (2.39)^{a}	2.76 (1.65)^{a}	89.45 (71.09)^{c}	85.76 (67.86)^{c}
Untreated control (T7)	11.8 (3.42)^{a}	13.8 (3.71)^{c}	15.6 (3.94)	17.00 (4.12)^{c}	18.8 (4.33)^{c}	20.00 (4.46)^{e}	22.00 (4.68)^{f}	23.4 (4.83)^{d}	25.4 (5.03)^{d}	26.6 (5.15)^{e}	12.26 (3.49)^{d}	--	--
CD (0.05)	0.67	0.35	0.28	0.28	0.26	0.36	0.33	0.34	0.32	0.26	0.17	5.53	2.97
CV(%)	31.67	57.80	43.70	39.16	77.58	56.91	49.31	74.55	56.59	42.59	41.24	11.94	10.63

Each observation represents mean of 5 replications; Figures in parentheses except last two columns which are asin transformations are √n; similar superscripts in a column indicate values statistically on par

Fig:51.

Fig. 1. Effect of treaments on Population of Green apple aphid, *Aphis pomi* and % reduction over control on apple during 2020

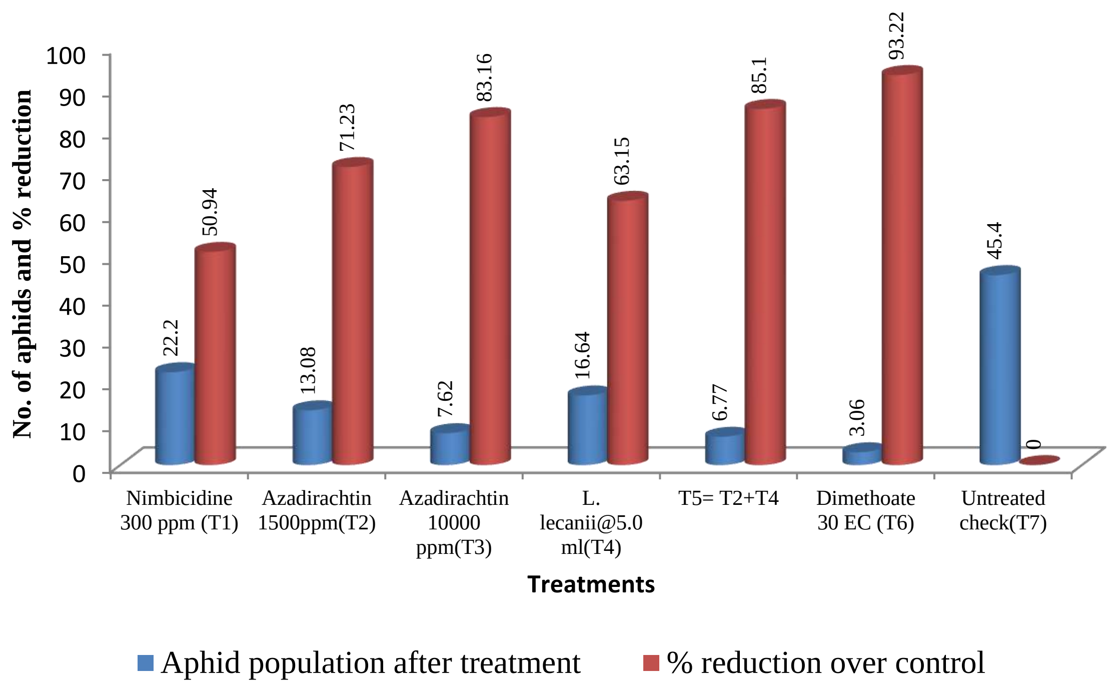


Fig. 2. Effect of treatments on mean population and % reduction over control in two spotted spider mite, *Tetranychus urticae* and European red mite, *Panonychus ulmi* on apple during 2020

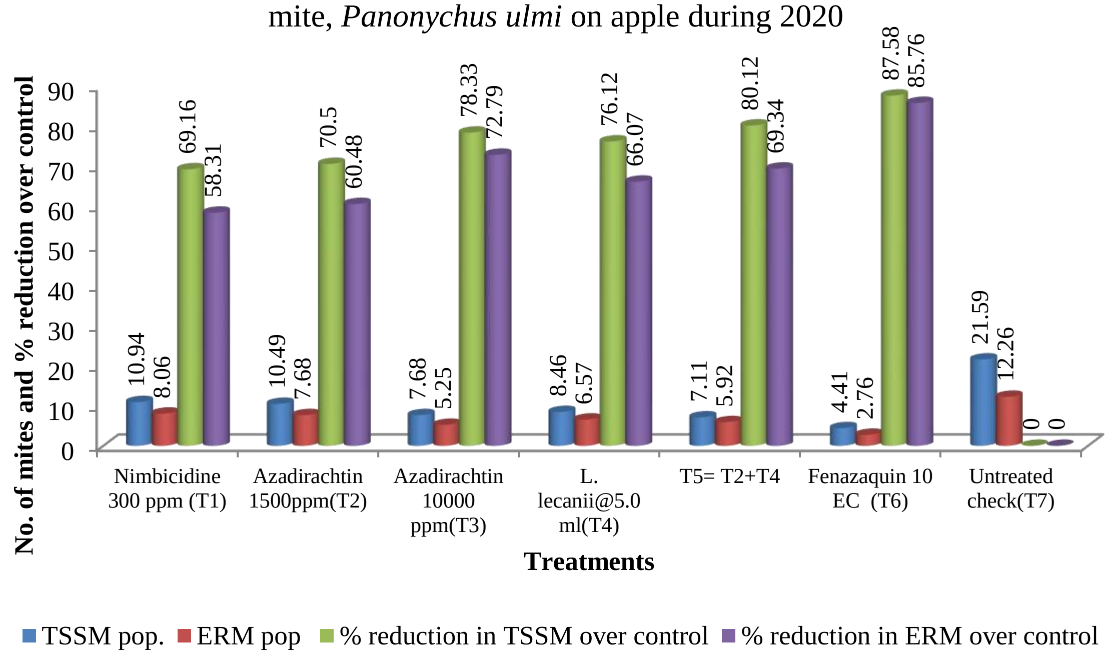


Plate 1

16.4 Organic management of woolly apple aphid, *Eriosoma lanigerum* infesting apple in high density and traditional orchards

Given heavy infestation of woolly apple aphid both in high density as well as traditional orchards of apple in the University campus of SKUAST-K, Shalimar during September' 2020, anddirections from the HoD, Fruit science, SKUAST-K for organic management of the pest, some commercial biopesticides were evaluated both in the laboratory as well as field condition.

Infested twigs from the field were collected and kept in a flask containing water with an open-end clogged with cotton. Biopesticides such as *Lecanicillium lecanii*, *Metarhizium anisopliae* and azadirachtin (Neem seed kernel extract) at different concentrations (Table 197 & 198) were used. Chemical check with Chlorpyriphos 50 %+ Cypermethrin 5% EC and untreated check were also included for comparison. In laboratory condition sprays on infested twigs were made by hand sprayer in the morning and observations were made after three days of the treatment. Infield, a foot sprayer was used to provide treatment both in high density as well as traditional orchard twice a week. Each experiment was replicated thrice. Data on aphid density per colony was recorded before and after the treatment. Post-treatment count was made seven days after the treatment from randomly selected three colonies/ treatment.

On an average, number of aphids^{-}colony ranged 45.33 to 62.66 in laboratory samples (Table 197) and 40.66 to 70.33 in field conditions (Table 198). Difference in aphid density$^{-colony}$ a day before treatment was found statistically non significant in laboratory samples (F= 1.80 NS; d.f = 16 (8); p= 0.151) whereas significant in field (F= 5.98**; d.f = 16 (8); p= 0.001).

Laboratory observation:As a result of treatments, the difference in aphid density$^{-colony}$ among the treatments was found statistically significant (F= 137.62**; d.f = 16 (8); p= 0.001) when compared using one way ANOVA. Maximum % reduction in aphid density over treatment was observed in case of Chlorpyriphos 50 %+ Cypermethrin 5% EC (95.65) followed closely by *Metarhizium anisopliae* @ 10.0 ml^{-l} (94.69) and *Lecanicillium lecanii* @ 10.0 ml^{-l} (88.62). The above entomofungii at recommended dose i.e. 5.0 ml^{-l}of water however exhibited 56.66 and 46.67per cent reduction. Among botanicals, Azadirachtin 10000 ppm @ 2.0 ml^{-l}of water showed the highest (80.06) per cent reduction. A similar pattern was obtained for per cent reduction over control (Table 197). Although azadirachtin was found a potential repellent aphids were found to recolonize after 6-7 days.

Field observation : In field condition also,Chlorpyriphos 50 %+ Cypermethrin 5% EC @ 1.25 ml^{-l} of watercaused maximum reduction in aphid density (96.32) (Plate 3 Fig. 4) followed closely by *M. anisopliae* @ 10.0 ml^{-litre} of water (94.75) and Azadirachtin 10000 ppm @ 2.0 ml^{-l}(85.19) in terms of per cent reduction over control. Bio efficacy of *M. anisopliae* was found statistically on par withChlorpyriphos 50 %+ Cypermethrin 5% EC. *L. lecanii* @ 10.0 ml^{-l}also caused 67.30 per cent reduction. However at recommended dose (5.0 ml^{-l}of water) per cent reduction in aphid density was 58.83 and 53.82 for *L.*

lecanii and *M. anisopliae* respectively (Table 198)(Plate 4, Figs. 5-8). Per cent reduction in aphid density in response to treatments was found statistically significant in reduction over pre treatment(F= 36.39**; d.f = 14 (7); p= 0.001) as well as reduction over control (F= 20.24**; d.f = 14 (7); p= 0.001).

Details of commercial biopesticides are given in Table- 199.

Table 197. Laboratory evaluation of Biopesticides against woolly apple aphid, *Eriosoma lanigerum* infesting apple in Kashmir, during 2020-21

Biopesticides	Dose$^{-\ lit.}$ of water	Pre treatmentcount/ colony	Post-treatment count/ colony	% reduction over Treatment	% reduction over Control
L. lecanii ($1x10^8$ CFU/ml) (T1)	5.0 ml$^{-\ lit}$	47.00 (6.83)[a]	25.00 (4.98)[cd]	46.67 (43.09)[b]	60.05 (50.87)[b]
L. lecanii ($1x10^8$ CFU/ml) (T2)	10.0 ml$^{-\ lit.}$	45.33 (6.73)[a]	5.00 (2.22)[ab]	88.62 (70.39)[c]	92.01 (73.67)[bc]
Azadirachtin 300 ppm (T3)	5.0 ml$^{-\ lit.}$	60.66 (7.78)[a]	52.66 (7.25)[d]	12.93 (20.79)[a]	16.08 (22.32)[a]
Azadirachtin 10000 ppm (T4)	1.0 ml$^{-\ lit.}$	53.00 (7.28)[a]	17.0 (4.12)[c]	67.62 (55.33)[bc]	72.93 (58.68)[b]
Azadirachtin 10000 ppm (T5)	2.0 ml$^{-\ lit.}$	48.00 (6.92)[a]	9.33 (3.03)[b]	80.06 (63.72)[c]	85.19 (67.49)[bc]
M. anisopliae ($1x10^8$ CFU/ml)(T6)	5.0 ml$^{-\ lit.}$	50.00 (7.07)[a]	21.66 (4.64)[c]	56.66 (48.84)[b]	65.24 (53.98)[b]
M. anisopliae ($1x10^8$ CFU/ml)(T7)	10.0 ml$^{-\ lit.}$	62.66 (7.91)[a]	3.33 (1.82)[a]	94.69 (76.68)[cd]	94.75 (76.77)[c]
Chlorpyriphos 50 %+ Cypermethrin 5% EC (T8)	1.25 ml$^{-\ lit.}$	51.00 (7.14)[a]	2.33 (1.48)[a]	95.65 (78.06)[cd]	96.32 (79.21)[c]
Control (T9)	-	61.33 (7.83)[a]	65.33 (8.07)[e]	--	--
CD (0.01)	-	1.24	0.72	6.80	9.55
CV (%)		18.06	96.99	40.39	35.80

Each observation represents a mean of 3 replications; Figures in parentheses except last two columns which are asin transformations are √n; similar superscripts in a column indicate values statistically on par

Table 198. Field efficacy of Biopesticides against woolly apple aphid, *Eriosoma lanigerum* infesting apple in Kashmir, during 2020-21

Biopesticides	Dose$^{-\ lit.}$ of water	Pre-treatment count/ colony	Post-treatment	% reduction over Treatment	% reduction over Control

			count/ colony		
L. lecanii ($1x10^8$ CFU/ml)(T1)	5.0 ml$^{-lit.}$	40.66 $(6.36)^a$	31.66 $(5.62)^d$	21.84 $(27.81)^b$	
L. lecanii ($1x10^8$CFU/ml) (T2)	10.0 ml$^{-lit.}$	48.00 $(6.90)^a$	25.66 $(5.03)^d$	46.91 $(43.22)^c$	67.30 $(55.59)^{bc}$
Azadirachtin 300 ppm (T3)	5.0 ml$^{-lit.}$	56.00 $(7.48)^a$	49.33 $(7.01)^e$	12.09 $(18.82)^a$	35.29 $(36.24)^a$
Azadirachtin 10000 ppm (T4)	1.0 ml$^{-lit.}$	64.00 $(7.99)^a$	37.33 $(6.10)^{de}$	41.58 $(40.15)^c$	51.48 $(45.84)^b$
Azadirachtin 10000 ppm (T5)	2.0 ml$^{-lit.}$	53.00 $(7.27)^a$	17.66 $(4.16)^c$	67.06 $(55.08)^d$	77.35 $(61.68)^{bc}$
M. anisopliae ($1x10^8$ CFU/ml)(T6)	5.0 ml$^{-lit.}$	63.66 $(7.96)^a$	35.66 $(5.96)^c$	43.97 $(41.53)^c$	53.82 $(47.19)^b$
M. anisopliae ($1x10^8$ CFU/ml)(T7)	10.0 ml$^{-lit.}$	55.00 $(7.40)^a$	10.33 $(3.17)^b$	80.79 $(64.38)^e$	86.41 $(68.66)^c$
Cyclone (T8)	1.25 ml$^{-lit.}$	61.33 $(7.82)^a$	5.00 $(2.22)^a$	91.75 $(73.39)^f$	93.40 $(75.21)^c$
Control (T9)	-	70.33 $(8.38)^a$	77.00 $(8.76)^f$	--	--
CD (0.05)		9.13	0.71	7.47	7.12
CV (%)		18.04	66.47	52.85	29.98

Each observation represents a mean of 3 replications; Figures in parentheses except last two columns which are asin transformations are √n; similar superscripts in a column indicate values statistically on par

Table 199. Details of Bio pesticides used during 2020-21

S. No.	Technical name	Concentration	Trade name	Manufacturer
1.	Azadirachtin	300 ppm	Nimbecidine	T. Stane, Coimbatore,
2.	Azadirachtin	10000 ppm	Neem Baan	M/S Ozone Biotech, Faridabad
3.	Azadirachtin	1500 ppm	Believe	MD Biocolas, Haryana
4.	*Metarhizium anisoplae*	CFC count (2x 10^9/ ml	META KILL	RomvijayBioo Tech P. Ltd. Pondicherry
5.	*Lecanicillium lecanii*	CFC count (2x 10^9/ ml	VERELAC	RomvijayBioo Tech P. Ltd. Pondicherry

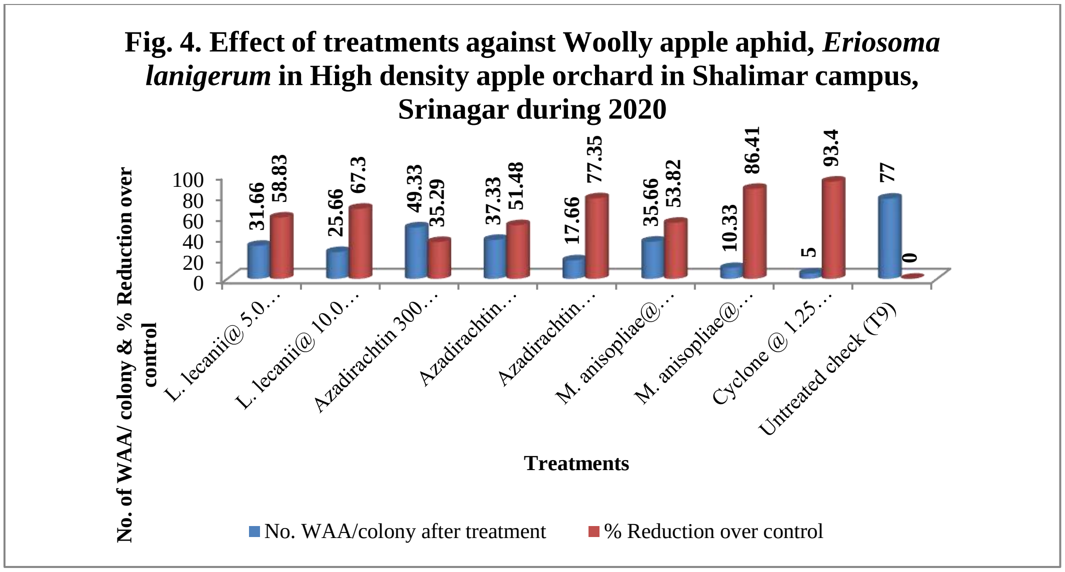


Fig:52.

Plate 3

Fig:53. Woolly apple aphid before and after treatments. 5-6. Woolly apple aphid on High-density apple orchard. 7-8. Reduced attack of WAA after treatments.

17. Biological Control Citrus Pests

17.1 Evaluation of different isolates of entomopathogenic fungi against citrus thrips

Centres: Tirupati

Duration: 3 years, Start date: 2020

Objectives: To study the effect of different isolates of entomopathogenic fungi against citrus thrips

Experimental material: Existing orchard with 6 x 6m spacing.

Age of plants:8 years (Tirupati)

Treatment details: **Table 200.**

T_1	*Beauveria bassiana* (NBAIR Strain) @ 5g/ Litre
T_2	*Metarhizium anisopliae* (NBAIR Strain) @ 5g/ Litre
T_3	*Lecanicium lecanii* (NBAIR Strain) @ 5g/ Litre
T_4	Local check (Acephate 75SP @ 0.1%)
T_5	Control

Design: RBD

Replications:5

Plants/replication: 3

Variety: Sathgudi

Observations:The per cent leaf infestation due to thrips on foliage at 0 days (precount) and 3, 7 and 14 days after the second spray and for fruits, the percent infested fruits will be counted. The observed data for per cent thrips infestation on leaf and fruits infestation will be analysed statistically and the values will be converted into arc sine transformed values. The yield data will be recorded and expressed into tonnes/ha.

Time of spray: First spray at the peak activity of the pest and second at 14 days after the first spray for thrips damaging leaf and in case of thrips, treatments should be initiated immediately after fruit set (10 days after flowering)

Results: The treatments were imposed on 11.01.2021 and the second application was carried out on 28.01.2021 on the sweet orange cultivar, Sathgudi. The preliminary results in table 201 showed that *Beauveria bassiana*@5g/L was found effective with the least infestation by thrips on fruits (11.68%) followed by *Lecanicilium lecanii*@5g/L (13.10%) and *Metarhizium anisopliae*@ 5g/L(16.82%) as compared to local check, acephate 75SP with 17.34% infestation and the maximum infestation was recorded in control with 24.14% fruits infested.

Table 201. Efficacy of entomopathogens against thrips infesting sweet orange

Treatments	Fruits infestation * (%)	No. of fruits/tree*	Yield (t/ha)
T_1:*Beauveria bassiana* (NBAIR Strain) @ 5g/Litre	11.68	244.29	-

T_2:*Metarhizium anisopliae* (NBAIR Strain) @ 5g/Litre	16.82	167.37	-
T_3:*Lecanicilium lecanii* (NBAIR Strain) @ 5g/Litre	13.10	193.14	-
T_4:Local check (Acephate 75SP @ 0.1%)	17.34	160.25	-
T5: Control	24.14	185.36	-
SE (m±)	-	-	-
CD at 5%	-	-	-
CV at 5%	-	-	-

*Only preliminary raw data collected from fruits on tree, statistical analysed data will be only known at harvest (Probably :Aug-Sept)

17.2 Evaluation of different isolates of entomopathogenic fungi against citrus rust and Green mites

Centres: Tirupati

Status: New

Duration: 3 years, Start date: 2020

Objectives: To study the effect of different isolates of entomopathogenic fungi against citrus Rust and Green mites

Experimental material: Existing orchard with 6 x 6m spacing

Treatment details: 5 **Table 202.**

T_1	:	*Beauveria bassiana* (NBAIR Strain) @ 5g/ Litre
T_2	:	*Metarhizium anisopliae* (NBAIR Strain) @ 5g/ Litre
T_3	:	*Lecanicium lecanii* (NBAIR Strain) @ 5g/ Litre
T_4	:	Local check (Propargite 57EC @0.057%)
T_5	:	Control
Treatments should be given during an active period of the pest twice at 15 days interval		

Design: RBD

Replications: 4

Plant/replication: 2

Variety: Sathgudi

Observations: The population counts of mitesbefore and 3, 7 and 14 days after treatment will be recorded. In the case of rust mites, observation on infested fruits (%) before harvest will be noted and the yield data will be recorded and expressed into tonnes/ha.The observed data for population counts on leaf and fruits infestation will be analysed statistically and the values will be converted into the square root and arcsine transformed values, respectively.

Results: The treatments were imposed on 11.01.2021 and the second application was carried out on 28.01.2021 on the sweet orange cultivar, Sathgudi. The preliminary results in table 203 showed that *Lecanicilium lecanii*@5g/Lwas found very effective with least infestation by rust mites on fruits (3.32%) followed by *Beauveria bassiana*@ 5g/L(4.15%) as compared to local check, propargite with 4.59% infestation and the maximum infestation was recorded in control with 16.52 % fruits infested.

Table 203. Efficacy of entomopathogens against mites infesting sweet orange

Treatments	Fruits infestation by rust mites * (%)	No. of fruits/tree*	Yield (t/ha)
T_1:*Beauveria bassiana* (NBAIR Strain) @ 5g/Litre	4.15*	192.30*	-
T_2:*Metarhizium anisopliae* (NBAIR Strain) @ 5g/Litre	8.70	163.89	-
T_3:*Lecanicilium lecanii* (NBAIR Strain) @ 5g/Litre	3.32	168.27	-
T_4:Local check (Propargite 57EC @ 0.1%)	4.59	178.45	-
T5: Control	16.52	188.60	-
SE (m±)	-	-	-
CD at 5%	-	-	-
CV at 5%	-	-	-

*Only preliminary raw data collected from fruits on tree, statistical analysed data will be only known at harvest (Probably:Aug-Sept)

18. Biological Control Anola Pests

18.1 Biological control of anola mealy bug using entomopathogens

18.1.1 SKUAST, Jammu

Experimentla details

Number of treatments: 5

Number of replications: 5

Design: RBD

Two trees per replication in Aonla

Treatment details **Table 204.**

T1	*B. bassiana* (NBAIR-Bb-5a) @ 5 g/L
T2	*Metarhizium anisopliae*(NBAIR-Ma-4) @ 5 g/L

T3	*Lecanicillium lecanii*(NBAIR-VI-22) @ 5 g/L
T4	Azadirachtin 10000 ppm @ 1 ml/L
T5	Untreated Control

Observations to be recorded- Pre and post spray mealy bug counts

Table 205:- Percent reduction in mealy bug nymphs and adults

Table 205.

Treatments	Pre spray count	Post spray count (mean no. per 10 cm twig)		Percent Reduction at 7 DAS	Fruit Yield (kg/tree)
		3 DAS	7 DAS		
T1	6.80	6.00	4.40	35.29 (36.43)	60.45
T2	7.20	7.53	4.53	36.62 (37.21)	64.90
T3	7.40	7.53	5.33	27.98 (31.88)	41.35
T4	7.13	5.53	4.53	36.53 (37.16)	64.05
T5	7.33	8.13	8.53	-	26.40
CD at 5%	N.S.	1.31	0.96	(2.78)	1.514

Figures in parenthesis are arc-sine transformed values

DAS – Days After Spray

Results -

Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, along with Azadirachtin 10000 ppm were assessed against Aonla mealy bug. Significantly highest percent reduction in mealybug population was recorded in *M. anisopliae* and Azadirachtin spray (36.62 and 36.53% reduction) followed by *B. bassiana* spray (35.29% reduction) at 7 DAS. At 3 DAS mealy bug population was significantly lowest in Azadirachtin spray (5.53 mealy bug / 10 cm twig). Significantly highest mealy bug population was recorded in the untreated control (8.53 mealy bugs / 10 cm twig).


Fig:54. Aonla mealy bug

19.Biological Control Litchi Pests

19.1 Bio-intensive management of litchi fruit borer, *Conopomorpha sinensis* (Bradley) in litchi

19.1.1 PAU, LUDHIANA

Location: Fruit Research Station, Gangian (Hoshiarpur)

Variety :Seedless Late

Treatments :03

1. BIPM

Ploughing in the orchard during March-April

Regular clean cultivation throughout the year

Regular collection and destruction of fallen infested fruits during May-June

Light trap @ 1 per acre during April

Releases of *T. embryophagum*@ 4000 parasitized eggs per tree 5-7 times at 7-10 days interval starting from initiation of flowering to colour break stage

2. Farmer's practice (chemical control)

3. Untreated control

The experiment is in progress

PLANTATION CROPS

20. Biological Control Coconut Pests

20.1 Surveillance of rugose spiralling whitefly in coconut and population of natural biocontrol agents

20.1.1 ICAR-NBAIR, Bengaluru

During 2020-21, about five surveys on incidence and infestation of rugose spiralling whitefly were conducted in Ramanagara, Mandya and Bengaluru rural districts in Karnataka. The intensity of RSW was recorded as low (<10 live egg spirals or adults/leaflet) to medium (11-20 live egg spirals or adults/leaflet) in most the surveyed locations in Karnataka (Table 206). The major host plants recorded were coconut, banana, sapota, Indian almond, custard apple, mango, oil palm and many ornamental palm plants. Besides RSW, infestation of palm infestation whitefly, *Aleurotrachelus atratus* was more predominant across the study location and intensity was moderate to severe; infestation Bondars nesting whitefly, *Paraleyrodes bondari* and nesting whitefly, *Paraleyrodes minei* was low to moderate level. Natural enemies complex associated with RSW were documented and determined the efficacy at field level during survey. RSWwas in co-existence with *P. bondari, P. minei, A. dispersus* and *A. atratus* on coconut. The most predominant parasitoid, *Encarsiaguadeloupae* was found to very effective in suppressing the RSW to the extent of 91% in several host plants. Besides, parasitoid, *Encarsia dispersa*, chrysopid, *Pseudomallada astur* and several coccinellids associated with RSW colony. *Pseudomallada* (*=Dichochrysa*)sp. *nr. astur, Cybochephalus indicus, Chilocorus nigrita* and *Jauravia pallidula* was found to feed on other invasive whiteflies whitefly. No natural parasitism observed on this pest so far.

Table 206. Intensity of rugose spiralling whitefly on coconut in Karnataka

District	Location	Intensity of RSW (Low/Moderate /High)
Mandya	Madduru	Low to moderate

	Malavalli	Low
	Mandya	Moderate
Ramanagara	Magadi	Low
	Bidadi	Moderate
	Kanakpura	Moderate
Bengaluru rural	Hessarghatta	Low
	Nelamangala	Low
	Shivakote	Low

Low: <10 live egg spirals or adults/leaflet; Moderate: 10-20 live egg spirals or adults/leaflet; High: >20 live egg spirals or adults/leaflet

20.1.2 KAU, Vellayani

Surveillance was commenced by October 2020, to study the population build-up of RSW and the biotic and abiotic factors in coconut. Coconut palms were selected in three RSW infested gardens Location I, Location II and Location III, from Vellayani ecosystem, which is a peninsular area. Five palms were selected at random and tagged for taking observations. Four leaflets collected from two opposite sides of the lower whorl were brought to the lab and counted for number of live spiral colonies, number of pupae per spiral, number of parasitized pupae and presence of other natural enemies and sooty mould feeders. Observations were recorded at monthly intervals. Corresponding weather data was also recorded from Agro meteorological station at College of Agriculture, Vellayani

Fig:55. Assessment of population of RSW in the field and laboratory

In Location I, RSW population was high to severe during October 2020 to March 2021, with a gradual increase in number of live spirals (Table 207). The corresponding parasitism levels were 59.29 to 71.26%.Unlike in the previous year there was no species displacement by nesting whitefly,*Paraleyrodes minei*, though Bondar's nesting whitefly, *Paraleyrodes bondari* was present during January to February 2021.

Population of RSW was medium throughout the observation period in Location 2. The parasitism level ranged from 55.35 to 63.55%.In the Location 3, population of RSW was low till December 2020 and thereafter there was a gradual increase to moderate levels till

March 2021. Extent of parasitism was 33.09% to 65.39%. The period of low parasitism coincided with lest pest density (Table 208).

Table 207. Number of colonies of infestation and extent of parasitism of RSW during 2020-21 at KAU Vellayani

Palm No.	October 20		November 20		December 20		January 2021		February 2021		March 2021	
	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	3.60	63.72	5.50	57.89	6.50	55.00	10.50	56.52	12.50	80.00	14.50	73.07
P2	4.50	62.60	11.50	57.14	12.00	56.52	12.50	56.52	13.00	77.27	10.50	68.00
P3	12.50	66.67	12.50	62.96	13.50	65.38	14.50	46.15	15.00	62.96	15.50	56.89
P4	4.75	71.43	8.50	66.66	10.50	75.00	10.50	76.19	11.50	73.91	12.50	69.23
P5	15.50	51.22	15.25	75.00	16.50	55.55	16.50	61.11	17.00	62.16	17.50	64.10
Mean	7.22	63.12	10.65	63.93	11.8	61.49	11.10	59.29	13.80	71.26	14.10	66.25
Severity Index	H		H		S		S		S		S	
Location-II												
P1	15.50	61.90	14.00	65.21	15.50	64.07	15.00	62.5	16.0	63.33	16.5	58.82
P2	4.50	66.67	4.00	60.00	4.50	50.00	5.00	71.42	5.00	71.42	5.50	75.00
P3	3.50	42.85	3.00	60.00	3.50	50.00	3.65	66.67	4.00	71.42	3.75	77.77
P4	4.20	42.85	4.00	66.67	3.75	71.42	4.00	44.44	4.50	45.45	4.75	61.53
P5	4.50	62.50	4.00	71.42	4.25	42.85	4.75	44.44	4.75	44.44	5.00	44.64
Mean	6.44	55.35	5.80	64.66	6.30	55.66	6.49	57.89	6.85	59.21	7.0	63.55
Severity Index	M		M		M		M		M		M	
Location-III												
P1	5.50	80.95	5.00	75.00	5.50	61.90	5.75	65.21	8.50	66.66	10.5	68.00
P2	2.50	57.14	2.00	66.66	2.50	28.57	2.75	60.00	4.50	50.00	5.00	60.00
P3	2.00	66.66	1.50	66.66	2.50	33.33	3.50	28.57	3.75	50.00	4.50	50.00
P4	2.50	88.88	2.00	57.14	2.50	33.33	2.75	28.57	3.50	50.00	5.00	60.00
P5	1.75	33.33	1.50	40.00	1.75	33.33	2.50	33.33	2.75	57.14	3.50	60.00
Mean	2.85	65.39	2.40	61.09	2.95	38.09	2.65	43.13	4.60	54.76	5.60	59.60

Severity index	L	L	L	L	M	M

Low (3 infested leaflets/frond); M (4to7 infested leaflets/frond); H (>10 infested leaflets/frond); S (>10infested leaflets/frond with sooty mould)

Per cent leaves infested /palm and leaflets infested/leaf of RSW during 2020-21 at KAU Vellayani

Table 208.

Palm No.	October 20		November 20		December 20		January 2021		February 2021		March 2021	
	Leaves infested /palm (%)	Leaflets infested/palm (%)	Leaves infested /palm (%)	Leaflets infested/palm (%)	Leaves infested /palm (%)	Leaflets infested/palm (%)	Leaves infested /palm (%)	Leaflets infested/palm (%)	Leaves infested /palm (%)	Leaflets infested/palm (%)	Leaves infested /palm (%)	Leaflets infested/palm (%)
P1	85.47	85.00	86.41	91.22	87.50	92.22	91.22	95.00	91.22	95.00	92.22	96.66
P2	81.37	53.36	81.37	53.56	82.27	55.55	82.47	55.55	85.00	56.68	85.00	60.36
P3	75.68	59.69	75.68	59.69	77.36	60.24	80.00	66.66	80.00	68.36	82.36	71.58
P4	70.31	60.24	70.31	60.24	75.00	61.11	75.00	61.11	80.00	66.66	81.37	72.22
P5	71.58	59.69	81.37	60.24	81.37	64.78	82.36	64.78	86.41	71.00	86.41	71.55
Mean	76.88	63.59	79.02	64.99	80.76	66.78	82.21	68.62	84.52	71.54	85.47	74.47

20.1.3 DRYSRHU, Ambajipeta

The observation on population of various life stages of rugose spiralling whitefly (RSW) was collected at standard week's interval at monthly intervals (Table 209). The RSW population was collected from the variety East coast tall of 10 to 15 years age from three different blocks of HRS, Ambajipeta farm. The mean number of spirals of RSWranged between 0.45 during March 2021 to 21.50 per leaflet during April 2020 while the mean number of nymphs of RSW ranged between 2.25 to 47.50 per leaflet. The mean number of pupae ranged between 1.85 to 32.40 and 4.25 to 72.70 of adult RSW. The peak population of all stages was observed in April, 2020 and slowly decreased consequently throughout the observational period. For the first time,Bondars nesting whitefly (BNW) wasrecorded on coconut in the observational blocks in July 2020. A high population was observed in the month of March, 2021. The mean number of spirals of BNWwas ranged between 7.65 to 62.50 spirals per leaflets during the observational period. The mean number of nymphs of BNWwas ranged between 12.35 to 98.50 nymphs per leaflet. The mean number of pupae ranged between 9.85 to 72.30 and adults was ranged between 12.50 to 98.50 per leaf. Interestingly, there was inverse relation between RSW and BNW population build up (Table 209).

Table 209. Incidence of rugose spiralling white fly and Bondars nesting white fly during 2020-21 at Ambajipeta, East Godavari district

Month	Rugose spiralling white fly (RSW)				Bondars nesting white fly (BNW)			
	Mean spirals / leaflet	Mean nymphs / leaflet	Mean pupae / leaflet	Mean adult RSW/ leaflet	Mean spirals / leaflet	Mean nymphs / leaflet	Mean pupae / leaflet	Mean adult RSW/ leaflet
April, 2020	21.50	47.50	32.40	72.70	0.0	0.0	0.0	0.0
May, 2020	13.25	39.75	26.30	66.35	0.0	0.0	0.0	0.0
June, 2020	7.80	27.15	19.50	53.50	0.0	0.0	0.0	0.0
July, 2020	3.75	20.50	12.30	42.75	7.65	12.35	9.85	12.50
August, 2020	2.50	17.50	9.75	32.25	19.35	25.25	15.45	25.25
September, 2020	2.25	13.75	8.25	24.85	25.65	42.50	21.75	39.80
October, 2020	1.75	9.30	7.80	12.65	32.75	58.30	25.25	43.60
November, 2020	1.00	5.25	6.80	10.35	37.60	71.25	36.80	59.75
December, 2020	0.75	3.75	5.20	9.65	42.50	78.75	42.30	65.75
January,2021	0.65	3.25	3.15	9.15	51.30	81.50	54.70	72.50
February, 2021	0.50	2.85	2.00	6.85	58.50	87.50	63.82	89.30
March,2021	0.45	2.25	1.85	4.25	62.50	98.50	72.30	98.50
Mean ± SE	4.68±1.88	16.07±4.38	11.27±2.83	28.77±7.07	28.15±6.65	46.32±10.84	28.51±7.34	42.24±10.18

20.1.4 KAU, Thrissur

Monitoring of rugose spiralling whitefly population and their natural enemies was carried out at Thrissur and Palakkad at districts during 2020-21. Observations were recorded at fortnightly intervals from October, 2020 as per approved technical programme. The results on mean whitefly population as well as mean parasitism were given. The build-up of pest started in October, possibly due to the delayed withdrawal of the South West monsoon. The whitefly infestation broadly followed the pattern observed in 2018-20 though the severity of infestation was high well into March, unlike in previous years when it had declined by January under the regulatory pressure from the parasitoid, *Encarsia guadeloupae*.

Mean parasitism by *E. guadeloupae* during the study period ranged from 17.58 to 85.96 % at Thrissur and from 35.72 to 62.10 % at Palakkad. The mean parasitism showed fluctuations and also failed to reach the levels observed during previous years at either of the locations. The possible reason for the low levels of in parasitism could be the presence of the two alien species of whiteflies, namely *Paraleurodes bondari* and *P. minei*, which are hardly parasitized by *E. guadeloupae.*

20.1.5 RARS, Kumarakum

Incidence of rugose spiralling whitefly in coconut in three localities *viz.*,Kumarakom, Mocompu and Vyttila was observed over a period of one year from April 2020 to March 2021 (Table 210). Since the population of RSW was found to be very less, observations on surveillance was recorded with respect to Bondar's nesting whitefly alone from April 2020 onwards, just as in previous year. Per cent infestation was noticed to be increasing from June 2020 to March 2021 in all the three localities, where Vyttila recorded the highest infestation (97.00%) in March. As far as the intensity of damage is considered, Moncompu was observed with the highest infestation (99.01%) in March, where the other two locations were not far behind. This increasing trend in intensity, especially from November might be due to the increasing atmospheric temperature.

Live colonies per leaflet was also found to be increasing from November onwards in all the three locations, though there were some decline in the count in between, in Moncompu and Vyttila. Compared to the other two locations, live colony count observed from Kumarakom was noted to increase at an alarming rate, where there was a hike in the count after October. Peak colony count of 21.85 was obtained in the month of March in Kumarakom, which was the highest among all the three locations. This might be due to the rise in temperature and relative humidity and the absence of parasitoids which might have favoured the smooth establishment of colonies.

Table 210. Severity of infestation and extent of parasitism of rugose spiralling whitefly in Thrissur district during 2020-21

Palms	13-10-2020		02-11-2020		16-11-2020		3-12-2020		21-12-2020		05-01-2021		19-01-2021		01-02-2021		15-02-2021		02-03-2021		16-03-2021		31-03-2001	
	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)
P1	L	50.0	L	57.14	M	100.00	H	15.00	H	60.27	S	14.00	S	57.67	H	36.83	S	2.36	S	59.52	H	60.79	S	90.45
P2	L	75.0	M	75.00	M	75.00	S	0.00	S	30.96	S	37.56	S	75.00	S	75.68	S	52.82	S	84.02	H	70.52	S	72.22
P3	L	40.92	M	40.00	HH	75.00	H	0.00	S	12.50	S	72.60	S	71.15	S	76.66	S	42.42	H	77.36	S	63.75	S	32.21
P4	L	8.00	L	0.00	M	100.00	M	27.07	S	52.38	S	30.48	S	44.11	S	84.01	H	28.36	S	67.57	S	49.45	H	83.96
P5	L	73.64	M	75.00	S	59.37	H	45.84	H	33.11	H	71.42	S	58.33	S	41.97	H	31.21	H	83.09	S	71.70	H	65.00
Mean		49.51		49.43		81.87		17.58		37.84		45.21		61.25		63.03		31.43		74.31		63.24		85.96

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 211. Severity of infestation and extent of parasitism of rugose spiralling whitefly in Palakkad district during 2020-21

Palms	28-10-2020		12-11-2020		25-11-2020		9-12-2020		23-12-2020		13-01-2021		22-01-2021		08-02-2021		25-02-2021		10-03-2021		25-03-2021	
	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)
P1	L	38.83	M	50.00	M	56.81	H	71.66	S	50.00	M	50.27	M	51.76	S	55.11	H	69.58	H	87.90	H	61.61
P2	L	50.00	L	100.00	H	0.00	H	50.00	H	75.00	H	71.17	S	33.79	S	53.90	S	70.79	S	48.77	S	75.00
P3	L	50.00	L	100.00	M	50.00	H	50.00	S	25.00	M	39.91	S	70.94	S	79.39	S	70.93	S	17.69	S	82.32
P4	M	60.00	M	45.25	M	50.00	H	0.00	S	0.00	H	7.19	S	56.16	S	35.43	S	60.17	S	87.48	S	88.75
P5	L	85.87	L	100.00	H	75.00	S	25.00	S	100.00	H	67.86	S	10.13	S	42.67	S	46.25	S	82.73	S	100.00
Mean		56.94		79.05		46.36		39.33		50.00		47.28		44.55		66.62		63.54		81.14		81.53

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 212. Severity of infestation of Bondar's nesting whitefly at three different locations during 2020-21 at Kumarakum

Location	Month	Infestation (%)	Intensity of damage (%)	Live colonies /leaflet	Severity of infestation
Kumarakom	April, 2020	80.44	71.57	5.90	Low
	May, 2020	79.61	71.78	6.00	Low
	June, 2020	79.94	71.80	2.50	Low
	July, 2020	80.71	71.81	3.90	Low
	August, 2020	86.92	69.84	8.65	Low
	September, 2020	89.13	75.07	7.25	Low
	October, 2020	89.25	80.05	10.40	Medium
	November, 2020	89.44	81.10	15.55	Medium
	December, 2020	91.17	78.30	15.75	Medium
	January, 2021	91.17	80.71	18.15	Medium
	February, 2021	91.17	86.27	18.25	Medium
	March, 2021	92.28	90.54	21.85	High
Moncompu	June, 2020	84.92	78.23	6.70	Low
	July, 2020	85.12	86.01	7.80	Low
	August, 2020	85.22	85.61	7.15	Low
	September, 2020	85.56	85.42	3.95	Low
	October, 2020	86.00	91.44	6.05	Low
	November, 2020	87.94	93.62	4.85	Low
	December, 2020	88.98	96.06	5.60	Low
	January, 2021	88.98	97.58	6.50	Low
	February, 2021	92.43	97.84	8.65	Low
	March, 2021	92.43	99.01	11.75	Medium
Vyttila	June, 2020	89.59	88.38	7.40	Low
	July, 2020	89.15	95.92	7.45	Low
	August, 2020	90.27	97.64	10.15	Medium
	September, 2020	89.61	89.63	3.50	Low
	October, 2020	88.90	95.17	7.35	Low
	November, 2020	96.00	89.43	3.85	Low
	December, 2020	96.40	96.16	7.75	Low
	January, 2021	96.58	99.50	8.20	Low
	February, 2021	96.58	98.61	12.25	Medium
	March, 2021	96.66	98.97	12.55	Medium

20.2. Biological suppression of rugose spiralling whitefly in coconut

20.2.1 RARS, Anakapalle

During 2020-21, Per cent reduction in rugose spiralling whitefly intensity was observed high in T_1- *Isaria fumosorosea* (Pfu-5) sprays + *Encarsia guadeloupae* release (70.6%) after two sprays than one spray (31.67%) due to parasitization by *Encarsia guadeloupae* released after first spraying of Pfu-5 and in T_2 –Pfu-5 sprays + predator, *Dichochrysa astur* release (70.6%) after two sprays than one spray (31.67%) due to *D. astur* released after first spraying of Pfu-5 (Table 213). Reduction in white fly intensity was low in T_3 - Neem formulation 10000 ppm sprays (21.37%) after two sprays than one spray (16.82%).

Table 213. Efficacy of biorationals on the bio-suppression of rugose spiralling whitefly during 2020-21 at Anakapalle

Treatment*	Before spray			15 days after first spray		15 days after second spray			Reduction in intensity(%)	
	Infestation (%)	Intensity (%)	Live colonies /leaflet	Intensity (%)	Live colonies/ leaflet	Infestation (%)	Intensity (%)	Live colonies/ leaflet	After one spray	After two sprays
T_1	56.12	62.05	34.50	42.40	12.00	6.01	18.20	10.30	31.67	70.60
T_2	37.51	42.52	43.20	29.31	11.00	6.25	13.40	8.70	31.07	68.50
T_3	49.80	56.02	39.10	48.60	25.20	31.60	44.05	24.60	16.82	21.37

*T1: *Isaria fumosorosea* (Pfu-5) + parasitoid, *Encarsia guadeloupae*; T2: *Isaria fumosorosea* (Pfu-5) + predator, *Dichocrysa astur*; T3:Neem formulation 10000 ppm

20.2.2 ICAR-CPCRI, Kayamkulam

The experiment was initiated during January 2021 on juvenile Kalpasankara palms to evaluate the efficacy of biorationals for the bio-suppression of rugose spiralling whitefly mainly coinciding the rising phase of the pest. Four treatments were superimposed with ten palms per treatment and sampling made on four leaflets per palm. 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%), water spray and conservation biological control could reduce the RSW population significantly ranging from 0.18-0.73 (Table 9). Palms sprayed with *Isaria fumosorosea* registered highest RSW population (0.95) after one-month of treatment. However, after two months all treatments were found on par indicating the importance of pesticide holiday approach and conservation biological control in the biological pest suppression of RSW with higher parasitism (58.8%) by *Encarsia guadeloupae*.

The least reduction was observed on palms exposed to *Isaria fumosorosea* (36.7%), whereas, neem oil treated palms registered highest pest reduction of 82.4%. Good health management practices are very much important in recouping palm health and thus to reduce the pest impact.

Table 214. Efficacy of biorationals on the bio-suppression of rugose spiralling whitefly during 2020-21 at Kayamkulam

Treatment	Rugose spiralling whitefly population (No.)					Parasitism (%)
	Pre-treatment	After one month	Reduction (%)	After two months	Reduction (%)	
T_1	0.78 (1.33)	0.73 (1.29)[ab]	6.41	0.30 (1.13)	61.5	58.8
T_2	0.98 (1.26)	0.95 (1.37)[a]	3.06	0.62 (1.20)	36.7	46.8
T_3	0.85 (1.30)	0.18 (1.08)[b]	78.8	0.15 (1.07)	82.4	45.9
T_4	0.53 (1.20)	0.18 (1.07)[b]	66.0	0.28 (1.12)	47.2	54.3
CD (*P*=0.05)	NS	0.217		NS		

T1-Conservation biological control; T2-Application of *Isaria fumosorosea;* T3-Application of neem oil 0.5%, T4-Water spray

Table 215. Efficacy of biorationals in the bio-suppression of Bondar's nesting whitefly during 2020-21 at Kayamkulam

Treatments	Bondar's nesting whitefly population (No.)				
	Pre-treatment	After one month	Reduction (%)	After two months	Reduction (%)
Conservation biological control of *Encarsia guadeloupae*	2.38 (1.83)[b]	2.13 (1.73)	10.50	1.00 (1.38)	57.98
Isaria fumosorosea(Pfu-5)	5.35 (2.48)[a]	3.33 (2.02)	37.76	1.00 (1.39)	81.31
Neem oil 0.5%	6.42 (2.69)[a]	2.55 (1.86)	60.28	1.18 (1.46)	81.61
Water spray	4.75 (2.37)[a]	2.53 (1.84)	46.74	0.90 (1.35)	81.05
CD (*P*=0.05)	0.46	NS		NS	

T1-Conservation biological control; T2-Application of *Isaria fumosorosea*; T3-Application of neem oil 0.5%, T4-Water spray

20.2.3 DRYSRHU, Ambajipeta

The first spray was given on first week of December, 2020 and subsequent spray at 15 days interval. Data on survival of various stages of whitefly population were transformed into √x+0.5 values before subjecting to analysis of variance. The experiment was carried out in coconut of 9 years age and average incidence in and around the experimental block varied from medium to high incidence. There were no significant difference in various stages of RSW in the pre treatment count was observed (Table 216). Fifteen days after treatment imposition, lowest number of egg spirals was recorded in neem oil spray and *I. fumosorosea* treatment (1.54 and 2.69, egg spirals respectively). Significantly the lowest number of RSW infested leaflets /leaf was recorded in *I. fumosorosea* treatment (38.98 %). A high number of egg spirals were observed in natural conservation of *E. guadeloupae* treatment. The nymphal and adult population was also observed to be low in neem oil treatment compared to other treatments and was followed by *I. fumosorosea* treatment. A number of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet (3.62) was recorded in natural conservation of *E. guadeloupae* treatment while a high aborted nymph/pupae was recorded in neem oil and water spray (Table 217).

While 15 days after second spray, lowest number of egg spirals were recorded in neem oil and *I. fumosorosea* treatment (1.06 and 1.48 egg spirals). The lowest number of RSW infested leaflets /leaf was observed in neem oil treatment. A high number of egg spirals were observed in natural conservation of *E. guadeloupae* treatment. However, a low nymphal and adult population was observed inneem oil treatment followed by *I. fumosorosea* treatment. A high of number (19.40) of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet was recorded in natural conservation of *E. guadeloupae* treatment 30days after observation (Table 217).

Table 216. Rugoses piralling whitefly population in various treatments before treatments imposition at Ambajipeta

Treatments	Leaves infested with RSW/palm (Incidence %)**	Infested leaflets /leaf (from 4 sample leaves/palm) (Intensity %)**	Number of live population/leaflet*			Number of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet	Aborted nymph /pupae
			Egg spirals	nymph	adult		
T_1	80.56 (63.85)	76.74 (61.19)	8.56 (3.01)	22.28 (4.77)	16.56 (4.13)	2.16 (1.62)	0.49 (0.99)
T_2	81.47 (64.51)	77.42 (61.70)	8.02 (2.91)	20.98 (4.63)	20.05 (4.53)	1.61 (1.44)	0.38 (0.93)
T_3	79.31 (63.07)	79.50 (63.09)	8.75 (3.03)	22.33 (4.78)	19.90 (4.51)	2.03 (1.58)	0.23 (0.84)
T_4	81.42	80.83	9.03	22.68	17.85	2.46	0.40

	(64.49)	(64.04)	(3.08)	(4.81)	(4.28)	(1.71)	(0.93)
SEm	-	-	-	-	-	-	-
CD (5%)	NS	NS	NS	NS	NS	NS	NS

T1-Conservation biological control; T2-Application of *Isaria fumosorosea*; T3-Application of neem oil 0.5%, T4-Water spray; *Fig in parenthesis are √x+0.5 transformed values;** Fig in parenthesis are arc sign transformed values

Table 217. Rugose spiralling whitefly population in various treatments during 2020-21 atAmbajipeta

Treatments	Leaves infested with RSW/palm (Incidence %)**	RSW infested leaflets /leaf (from 4 sample leaves/palm) (Incidence %)**	Number of live population/leaflet*			Number of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet	Aborted nymph/ pupae
			Egg spirals	Nymph	Adult		
15 days after first spray							
T_1	82.69 (65.47)	81.44 (64.49)	7.89 (2.89)	23.96 (4.94)	17.12 (4.03)	3.62 (2.10)	1.52 (1.39)
T_2	54.60 (47.76)	38.98 (38.63)	2.69 (1.76)	5.25 (2.36)	2.16 (1.59)	1.04 (1.23)	1.00 (1.20)
T_3	47.64 (43.64)	46.06 (42.68)	1.54 (1.41)	4.05 (2.12)	1.15 (1.23)	0.08 (0.76)	2.78 (1.77)
T_4	44.92 (42.08)	46.17 (42.77)	2.99 (1.85)	6.16 (2.58)	2.39 (1.69)	0.54 (0.98)	2.53 (1.74)
SEm	2.44	2.67	0.14	0.25	0.28	0.12	0.08
CD (5%)	7.36	8.05	0.41	0.76	0.84	0.36	0.24
15 days after second spray							
T_1	93.38 (75.15)	88.99 (70.68)	6.64 (2.66)	40.53 (6.40)	16.34 (4.10)	19.40 (4.46)	3.92 (2.08)
T_2	38.73 (38.47)	31.77 (34.13)	1.48 (1.39)	2.81 (1.80)	0.91 (1.17)	0.54 (1.00)	2.63 (1.75)
T_3	39.28 (38.73)	29.00 (32.16)	1.06 (1.24)	1.82 (1.51)	0.44 (0.95)	0.04 (0.73)	5.88 (2.52)
T_4	37.46 (37.66)	37.64 (37.72)	1.58 (1.42)	3.65 (2.02)	1.05 (1.21)	0.25 (0.85)	5.13 (2.36)

SEm	1.71	3.90	0.13	0.41	0.26	0.31	0.11
CD (5%)	4.99	7.37	0.40	1.22	0.37	0.93	0.33

T1-Conservation biological control; T2-Application of *Isaria fumosorosea*; T3-Application of neem oil 0.5%, T4-Water spray; *Fig in parenthesis are √x+0.5 transformed values; ** Fig in parenthesis are arc sign transformed values.

20.2.4 KAU, Thrissur

An experiment was conducted in farmer's field at Anakkappara in Palakkad district from January 2021 to March 2021 to evaluate the efficacy of *Isaria fumosorosea* (Pfu-5) in managing whitefly infestation on coconut. The observations included number of live colonies, number of total leaves and infested leaves per palm as well as total number of whitefly colonies before and 60 days after first spraying. There were no significant differences between the treatments in terms of number of live colonies of rugose spiralling whitefly except at thirty days after second spray (Table 218). Significantly low mean number of live colonies of the whiteflies was observed on trees sprayed with neem oil (4.02) as well as with water (4.36), both being on par with each other. Trees sprayed with Pfu-5and unsprayed trees had higher mean number of RSW colonies at 6.75 and 6.93, respectively. The above treatments were again at par. The number of infested leaves also was identical among the treatments (Table 219).

Fig:56.

Table 218. Effect of *Isaria fumosorosea* on population of rugose spiralling whitefly at Palakkad

Treatment	Number of live colonies				
	Pre-count	15 DAS1	15 DAS2	30 DAS2	45DAS2
T1: Natural conservation of *Encarsia guadeloupae*	7.32 (2.66)	6.46 (2.50)	6.25 (2.39)	6.75 (2.56)[a]	5.36 (2.27)
T2: *Isaria fumosorosea* (Pfu-5)	6.46 (2.52)	6.89 (2.60)	6.43 (2.46)	6.93 (2.61)[a]	4.86 (2.18)
T3: Neem oil (0.5%)	6.00 (2.42)	4.75 (2.10)	4.67 (2.11)	4.02 (1.93)[b]	4.75 (2.15)
T4: Water spray	6.03 (2.43)	6.07 (2.43)	4.89 (2.18)	4.36 (2.06)[b]	3.07 (1.70)
CD @ 5%	NS	NS	NS	0.48	NS

* Mean of 28 observations. Values in parenthesis are square root transformed values

Table 219. Number of total fronds and infested fronds per palmat Palakkad

Treatment	Total fronds/palm	Infested fronds/palm
T1: Natural conservation of *Encarsia guadeloupae*	19.00	12.23
T2: *Isaria fumosorosea*(Pfu-5)	19.91	10.91
T3: Neem oil (0.5%)	20.31	10.17
T4: Water spray	21.51	11.71

The extent of parasitism of RSW also was comparable among the different treatments except at 45 days after spraying. Forty five days after second spray untreated trees as well as trees sprayed with *I. fumosorosea* had significantly higher mean number of parasitized colonies at 14.53 and 14.39 respectively, as compared to water spray with an average of 6.25 number of colonies (Table 220). In case of nesting whiteflies, the treatments remained non-significant even after two rounds of spray (Table 220).

Table 220. Effect of different treatments on population of rugose spiralling whitefly and nesting whiteflies and extent of parasitismat Palakkad

Treatment	No. of healthy RSW colonies*					No. of parasitized RSW colonies*				
	Pre-count	15 DAS1	15 DAS2	30 DAS2	45 DAS2	Pre-count	15 DAS1	15 DAS2	30 DAS2	45 DAS2
Rugose spiralling whitefly										
T1-Natural conservation	11.68 (3.19)	11.71 (3.28)	4.64 (2.01)	8.03 (2.84)	7.5 (2.73)^{ab}	9.25 (2.69)	5.8 (2.49)	14 (3.67)	18.32 (4.19)^{ab}	14.53 (3.57)^{a}
T2- *I. Fumosorosea*	10.35 (3.18)	10.21 (2.96)	10.25 (2.89)	19.25 (4.24)	12.03 (3.10)^{a}	8.43 (2.56)	5.82 (2.45)	13 (3.30)	25.71 (4.99)^{a}	14.39 (3.69)^{a}
T3-Neem oil (0.5%)	7.64 (2.81)	12.53 (3.25)	7.68 (2.39)	10.78 (2.94)	3.53 (1.93)^{bc}	8.25 (2.49)	6.7 (2.47)	14.68 (3.37)	12.00 (3.28)^{b}	10.93 (3.05)^{ab}
T4-Water spray	10.32 (3.25)	10.21 (3.04)	6.28 (2.46)	11.53 (3.24)	2.14 (1.48)^{c}	7.25 (2.59)	11.28 (3.21)	13.75 (3.60)	13.21 (3.58)^{b}	6.25 (2.24)^{b}
CD @ 5%	NS	NS	NS	NS	1.03	NS	NS	NS	0.96	1.08
Nesting whitefly										
T1-Natural conservation	2.61 (1.68)	0.21 (0.82)	2.11 (1.55)	2.36 (1.65)	1.68 (1.44)	1.11 (1.17)	0.14 (0.74)	2.18 (1.56)	4.75 (2.22)	1.82 (1.26)
T2- *I. Fumosorosea*	3.54 (1.96)	0.39 (0.89)	1.61 (1.38)	2.54 (1.68)	1.86 (1.41)	1.79 (1.34)	0.25 (0.85)	1.36 (1.28)	4.68 (2.15)	1.54 (1.15)
T3-Neem oil (0.5%)	3.14 (1.78)	0.46 (0.95)	1.18 (1.26)	2.54 (1.61)	1.00 (1.21)	0.71 (0.99)	1.96 (1.30)	2.61 (1.63)	2.36 (2.59)	3.25 (1.69)

T4-Water spray	4.00 (2.04)	0.39 (0.91)	1.14 (1.24)	1.36 (1.29)	0.79 (1.08)	0.36 (0.88)	3.54 (1.71)	2.18 (1.55)	2.96 (1.79)	1.16 (0.96)
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Mean of 28 observations. Values in parentheses are square root transformed values

20.2.5 RARS, Kumarakum

Efficacy of entomopathogenic fungi, *Isaria fumosorosea* (Pfu-5)' @ 1x10^8cfu/ml, neem oil @ 0.5 % and water spray against nesting whitefly, *Paraleurodes bondari* was tested under field conditions. Results were compared with the untreated plot where *Encarsia guadeloupae* population is naturally conserved (Table 221). Significant reduction in live colonies/ leaflet was noticed in treatments with Pfu-5 and neem oil @ 0.5 % at 10 DAS, where both these treatments were on par with each other. However, at 60 DAS, only Pfu-5 could bring significant reduction in the live colony count, where it could cause 57.70% reduction in the number of colonies, compared with the untreated palms. This was followed by treatment with neem oil and soap (23.23%). Water spray could not bring any notable reduction in colony count.

Both the treatments with *I. fumosorosea* (Pfu-5) and neem oil spray could significantly reduce healthy nymphs per leaflet at 20 DAS. Though both treatments were found to be statistically on par, neem oil spray could cause 49.19 % reduction over control, where *I. fumosorosea* (Pfu-5) could only result in 25.31% reduction. However, at 60 DAS, treatment with *I. fumosorosea* (Pfu-5)' brought 61.54% reduction in healthy nymph count over control, which was statistically superior to all other treatments. This was followed by neem oil spray which caused 34.90 % reduction. However, significant reduction in per cent infestation and intensity could not be obtained at 10, 20 or 60 DAS in any of the treatments. Due to the inability of *E. guadeloupae* to parasitize *Paraleurodes bondari* and also due to the absence of other efficient parasitoids, the untreated plot was observed with the highest per cent infestation, intensity, live colonies/ leaflet and healthy nymphs, when compared with the other treatments.

Table 221. Biological suppression of Bondar's nesting whitefly in coconut at KAU, Kumarakom

Treatment	Pre-count*				10 days after spraying				20 days after spraying			
	Infestation (%)	Intensity (%)	Live colonies/ leaflet	Healthy Nymphs/ leaflet	Infestation (%)	Intensity (%)	Live colonies/ leaflet	Healthy Nymphs/ leaflet	Infestation (%)	Intensity (%)	Live colonies/ leaflet	Healthy Nymphs/ leaflet
T1	97.65 (9.93)	99.03 (10.00)	4.67 (2.35)	14.77 (3.79)	97.65 (9.93)	99.88 (10.04)	8.55 (3.03)	18.10 (4.30)	97.65 (9.93)	99.81 (10.04)	7.42 (2.80)	13.92 (3.81)
T2	90.99 (9.58)	97.97 (9.95)	7.77 (2.90)	14.10 (3.77)	90.99 (9.58)	95.72 (9.86)	5.05 (2.44)	8.10 (2.96)	90.99 (9.58)	96.50 (9.86)	5.42 (2.50)	10.40 (3.23)
T3	88.34 (9.42)	93.02 (9.68)	5.05 (2.42)	9.10 (3.12)	88.34 (9.42)	93.74 (9.27)	5.20 (2.47)	8.32 (2.30)	88.34 (9.45)	86.35 (9.27)	4.77 (2.37)	7.07 (2.74)
T4	92.23 (9.64)	94.11 (9.74)	5.45 (2.45)	17.25 (4.06)	92.23 (9.64)	91.84 (9.59)	7.80 (2.90)	17.27 (4.12)	92.23 (9.64)	91.77 (9.59)	7.07 (2.79)	13.12 (3.73)
CD (0.05)	NS	NS	NS	NS	NS	NS	0.45	0.77	NS	NS	NS	0.71
CV	5.43	4.16	23.46	29.56	5.43	4.93	17.98	23.31	5.49	8.45	20.37	22.66

	60 days after spraying				Reduction in live colonies (%) /leaflet @ 20 DAS	Reduction in live colonies (%) /leaflet @ 60 DAS	Reduction in healthy nymphs /leaflet (%) @ 20 DAS	Reduction in healthy nymphs (%) /leaflet @ 60 DAS
	Infestation (%)	Intensity (%)	Live colonies/ leaflet	Healthy Nymphs/ leaflet				
T1	98.49 (9.97)	99.82 (10.04)	10.22 (3.31)	21.77 (4.70)				
T2	91.46 (9.60)	99.12 (10.00)	4.32 (2.27)	8.37 (2.30)	26.94 %	57.70 %	25.31 %	61.54 %
T3	89.60 (9.49)	97.10 (9.90)	7.85 (2.95)	14.17 (3.82)	35.69 %	23.23 %	49.19 %	34.90 %
T4	93.10 (9.70)	92.67 (9.66)	9.62 (3.21)	19.70 (4.53)				
CD (0.05)	NS	NS	0.52	0.70				
CV	5.06	4.01	19.05	18.89				

*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

20.2.6 TNAU, Coimbatore

In a field trial conducted at coconut farm, TNAU, Coimbatore, population of RSW nymphs was minimum (12.40Nos.) in the coconut trees sprayed with neem oil 0.5% followed by 12.80 numbers of nymphs in foliar application of Pfu-5 @ 1x10^8cfu/ml (Table 222). Foliar water spray (15.50Nos.) and *Encarsia guadeloupae* (natural conservation) (21.6Nos.) on 15th day after 2nd spraying. Parasitized nymphs were significantly more in *E. guadeloupae* (natural conservation) (32.50%) than in foliar application of Pfu-5 @ 1x10^8cfu/ml (18.0%), foliar application of neem oil 0.5% (19.0%) and foliar water spray (21.5%) on 15th day after 2nd spraying (Table 222). There was reduction in nymphal population in *E. guadeloupae* (natural conservation) (13.20Nos.) on 60th day after 2nd spraying, when compared with foliar application of Pfu-5 @ 1x10^8cfu/ml, foliar water spray and foliar application of neem oil 0.5%. Parasitized nymphs was maximum in *E. guadeloupae* (natural conservation) (35.00%) followed by and foliar application of neem oil 0.5% (26.5%), Pfu-5 @ 1x10^8cfu/ml (26.0%) and foliar water spray (24.5%) on 60th day after 2nd spraying.

Table 222. Biological suppression of rugose spiralling whitefly in coconut at Coimbatore during 2020-21

Treatment	15 day after 2nd spray					60 days after 2nd spray				
	Fronds infested with RSW %*	Leaflets infested with RSW %*	No.of live colonies /leaflet **	No. of nymphs /leaflet **	% parasitized nymphs /leaflet *	Fronds infested with RSW %*	Leaflets infested with RSW %*	No.of live colonies /leaflet **	No. of nymphs /leaflet**	Parasitized nymphs /leaflet * (%)
T1	44.75 (41.94)^b	30.78 (33.64)^b	3.80 (1.94)^c	21.6 (4.66)^b	32.50 (34.75)^a	38.33 (28.89)^a	23.46 (28.96)^a	3.30 (1.79)^a	13.20 (3.70)^a	35.50 (36.57)^a
T2	26.73 (30.90)^a	21.92 (27.85)^a	3.50 (1.87)^b	12.80 (3.58)^a	18.00 (25.10)^b	44.68 (31.56)^b	27.47 (31.60)^b	5.30 (2.29)^b	15.90 (4.05)^b	26.00 (30.65)^b
T3	23.26 (28.55)^a	22.65 (28.37)^a	3.10 (1.76)^a	12.40 (3.51)^a	19.00 (25.84)^c	43.96 (31.61)^b	27.53 (31.64)^b	5.80 (2.38)^b	17.40 (4.23)^c	26.50 (30.98)^b
T4	23.33 (28.61)^a	23.44 (28.91)^a	3.40 (1.84)^b	15.50 (3.91)^a	21.50 (27.62)^d	47.30 (33.19)^b	30.09 (33.26)^c	6.20 (2.47)^b	18.60 (4.37)^d	24.50 (29.66)^c
SEd	2.315	1.527	0.015	0.339	0.304	1.228	0.239	0.137	0.028	0.373
CD(P=0.05)	4.862	3.207	0.031	0.711	0.639	2.578	0.502	0.288	0.059	0.784

T1- Encarsia guadeloupae natural conservation; T2- Foliar application of *Isaria fumosorosea* (pfu-5) @ 1x108cfu/ml (Two sprays at 15days intervals); T3-Foliar application of neem oil 0.5% (neem oil 5 ml+soap powder 10g /litre of water)(Two sprays at 15 days intervals); T4-Foliar water spray (2 sprays at 15 days intervals). Figures in parentheses are arcsine transformed values* and square root transformed values** ;Means followed by a common letter in a column are not significantly different
Values are mean of eight replications.

20.3. Field evaluation of bioagents against rugose spiralling whitefly on coconut
20.3.1 UAHS, Shivamogga

In this experiment, the activity of biocontrol agents against rugose spiralling whitefly was recorded. The bioagents such as *Isaria fumosorosea*, *Encarsia guadeloupae*, *Beauveriabassiana*, *Metarhizium anisopliae* and *Lecanicillium lecanii* were used to control the RSWin coconut two sprays were taken at weekly interval and the pest population from randomly selected five plants before and after each spray / release of predator will be recorded. Before spray, the per cent infestation of RSW was ranges from 44.41 to 72.54) and intensity was ranges from 42.25 to 65.04 and live colonies value was ranges from 21.00 (27.27) to 39.63 (39.01) (Table 223).

Table 223. Field evaluation of bio agents against rugose spiralling whitefly on coconut

Treatments	RSW before spray		
	Infestation (%)	Intensity (%)	Live colonies /leaflet
T_1 : *Isaria fumosorasea*(NBAIR) @ 5g /L	72.54 (58.39)	63.76 (52.9)	39.63 (39.01)
T_2 : *Encarsia guadeloupae*@ 600 adults /acre	57.63 (49.38)	52.23 (46.2)	35.04 (36.29)
T_3 : *Beauveria bassiana*(UAHS-18) @ 1 x 10^8cfu/ ml - 3 ml /L	61.91 (51.89)	50.81 (45.46)	31.10 (33.89)
T_4 : *Metarhizium anisopliae*(UAHS-33) @ 1 x 10^8cfu/ ml - 3 ml /L	44.41 (41.79)	45.56 (42.45)	17.35 (24.61)
T_5 : *Lecanicillium lecanii*(UAHS-12) @ 1 x 10^8cfu/ ml - 3 ml /L	53.15 (46.80)	42.25 (40.54)	21.66 (27.73)
T_6 :Neem oil 1500 ppm @ 2 ml/L of water	56.69 (48.84)	65.04 (53.75)	25.35 (30.23)
T_7 : Untreated (check)	51.94 (46.11)	61.40 (51.58)	21.00 (27.27)
SEM±	0.39	0.31	0.32
CD@5%	1.17	0.93	0.95

The per cent infestation of RSW after first spray was minimum (28.32%) in treatment with *Encarsia guadeloupae* followed by the treatment with *Metarhizium anisopliae* @ 1 x 10^8cfu/ ml (3 ml /L) and it was on par with the with neem oil 1500 ppm @ 2 ml/L was observed (Table 224). Similarly, the number of live colonies was minimum (8.08)in the treatment with *E. guadeloupae* followed by the treatment with M.*anisopliae*, the maximum number of colonies (18.35) were observed in the untreated control. The per cent intensity of RSW was minimum (14.25%) in the treatment T2 and maximum (48.11%) was observed in the untreated check after the second spray. Similarly, the number of live colonies was minimum (5.33)in treatment with *E. guadeloupae* followed by 6.16 the treatment with *M. anisopliae*, the minimum number of live colonies 16.86 were observed in the control treatment.

Per cent reduction in intensity and live colonies of RSW population was recorded, after first spray maximum reduction in intensity (49.02%) and number of live colonies (52.80) was recorded in the treatment T2 (Table 225). Similarly after second spray,reduction in intensity (60.92%) and number of live colonies (89.66) also recorded in the same treatment T2 whereas the minimum reduction in intensity (3.64%) and live colonies (19.71), respectively were recorded in the untreated check. Similarly, after second spray minimum reduction in intensity (12.61%) and number of live colonies (21.64) recorded in the T7 untreated check.

Table 224. Effect of bioagents against rugose spiralling whitefly on coconut at Shivamogga

Treatments	RSW after first spray		RSW after second spray	
	Intensity (%)	Live colonies /leaflet	Intensity (%)	Live colonies /leaflet
T_1 :*Isaria fumosorasea*(NBAIR) @ 5g /L	30.09 (33.26)	20.2 (26.7)	12.16 (20.40)	8.21 (16.65)
T_2 :*Encarsia guadeloupae*@ 600 adults / acre	28.32 (32.15)	18.3 (25.32)	14.25 (22.17)	7.46 (15.85)
T_3 :*Beauveria bassiana*(UAHS-18) @ 1 x 10^8cfu/ ml (3 ml /L)	34.63 (36.04)	16.4 (23.88)	18.52 (25.48)	8.31(16.75)
T_4 :*Metarhizium anisopliae*(UAHS-33) @ 1 x 10^8cfu/ ml (3 ml /L)	28.5 (32.26)	10.32 (18.73)	17.33 (24.60)	6.16 (14.37)
T_5 :*Lecanicillium lecanii*(UAHS-12) @ 1 x 10^8cfu/ ml (3 ml /L)	26.25 (30.82)	12.16 (20.40)	16.17 (23.71)	5.33 (13.34)
T_6 :Neem oil 1500 ppm @ 2 ml/L of water	29.88 (33.13)	17.45 (24.69)	15.72 (23.35)	8.08 (16.51)
T_7 : Untreated (check)	59.32 (50.37)	18.35 (25.36)	48.11 (43.91)	16.86 (24.24)
SEM±	1.014	1.221	0.833	0.93
CD@5%	2.92	3.65	2.49	2.98

Table 225. Percent reduction in rugose spiralling whitefly on coconut at Shivamogga

Treatments	Intensity		Live colonies /leaflet	
	After one spray	After two sprays	After one spray	After two sprays
T_1 :*Isaria fumosorasea*(NBAIR) @ 5g /L	45.77 (42.57)	47.77 (43.72)	52.88 (58.61)	78.71 (62.52)
T_2 :*Encarsia guadeloupae*@ 600 adults /acre	49.02 (44.4)	52.80 (46.60)	60.92 (64.09)	89.66 (71.24)
T_3 :*Beauveria bassiana*(UAHS-18) @ 1 x 10^8cfu/ ml (3 ml /L)	31.84 (34.35)	47.26 (43.42)	43.55 (52.86)	73.27 (58.8)
T_4 :*Metarhizium anisopliae*(UAHS-33) @ 1 x 10^8cfu/ ml (3 ml /L)	36.2 (36.98)	40.51 (39.52)	41.96 (51.91)	64.49 (53.42)
T_5 :*Lecanicillium lecanii*(UAHS-12) @ 1 x 10^8cfu/ ml (3 ml /L)	37.86 (37.97)	43.85 (41.46)	41.72 (51.77)	75.39 (60.25)
T_6 :Neem oil 1500 ppm @ 2 ml/L of water	50.88 (45.5)	54.05 (47.32)	58.12 (55.62)	75.83 (60.55)
T_7 : Untreated (check)	3.64 (10.99)	12.61 (20.79)	19.71 (26.35)	21.64 (27.72)
SEM±	0.76	0.41	0.55	0.45
CD@5%	2.33	1.22	1.64	1.35

20.4. Area-wide demonstration of biological suppression of black headed caterpillar using *Goniozus nephantidis* and *Bracon brevicornis*

20.4.1 ICAR-CPCRI, Kayamkulam

Regular monitoring on the incidence of black headed caterpillar, *Opisina arenosella* was undertaken at Kottayam, Alappuzha and Kasaragod districts of Kerala. Moderate incidence of the pest was observed in coconut gardens at MogralPuttur, Kasaragod district during October 2019 with 30.6% pest incidence. To combat the pest incidence, pruning and destruction of infested fronds at lower whorls as well as timely augmentative release of *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoid/palm was undertaken during November 2019. During the post–release phase, the pest incidence was reduced significantly to 11.4%, 3.0% and 1.1% in March 2020, August 2020 and March 2021, respectively. Laboratory maintenance of parasitoids*viz.*, *Goniozus nephantidis* and *Bracon brevicornis* was continued and these parasitoids were supplied to State Parasite Breeding Stations and farmers as per demand. This is one of the classical success stories of augmentative biological control which could invariably reduce the pest incidence in most of the districts of Kerala ever since its commencement in 1950's by delivery of the bio-agents through boat laboratory. During 2020, a microlepidopteran Gelechiid, *Coconympha iriarcha* was found associated with the incidence of *O. arenosella* at Kasaragod, Kerala.

20.5. Converging biological suppression approaches for area-wide management of coconut rhinoceros beetle

20.5.1 ICAR-CPCRI, Kayamkulam

Coconut rhinoceros beetle, *Oryctes rhinoceros*: The emergence of *Oryctes rhinoceros* nudivirus (OrNV) resistant haplotype (Guam strain) of coconut rhinoceros beetle (CRB)in coconut plantations in south-east Asia led to a systematic surveillance in the look out of this Guam haplotype of CRB in India. Indian OrNV has been characterized and was found in similarity with identified genome. OrNV is being maintained *in vivo* in the grubs of *O. rhinoceros,* whereas it is maintained in cell lines of *Heteronychus arator* (F.) in all Pacific Island Countries.

In the surveillance programme, more than 1.3% of grubs of *O. rhinoceros* collected from natural breeding zone have been virosed in the country with characteristic gut clearing and proplapse symptoms. In addition, more than 90% infection was realized in the grubs of *O. rhinoceros* upon artificial *per os*feeding of OrNV suspension inferring the absence of Guam haplotype. It was reported that *Mse*Irestrictionsite polymorphism in amplified region of cytochrome oxidase gene (*COI*) of coconut rhinoceros beetle allowed A to G transition at nucleotide position 288 in the identification of CRB-Guam haplotype. However, molecular characterization of *COI* gene of coconut rhinoceros beetle collected from Kayamkulam, India had no A to G transition indicating the absence of CRB-Guam haplotype in the country.

As part of “Convergence of bio-control technologies for area-wide management of coconut rhinoceros beetle”, more than 50 kg of *Metarhizium majus* mass multiplied in semi-cooked rice was distributed to dairy farmers in Vallikunnanpanchayat since September 2020. The application procedure of the entomopathogenic fungus on the breeding sites was demonstrated by ICAR-CPCRI Crop Protection Scientists at the hamlet with few progressive dairy farmers under the co-ordination of the Agricultural Officer. The farmers were empowered on the technical know-how as well as sustainable impact of the technology mouldingVallikunnam as a bio-village model. A group of women farmers were also trained on the mass production of green muscardine fungus at farm level and inoculation in the breeding zones of the bio-village during February 2021. The initial attempt on the localized production made by the women farmers was a grand success which inculcated enormous confidence in the mass production programme. Farmer-participatory approach in localized production of bioagents and delivery at all breeding zone of the panchayat is the hallmark outcome of the programme. All dairy farmers in the village was provided with *M. majus* for delivery in to the cow dung pit. The pre-treatment data on the incidence of coconut rhinoceros beetle was presented in Table 226.

Table 226. Incidence of coconut rhinoceros beetle in Vallikunnam

Palms observed	Fronds infested per palm (%)	Leaf damage (%)	Spear leaf damage (%)

103	4.19	21.5	40.8

More than 4% fronds were attacked by coconut rhinoceros beetle in each palm. The leaf and spear leaf damage was found as 21.5% and 40.8%, respectively. The impact of the technology will be quantified in subsequent years. It was presently observed that at least two cow dung pits were completely devoid of grubs of rhinoceros beetle that had in fact surprised the farming community in the village and this cross learning and popularization of the technology is the key success of the bio-village concept.

Fig:57. Activities performed for localized production of entomopathogen in the area-wide management of coconut rhinoceros beetle

21. COCOA

21.1 *In vivo* evaluation of effective biocontrol agents against Phytophthora pod rot management in cocoa

21.1.1 DRYSRHU, Ambajipeta

After first spray, T_3 - Spraying of copper oxychloride (3g/litre of water) spray resultedin 56.26% reduction of pod rot followed by T_2 - Soil application of 50 g of *T. reesei* along with 5kg neem cake and T_1- spraying of *Trichoderma reesei* spore suspension (2×10^6cfu/ml) led to reduction in pod rot by 41.34 and 27.80%, respectively (Table 227). The treatment T_2 recorded 65.63% reduction in pod rot after 30 days and 84.19% reduction of pod rot after 45 days. While after second spray, T_3 and T_1 recorded 55.19 and 46.45% and after third spray 57.89 and 55.18% decrease in pod rot respectively over control . Over all mean disease reduction indicated that T_2 was superior over T_3 and T_1 with 64.24, 56.48 and 43.48% reduction in disease.

Table 227. Evaluation of bio control agents against *Phytophthora* pod rot in cocoa

	Disease incidence

Treatment	Pre-treatment	Post treatment incidence							
		First spray	Disease reduction over control	Second spray	Disease reduction over control	Third spray	Disease reduction over control	Mean disease incidence	Mean disease reduction over control
T1	34.58	24.32* (29.48)	27.80	18.32 (24.97)	46.45	16.32 (23.73)	55.18	19.65	43.48
T2	35.40	19.76 (26.28)	41.34	11.76 (19.86)	65.63	5.76 (13.70)	84.19	12.42	64.26
T3	34.80	14.73 (22.49)	56.26	15.33 (22.99)	55.19	15.33 (22.99)	57.89	15.13	56.48
T4	35.45	33.68 (35.45)	0.00	34.21 (35.76)	0.00	36.41 (37.01)	0.00	34.76	0.00
SEm	-	1.06		1.69		1.43			
CD (5%)	-	3.30		5.26		4.46			

* Fig in parenthesis are arc sign transformed values

VEGETABLE CROPS

22. Biological control of Tomato Pests

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

22.1.1 AAU, Anand

Objective: To study the incidence of pinworm of tomato and biodiversity of its natural enemies

Year of commencement: 2015-16

Work carried out during the current year:

In the year 2020-21 survey was conducted to ascertain the outbreak of invasive pest tomato pinworm in Gujarat.

Methodology:

Survey was conducted in randomly selected villages in few districts of Gujarat to determine the infestation of *T. absoluta*.

Initially during the crop growth period, the activity of adult moths was monitored by using sex pheromone traps.

Percentage of plants infested with *T. absoluta* was assessed by observing 10 randomly selected plants in every 100 sq. m crop area and leaves were observed for the presence of leaf mine caused by larva and fruits were also observed for the presence of pin head sized holes.

The incidence of *Tuta* in other crop fields *viz*., potato, brinjal, chilli, and tobacco was also surveyed and observations were recorded.

Observations recorded:

Date and place of survey

Crop plants infested and percent damage

Non host crops and weeds infested

4. Existing natural enemies in 25 randomly selected plants

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

Table 228. Survey details on tomato pinworm, *Tuta absoluta*

Date	Name of the farmer	Place	Host crop, non-host crops and weed plants	Natural enemies
26.10.2020	--	Agronomy farm, AAU campus	Tomato (NIL)	NIL
26.11.2020	Maganbhai R. Jadav	Village- Vadod, Ta-Anand, Dist. -Anand	Tomato (NIL)	NIL
	LaxmansinhS. Jadav	,,		
	Manabhai R. Parmar	,,		

	Ramabhai M. Jadav	,,		
01.12.20	Pareshbhai C. Talpada	Village- Karamsad, Ta.-Anand, Dist.-Anand	Tomato (NIL)	NIL
	Kanubhai A. Patel	Village- Runaj, Ta.-Sojitra, Dist.-Anand		

22.2 Role of Habitat manipulation for pest management in Tomato

22.2.1 CAU (Imphal)

Objective: To assess the influence of habitat manipulation on incidence of major insect pests of tomato and their natural enemies **Table 229.**

	Year of commencement	:	*Winter*, 2020-21
	Location	:	AICRP-Biocontrol farm, CAU, Pasighat
	Crop & variety	:	Tomato, Syngenta TO-1458
	Treatments	:	07
	Replications	:	03
	Design	:	Randomized block design (RBD)
	Spacing	:	60×45 cm
Treatments			
T_1	Tomato intercropped with Carrot and Marigold as border crop		
T_2	Tomato intercropped with Lentil and Coriander as border crop		
T_3	Tomato intercropped with Chickpea and Mustard as border crop		
T_4	Tomato intercropped with Field bean and Fennel as border crop		
T_5	Tomato intercropped with Pea and Dill as border crop		
T_6	Tomato intercropped with Buckwheat and Maize as border crop		
T_7	Tomato as sole crop		

Methodology:

Main crop, inter crop and border crop were raised and transplanted as per recommended agronomic practices.

Observations recorded:

Larval population/ plant: Five plants were randomly selected from each plot and observations on larval population of fruit borer's *viz. Helicoverpa armigera* and *Tuta absoluta* were recorded at weekly interval with the initiation of pest.

Natural enemies/ plant: The population of natural enemies' *viz*., coccinellids, syrphid fly and spiders were recorded in randomly selected five plants in each plot.

Yield (healthy marketable tomato fruits) - kg/plot

The data was statistically analyzed using suitable transformation.

Results:

The data on the influence of habitat manipulation on incidence and severity of fruit borers' damage in tomato is presented in the Table No. 230. The data reveals that the intercropping of tomato crop with carrot, chickpea and buck wheat has significant influence on incidence of tomato fruit borers. The pooled over data depicts that the treatment T_1 – tomato intercropped with carrot and bordered with marigold recorded the lowest fruit borers incidence (1.28 larvae/plant) and which was followed by the treatment T_3 – tomato intercropped with chickpea and mustard as a border crop (1.47 larvae/plant) and T_6-Tomato intercropped with Buckwheat and Maize as border crop (1.71 larvae/plant). The lowest number of fruit borers in these treatments was attributed to the presence of more number of natural enemies/plant due companion crops *viz*., mustard, carrot, buck wheat and trap crops like marigold, chickpea and maize. The natural enemies recorded were coccinellids, spiders and syrphids. The treatment T_6 recorded the natural enemy population of 7.15 per plant which was followed by the treatment T_1 (7.13/ plant) and T_3 (6.79/plant). The highest population of fruit borers was documented in the treatment T_7-tomato as a sole crop (3.25/plant) and this treatment recorded the lowest number of natural enemies/plant (3.53). With regard to the data on tomato fruit borers damage, the treatment T_1 – tomato intercropped with carrot and marigold as border crop recorded the lowest damage (16.60%) which was statistically at par with the treatment T_3- tomato intercropped with chickpea and bordered with mustard (17.15%) followed by T_6 (17.47%) *i.e.* tomato + buckwheat with maize at borders. The sole tomato treatment T_7 recorded the highest fruit borers' damage of 29.72%.

The influence of intercrops and border crops in reducing the pest incidence was reflected in yield of the crop. The highest yield of 16.15 t/ha was recorded in the treatment $T_{1,}$ followed by the treatment T_3 (16.12 t/ha) and T_3 (16.10 t/ha); these treatments found statistically at par with each other. The lowest yield of tomato fruits was recorded in the treatment T_7 sole crop (10.94 t/ha) and this was attributed to more incidence of pest and low population of natural enemies in sole crop. Hence, it can be concluded that the intercropping of tomato with chickpea, buck wheat, carrot and marigold, mustard, maize as border crops helps in reducing the pest incidence and conserving the natural enemies with higher fruit yield.

Table 230. Influence of habitat manipulation on incidence of tomato fruit borers and their natural enemies

Treatments	No. of fruit borers larva/plant (After week)						Percent Fruit damage/plant Pooled	No. of Natural enemies/ plant	Yield (t/ ha)
	1	2	3	4	5	Pooled			
T_1	1.08 (0.66)*	1.39 (1.37)	1.46 (1.39)	1.31 (1.32)	1.18 (1.32)	1.28 (1.32)	16.60 (24.03)**	7.13 (2.76)*	16.15
T_2	1.32 (1.25)	1.54 (1.54)	1.97 (1.55)	2.08 (1.59)	2.21 (1.59)	1.82 (1.50)	17.94 (25.05)	5.81 (2.50)	15.07
T_3	1.11	1.58	1.81	1.57	1.26	1.47	17.15	6.79	16.12

	(0.73)	(1.43)	(1.50)	(1.42)	(1.42)	(1.39)	(24.46)	(2.70)	
T_4	1.30 (1.19)	1.92 (1.53)	2.02 (1.56)	2.45 (1.60)	2.86 (1.70)	2.11 (1.60)	18.63 (26.51)	5.53 (2.45)	14.30
T_5	1.25 (1.06)	1.99 (1.56)	2.20 (1.62)	2.91 (1.67)	3.09 (1.83)	2.29 (1.65)	19.95 (25.55)	5.30 (2.40)	14.16
T_6	1.26 (1.09)	1.71 (1.48)	1.88 (1.53)	1.89 (1.52)	1.83 (1.52)	1.71 (1.47)	17.47 (24.69)	7.15 (2.75)	16.10
T_7	1.48 (1.69)	2.93 (1.84)	3.44 (1.98)	4.02 (2.08)	4.38 (2.12)	3.25 (2.92)	29.72 (33.00)	3.53 (2.00)	10.94
S. Em ±	0.07	0.16	0.17	0.18	0.19	0.18	0.91	0.14	0.13
C.D. at 5 %	0.21	0.48	0.53	0.55	0.57	0.55	2.79	0.42	0.41

* Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values, **Figures in the parentheses are arcsine transformed values, NS: Non significant, DAS: Days After Spray

Experimental plot view

Early leaf blight and witlting in tomato

Helicoverpa armigera bored tomato fruit

Pin head sized hole due to *Tuta absoluta*

Fig:58.

22.3 Frontline demonstration on biocontrol based pest management in Tomato

Objectives:

To demonstrate the biocontrol based pest management in tomato

To create awareness and promotion of adopting eco-friendly pest management by conducting field day

Year of commencement: 2020-21

Location: Farmers field, Jampani village, East Siang district, Arunachal Pradesh

Crop and Variety: Tomato, Syngenta TO-1458

Area: 2 ha

Treatments: 02

Repetitions: 10

Design: Large plot sampling CRD

Spacing: 60×45 cm
Plot size: 01 hafor each treatment
Treatment details:
Treatment 1: BIPM Module: Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds; raising marigold as trap crop; inoculative six release of *T. pretiosum* @ 50,000 per release, alternative application of *Beauveria bassiana*@0.05%, NBAII BtG4 2% against fruit borers and spraying of azadirachtin 1500 ppm @ 2 ml/lit; and *L. lecanii*(NBAIR) 1×108 spores/ g @ 5g/lit for sucking pests.
Source of Technology: NBAIR Bengaluru and IIVR Varanasi
Treatment 2: Farmers' practice (Chemical control) Spinosad 45 SC @0.4 ml/lit water alternative with Indoxacarb 14.5 SC @1ml/lit water against fruit borers and Imidacloprid 17.8 SL @0.5 ml/lit water at 15 days interval.
Methodology and observations recorded:
Tomato crop was raised by adopting standard agronomical practices. Total 10 quadrates were made in each treatment. Each quadrate served as one repetition. The observations on tomato fruit borer (*Helicoverpa armigera*) larval population/plant and damaged fruits/plant by *H. armigera* and *Tuta absoluta* were recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest. The observations on sucking pest complex *viz.* whiteflies and leaf hoppers population per plant were recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest.
Natural enemies–coccinellid beetles were recorded from each treatment at 15 days interval.
Yield (healthy marketable tomato fruits): t/ha
Results:

The data pertaining to the efficacy of different modules against major insect pests of tomato is presented in the Table 231. The BIPM module recorded the significantly lowest pest population of *H. armigera* (1.54 larvae/plant) and sucking pests (whiteflies and leaf hoppers) (7.70/plant) than that of chemical module (*H. armigera*–0.98 larvae/plant, Sucking pests – 4.61/plant). Whereas, the fruit damage was significantly lower in BIPM module (7.43%) as compared to chemical module (9.47%). The significant decrease in fruit damage in BIPM module was attributed to the successful integration of different biointensive components and it was reflected in yield of the crop. The BIPM module recorded the significantly higher yield (22.80 t/ha) as compared to chemical module (20.43 q/ha). Further, the population of coccinellids was also found statistically higher in BIPM module (4.43/plant). This result demonstrates the successful bio-intensive module, which helps in reducing the pest incidence and damage in tomato crop with higher fruit yield.

Table 231. Efficacy of different modules on pest incidence, fruit damage and yield of tomato

Modules	No. of *H. armigera* /Plant	No. of sucking pests /Plant	Fruit damage (%)	No. of Coccinellids/Plant	Yield (t/ha)

BIPM Module	0.98	4.61	7.43	4.43	22.80
Farmers practice	1.54	7.70	9.47	1.94	20.43
't' value	5.41*	2.94*	13.99*	4.90*	5.03*
Table $t_{0.05}$	3.18	2.78	4.30	2.78	4.30

*Significant at $t_{0.0.5}$

22.4 Field day as a part of FLD on biocontrol based pest management in tomato

To popularize the technology on large scale the field day was organized at farmer's field, Jampani village on 06th Feb 2021. During the programme around 25 participants were given with demonstrated on integration of different components of BIPM for sustainable crop production. The team of scientists from CHF, Pasighat interacted with participants on reducing the frequent usage of chemical pesticides as the farmers of Jampani area are depend more upon chemical method for vegetable pest control.

Field day of FLD on Biocontrol based Pest Management in Tomato at Farmers field Jampani, East Siang, Arunachal Pradesh

Fig:59.

22.4.1 Dr YS PUHF, Solan

***Tuta absoluta* on tomato**:

A total of 12 locations in districts Solan, Sirmaur, Bilaspur, Shimla and Kinnaur in Himachal Pradesh were surveyed to record the incidence of the *Tuta absoluta* on tomato from June to November, 2020 (Table 232). The pest was recorded at seven locations *viz.* Nauni, Deothi, Maryog, Sarahan, Dhaulakuan, Mangarh and Ghumarwin. The percentage of plants infested varied from 13 to 69 with the number of mines/leaf/infested plant varying from 0-4 and fruit infestation from 0-4% 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 revealed that the pest does not infest potato or brinjal when tomato is present in the adjacent fields. Furthermore, in higher hills of district Shimla and Kinnaur, 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 leaf miner.

Table 232. *Tuta absoluta* incidence on tomato at different locations

SN	Location	District	Plants infested (%)	Number of mines/leaf/infested plant	Fruit damage (%)
1	Nauni	Solan	22-68	0-3	1-3
2	Deothi	Solan	13 - 45	0-2	0-2
3	Maryog	Solan	27-61	1-3	1-4
4	Sarahan	Sirmaur	31 - 56	0-3	1-3
5	Dhaulakuan	Sirmaur	33-69	1-4	2-4
6	Mangarh	Sirmaur	23 - 47	1-3	0-3
7	Ghumarwin	Bilaspur	18-67	1-3	0-2
8	Duttnagar (Rampur)	Shimla	Nil	Nil	Nil
9	Kufri	Shimla	Nil	Nil	Nil
10	Theog	Shimla	Nil	Nil	Nil
11	Rekongpeo	Kinnaur	Nil	Nil	Nil
12	Pooh	Kinnaur	Nil	Nil	Nil

22.5 Demonstration on bio-intensive management of insect pests of tomato

Demonstration on the bio-intensive management of tomato pests was laid at three locations namely Deothi, Gaura and Sargaon covering an area of 1ha. Bio-intensive Integrated Pest Management (BIPM) module, targeting mainly *Tuta absoluta,* comprised 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). For comparison, chemical plots where the crop was sprayed with chlorantraniliprole 18.5EC and indoxacarb 14.5 EC alternatively at 15 days interval were also maintained. The treatment applications were started from June with the initiation of the attack of *T. 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 sprays of chlorantraniliprole 18.5EC and 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 on 100 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 at each picking were recorded and were pooled to get the total yield, which were extrapolated to get yield per hectare. The data were compared by t-test and the results of the experiment are presented in tables 233 and 234 and described as under.

Incidence of *T. absoluta*:

The number of mines by *Tuta absoluta* as recorded in the second week of July were statistically on par in both the plots and varied from 0.33 to 0.37 mines/ leaf. Seasonally the mine density remained nearly same in both the plots and varied from 0.33 to 0.46 mines per leaf in BIPM plots and 0.28 to 0.47 mines per leaf in chemical plots (Table 233).

Table 233. *Tuta infestation* on tomato leaves

Treatment	Mines/leaf on indicated weeks			
	July II	July IV	August II	August IV
BIPM	0.33 ± 0.11a	0.46 ± 0.21b	0.43 ± 0.18a	0.37 ± 0.24a
Chemical control	0.37 ± 0.14a	0.28 ± 0.13a	0.47 ± 0.15a	0.41 ± 0.19a

Similarly, the fruit infestation in the two plots remained almost same throughout the season and varied from 2.33 to 3.67% in BIPM plots and 1.67 to 4.0% in chemical plots (Table 234). The yield recorded in BIPM plots (31.3t/ha) was also statistically on par with that recorded in chemical treated plots (29.4t/ha).

Table 234. *Tuta absoluta* infestation on fruits

Treatment	Infested fruits (%) on indicated weeks					Yield (t/ha)
	July II	July IV	August II	August IV	Sept II	
BIPM	2.33 ± 0.83a	2.67 ± 0.73b	3.67 ± 0.91a	3.33 ± 0.72a	2.67 ± 0.79a	31.1 ± 5.9a
Chemical control	2.67 ± 0.71a	1.67 ± 0.36a	3.33 ± 0.33a	4.00 ± 0.84a	3.00 ± 0.58a	29.4 ± 5.1a

The incidence of *Helicoverpa armigera* remained very low throughout the cropping season and varied from 0.33 to 1.0% in different plots. Towards the end of the cropping season, a low incidence of tomato aphid, *Macrosiphum euphorbiae* was also noticed. The aphid population recorded on top 10 cm length of the shoot during second week of September was 18.7 in BIPM and 23.2 in chemical plots.

22.6 Large Scale Field Trials for the Management of *Helicoverpa armigera* (Hubner) on Tomato (MPUAT– 2 ha)

22.6.1 MPUAT, UDAIPUR

Variety: Location specific popular variety

Plot Size: 2.0 ha

Location: Farmer’s field at Madar and Brahamno ki Hundar (Badgaon)

Year: 2020-21

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:
The treatment applications were started at initial occurrence of *H. armigera* infestation and biopesticides wereapplied during evening hours at fortnightly interval.
Randomly select 10 plants/ $40m^2$ crop area were observed for presence of holes/ damage caused by the larva.
Observations were recorded at fortnightly interval from fruit formation to last harvest.
Fruit damage percentage and yield were recorded.
Results:
Demonstration experiment was conducted in *Rabi*, 2020-21. 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 (14.35 t/ha) which was at par with the yield recorded in BIPM package (12.80 t/ha). Significantly, low yield was recorded in untreated control (8.20 t/ha). It could be concluded that BIPM package had promising results in minimizing the pest damage with higher yield.

Table 235. Effect of different modules on incidence of *H. armigera* and yield of tomato during *Rabi*, 2020-21

Treatments	Modules/Treatments	*H. armigera* larvae /plant*	Fruit damage* (%)	Fruit yield (t/ha)
T1	BIPM Package	2.92	28.62	12.80
T2	Chemical Control	2.63	25.37	14.35
T3	Untreated Control	3.87	40.12	8.20

Installation of pheromone traps at farmers field demonstrations on tomato crop

Seed distribution of tomato for demonstrations at different villages.

Fig:60. Seed distribution of tomato for demonstrations at different villages.

22.6.2 PAU, LUDHIANA

Management of sucking pests in tomato under polyhouse condition

The tomato seedlings (variety MAHI) were transplanted under protected conditions following agronomic practices recommended by the PAU, Ludhiana on December 17, 2020. The crop was transplanted on raised beds with plant to plant spacing of 30 cm and row to row spacing of 90 cm (Fig. 1). The crop is being monitored for the incidence of sucking pests (aphids and whitefly). Till date, very low population of aphids as well as whiteflies has been recorded. The experiment is in progress and the report will be submitted after the completion of the experiment.

Fig:61. Tomato seedlings transplanted under protected conditions

22.7 SURVEY AND SURVEILLANCE OF NATURAL ENEMIES OF PIN WORM, *Tuta absoluta* ON TOMATO

22.7.1PJTSAU, HYDERABAD

Tomato pinworm:

Fixed plots survey was conducted in Shamshabad and Moinabadmandals of Rangareddy district. Tomato pinworm population was noticed in all the surveyed villages. The population was observed from 39 th to 49nd SMW during *vanakalam* (1.2-5 adults / trap). Roving survey was conducted in Medchal district. The population of pinworm was less than five adults/trap in surveyed villages. The population of pin worm was more in polyhouses compared to open cultivation.

Natural enemies of *T.absoluta* include the egg parasitoids *Trichogramma* sp. larval parasites *Cotesia* sp. and *Charops* sp. and the predatory bug , *Nesidiocorus*. Abundance studies showed that in five locations, mean population of spiders, Coccinellids, *Cotesia*, *Nesidiocorus*, *Charops* and *Trichogramma* in five village locations was 0.39, 0.32, 0.007, 1.00, 0.001 and 3.32 per quadrat.

Rabi surveys are in progress. Yeravali village in Shamshabadmandal recorded huge incidence of *T.absoluta* with more than 75% damage . Abundance studies showed that in five locations, mean population of spiders, Coccinellids, *Cotesia*, *Nesidiocorus*, *Charops* and *Trichogramma* in five village locations was 0.48, 0.38, 0.005, 1.20, 0.001 and 2.70 per quadrat. Abundance of spiders, Coccinellids, Nesidiocorus bugs was fond to be more in rabi than Kharif while abundance of *Cotesia*, and *Trichogramma chilonis* was more in *kharif* than *rabi*.

Table 236. VILLAGES SURVEYED

S.No	Villages	Mandals	Level of infestation of *T. absoluta*
1	Bahadurguda-1	Shamshabad , RR dt	Moderate
2	Bahadurguda-2		
3	Laxmithanda		
4	Nagaram		
5	Kasimboli-1	Moinabad , RR dt	Moderate
6	Kasimboli-2		
7	Bakaram-1		
8	Bakaram-2		
9	Bakaram-3		
10	Ameerpet	Maheshwaram, RR dt	Less
11	Dabilguda		

12	Imamguda		
13.	Nagaram		
14.	Venkannaguda		
15	Indurthi	Marrigudamandal, Nalgonda	Less - Moderate
16	Kondur		
17	Metichandapur		
18	Namapur		
19.	Tirgandlapalli		
20	Yergandlapalli		
21	Tammadpalli		
22	Somrajguda		

Fig:62. Severe infestation of *Tuta absoluta* in a field in Yeravali, village, Shamshabad, Rangareddy dt.

Table 237. Population of natural enemies (mean no./quadrat) (mean of five quadrats) - 2020-21 –village

Sl. no	Natural enemy	Laxmi thanda		Kasimbowli		Sayyedguda		Kondur		Nagaram		Mean	
		Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
1	Spiders	0.48	0.64	0.22	0.32	0.32	0.66	0.42	0.40	0.28	0.38	0.39	0.48
2	Coccinellids	0.26	0.36	0.30	0.36	0.36	0.43	0.43	0.46	0.32	0.31	0.32	0.38
3	*Cotesia* sp.	0.01	0.001	0.001	0.001	0.001	0.003	0.02	0.02	0.001	0.001	0.007	0.005
4	*Nesidiocoris bug*	1.09	1.12	0.98	1.34	1.34	1.34	0.87	0.98	1.05	1.21	1.00	0.005
5.	*Charops*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	1.20
6.	*Trichogramma chilonis*	3.6	2.4	2.4	2.1	2.9	3.2	2.8	2.6	4.9	3.2	3.32	2.7

22.8 Bio-intensive pest management of *Helicoverpa armigera*, *Tuta absoluta* and sucking pests of tomato

Treatment details

T1 = BIPM

Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds.

Raising marigold as trap crop

Use of ICAR-NBAIR pheromone trap @ 1 trap per plot.

Trichogramma achaeae / *Trichogramma pretiosum* @ 50,000 per release (6 releases)

Azadirachtin 1500 ppm @ 2 ml/lit.

Lecanicillium lecanii (NBAIR) 1×10^8 spores/ g @ 5g/lt for sucking pests

T2 = Chemical control

Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests

T3 = Untreated Control

Design	: RBD
Replications	: Seven
Plot Size	: 4×5 m
Variety	: Local
Season	: Rabi, 2020-21

Location: Farmers' fields, Laxmi Thanda, Shamshabad Mandal, Rangareddy district.

Methodology and observations:

The treatment applications will be started at initial occurrence of American pin worm. Six releases of parasitoids at weekly interval and three sprays of Bio Pesticides will be given during evening hours at fortnightly interval.

Randomly select 10 plants/ $40m^2$ and observe all the leaves for presence of leaf mine / sucking pests caused by the larva.

Randomly select 10 plants/ $40m^2$ and observe all the fruits for presence of holes/ damage caused by the larva.

Observations will be recorded at fortnightly interval from fruit formation to last harvest.

Fruit damage percentage and yield.

Cost-benefit ratio

RESULTS

BIPM package and Farmers package recorded lesser mined leaves/plant ranging from 1.55 to 1.74 compared to control (2.13/plot). Aphids and mirids were also lesser in BIPM and Farmers practice (1.54/leaf aphids each and 1.9-2.5 mirids/plant compared to control (3.93/plant and 3.7/plant, respectively). Untreated control however recorded higher predators (2.36/plant) compared to BIPM and Farmers practices. (0.57-1.73/plant). Parasitoids were more in the BIPM package plots and control plots (2.40-3.03/plant). Fruit damage by *H. armigera* was lesser (4.25-5.5%) in BIPM package and farmers package compare to control (10.0%). Yield (kg/plot) was 756, 803 and 267, respectively in BIPM package, farmers' package and in control plots. BIPM and Farmers' practices recorded on-par yield values, however, B:C ratios were 4.44 in BIPM package and 3.71 in farmers' practices (Table. 238).

Table 238. Impact of BIPM practices on pests, natural enemies and yield in tomato

Treatment	No.of mined leaves/plant	Aphids (no./leaf)	Mirids (no/plant)	Fruit damage (%)	Predators (no/plant)	Parasitoids (no./plant)	Yield (kg/plot)	B:C Ratio
BIPM package	1.74 (1.28)^{a}	1.54 (1.41)^{a}	2.5 (1.51)^{a}	5.5 (13.42)^{a}	1.73 (1.27)^{b}	2.40 (1.53)^{a}	756^{a}	4.44
Farmers package	1.55 (1.21)^{a}	1.59 (1.39)^{a}	1.9 (1.34)^{a}	4.25(11.52)^{a}	0.57 (0.74)^{c}	0.66 (0.75)^{b}	803^{a}	3.71
Untreated Control	4.74 (2.13)^{b}	3.93 (2.09)^{b}	3.7 (1.83)^{b}	10.0 (18.40)^{b}	2.36 (1.52)^{a}	3.03 (1.74)^{a}	267^{b}	-
CD (1%)	0.33	0.39	0.27	4.98	0.23	0.35	53.0	-
CV	5.67	11.25	12.33	12.92	14.96	10.91	21.34	-

Fig:63. The experiment was conducted in the fields of farmer Mr. N. Kumar, Laxmi Thanda, Shamshabad

a.  b. 

Fig:64. a) Close up of the sticky cum pheromone trap erected in the BIPM plot
b) View of the BIPM plot at Laxmi Thanda, Shamshabad with the pheromone trap , Sticky trap and border row of marigold.

Fig:65. One row of Marigold around the tomato plot

22.8.2 IIHR,Bengaluru

Bio-intensive pest management of *Helicoverpa armigera*, *Tuta absoluta* and sucking pests of tomato

Design: RBD, Variety: Arka Rakshak

The incidence of *Helicoverpa armigera* and *Tuta absoluta* was very negligible in this experimental trial. Therefore, could not give data on this trial.

23. Biological Control of Brinjal Pests

23.1 Development of bio-intensive pest management (BIPM) module for the management of shoot and fruit borer, *Leucinodes orbonalis* (Guenee) in brinjal

23.1.1 AAU, Anand

Objective: To develop biointensive pest management (BIPM) module for the management of shoot and fruit borer, *Leucinodes orbonalis* (Guenee) in brinjal

Table 239.

	Year of commencement	:	*Kharif*, 2020-21
	Location	:	Agronomy farm, AAU, Anand
	Crop &variety	:	Brinjal, ABH-1
	Treatments	:	03
	Repetitions	:	10
	Design	:	Large plot sampling CRD
	Spacing	:	90 x 60 cm
	Plot size	:	27 x 20 m
Treatments			
T_1	BIPM module		Intercropping of brinjal with coriander (2:1 row) Installation of pheromone trap - Lucilure @ 40/ ha Release of *Trichogramma chilonis* @ 100000/ ha Spraying of Azadirachtin 10000 ppm (20 ml/10 litre water) Spraying of *Bacillus thuringiensis* AAU-*Bt*1 (2×10^8cfu/g) 1% WP (50g/ 10 litre water) Spraying of entomopathogenic nematode (EPN) *Steinernema* sp. 1% WP (80g/ 10 litre water)
T_2	Chemical module		Alternate spraying of emamectin benzoate 5 SG, 0.0025% 5g/ 10 litre water andchlorantraniliprole 18.5 SC, 0.006% 3 ml/10 litre water - Three sprays at fifteen days interval with the initiation of pest.
T_3	Untreated control		-

Methodology:

Brinjal crop was raised by adopting recommended agronomical practices. For male moth catches of *L. orbonalis*, pheromone traps were installed@ 40/ha from 30 DAT. The egg parasitoid *Trichogramma chilonis* @ 100000/ ha was released at weekly interval with the initiation of pest. Three sprays of azadirachtin, two sprays of *Bt* and one spray of EPN were carried out during the cropping season. Isolation distance was maintained between the treatment modules. The data was statistically analyzed using suitable transformation.

Spray schedule **Table 240.**

Bioagent/Biopesticide	Spray	DAT
Azadirachtin	First	30
Bt	Second	45
EPN	Third	60
Azadirachtin	Fourth	75
Bt	Fifth	90
Azadirachtin	Sixth	105

Observations recorded:

Observations on male moth catches of *Leucinodes orbonalis* in pheromone trap was recorded at weekly interval from the installation of pheromone trap

Shoot damage (%) – Ten plants were randomly selected from each subplot and observations on damaged shoots was recorded at weekly interval after 15 DAT

Fruit damage (%) - The observations on fruit damage on number and weight basis was recorded from each treatment at each picking

Fruit yield (healthy marketable fruit) - kg/plot

Results:

The data on the efficacy of the different modules against shoot and fruit borer and yield of brinjal is presented in the Table 241.In BIPM module, 5.06 male moth catches of *L. orbonlais*/trap was documented. With regard to the observations on shoot damage recorded at weekly interval revealed the lowest shoot damage (2.85 %) in chemical module which was followed by BIPM module (3.65 %). Among three modules evaluated, the highest shoot damage was recorded in untreated control module (8.47%). With regard to the data on fruit damage recorded on number and weight basis depicts the significantly lowest fruit damage in chemical module (3.11 % on number basis, 3.61 % on weight basis) than the fruit damage recorded in BIPM module (4.32% on number basis, 5.47% on weight basis). The highest fruit damage was recorded in untreated control module (9.20% on number basis, 10.13% on weight basis). The shoot damage and fruit damage recorded in the modules was reflected in yield of the crop. The chemical module recorded the highest fruit yield of 515.72 q/ha and it was statistically at par with the fruit yield recorded in BIPM module (499.13 q/ha). The lowest fruit yield was recorded in untreated control module (137 q/ha). Based on these results it can be concluded that BIPM module is effective in reducing the shoot and fruit borer damage with higher fruit yield.

Table 241. Efficacy of different modules against shoot and fruit borer damage and yield of brinjal

Modules	Moth catches/ trap	Shoot Damage (%)	Fruit Damage (%)		Yield (q/ha)
			Number basis	Weight basis	
BIPM Module	5.06	11.02* (3.65)	11.99 (4.32)	13.53 (5.47)	499.13
Chemical Module	-	9.72 (2.85)	10.16 (3.11)	10.96 (3.61)	515.72
Untreated Control	-	16.92 (8.47)	17.66 (9.20)	18.56 (10.13)	137.00
S. Em ±	-	0.26	0.21	0.26	7.66
C.D. at 5 %	-	0.71	0.58	0.74	21.23
C. V. (%)	-	14.35	17.38	20.39	21.86

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

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

23.2.1 IIHR, Bengaluru

Variety:Arka Anand

No. of treatments: 8

No. of replications: Three

Design: RBD

Table 242. Bio-efficacy of microbial agents against *Myllocerous 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@ 1ml/l	4.66 (2.27)	1.66 (1.38)	12.33 (3.51)	5.33 (2.40)	6.44 (2.43)
T2	*M. anispoliae* AAU @ 5g/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 @ 5g/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@5g/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@5g/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)	5.66 (2.48)	2.00 (1.55)	2.55 (1.74)
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 %	NS	1.21	0.89	0.8	1.80

Table 243. 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	6.37	1.21	3.80	3.65
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	7.35	1.23	2.96	4.09
T5	*B. bassiana*NBAIR@ 5g/l	5.44	1.56	3.03	3.24
T6	*Heterorhabditis indica* @ 2.5 10^9 IJs ha^{-1}	5.41	1.17	3.45	4.09
T7	Imidacloprid @0.5 ml /l	4.97	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

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 was 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. 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 were recorded. The *B. bassiana* NBAIR and *M. anispoliae* AAU strains were showing significantly lower leaf damage scoring compared to other treatments.

23.3 Bio-intensive insect pest management in brinjal

KAU, Thrissur

An experiment on validation of biointensive integrated pest management (BIPM) in brinjal was carried out at College of Horticulture, Vellanikkara from October 2019 to May 2020, as per the details given below.

Design: RBD

Variety: Haritha

Plot size: 1 cent/ replication

Treatments: 3

T1: BIPM

T2: Farmers' practice

T3: Untreated Control

Replications: 7 **Table 244.**

Treatment details for shoot and fruit borer	
T1	Release of *Trichogramma chilonis* @100,000 per ha, 7 releases *Bacillus thuringiensis* @ 5ml/litre – Two sprays @ 15 day interval
T2	Flubendiamide 25 g a.i ha^{-1} -Two sprays @ 15 day interval
Treatment details for mealybug	
T1	*Lecanicillium lecanii* (NBAIR strain) 10^{8} spores/ml – Two sprays @ 15 day interval
T2	Imidacloprid 30 g a.i ha^{-1} – Two sprays @ 15 day interval

The results of mean fruit damage and mean mealy bug count are given in Table 244 and 245, respectively.

Table 245. Effect of BIPM package on fruit damage by *Leucinodes orbonalis*

Treatments	Mean fruit damage (%)							Economic yield (q/ha)
	Preco-unt	5 DAS1	10 DAS1	5 DAS2	10 DAS2	15 DAS2	Cumulative mean fruit damage	
T_1: BIPM	22.21 (29.83)	35.70 (38.91)[b]	41.22 (39.81)[b]	54.41 (47.79)[b]	41.95 (41.72)[b]	52.02 (46.78)	45.40 (42.33)[b]	84.67[a]
T_2: Farmer's practice	30.72 (35.18)	45.25 (47.61)[b]	48.61 (44.56)[b]	64.51 (53.94)[ab]	52.04 (47.20)[ab]	55.73 (48.51)	55.69 (48.30)[b]	50.52[b]
T_3:Untreated control	30.28 (32.83)	73.43 (61.82)[a]	67.39 (54.14)[a]	81.91 (62.58)[a]	63.28 (52.49)[a]	45.50 (44.89)	70.74 (57.57)[a]	19.17[c]
CD @ 0.05	NS	10.65	6.54	9.39	5.62	NS	6.34	9.35
CV	17.55	18.49	12.15	14.72	10.23	16.88	11.02	38.99
SE	2.18	4.24	2.91	3.14	2.72	2.98	13.39	3.05

DAS- Days after spray. *Figures in parenthesis are arc sin transformed values

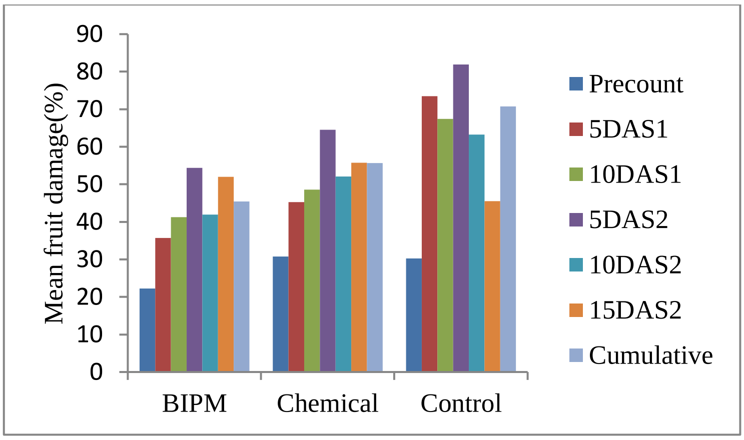


Fig:66. Effect of BIPM and chemical methods on fruit damage by BSFB in brinjal

Table 246. Effect of BIPM package on brinjal for the management of mealybug

Treatments	Mean number of mealybugs per leaf						
	Precount	5DAS1	10DAS1	15DAS1	5DAS2	10DAS2	15DAS2
T_1: BIPM	46.08 (6.13)	13.57 $(3.41)^{ab}$	17.05 (3.75)	19.89 (4.09)	0 $(0.71)^{b}$	0 $(0.71)^{b}$	2.1 (1.39)
T_2: Farmer's practice	22.86 (4.19)	7.19 $(1.95)^{b}$	6.89 (2.30)	1.89 (1.15)	0.57 $(0.91)^{b}$	0 $(0.71)^{b}$	0.03 (0.73)
T_3: Untreated control	16.98 (3.42)	36.63 $(5.64)^{a}$	18.00 (3.90)	38.83 (4.77)	18.83 $(3.50)^{a}$	8.98 $(2.42)^{a}$	2.33 (1.47)
CD @ 0.05	NS	2.430	NS	NS	1.969	1.385	NS
CV	50.23	56.89	52.09	80.97	99.18	93.04	56.19
SE	6.54	4.4	2.75	8	3.30	1.83	0.56

DAS-Days after spraying. *Figures in parenthesis are square root transformed values

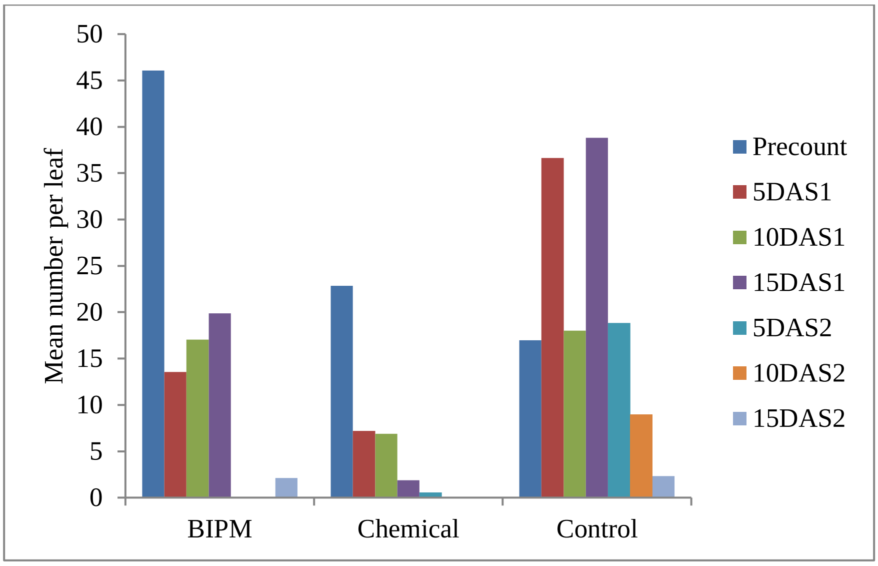


Fig:67. Effect of BIPM on mealybug infestation in brinjal

Table 247. Benefit cost analysis

Treatments	Total Cost (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C
BIPM	34876	127005	92129	2.64
Farmer's practice	34436	75780	41344	1.20
Untreated control	29776	28755	1071	-

Shoot damage was very low during the early vegetative stages of the crop. Marked infestation by BSFB was observed only during reproductive stage of crop growth. Five days after first treatment, the mean fruit damage is 35.70% in BIPM plots which was significantly superior to untreated control and was on par with plots treated with flubendiamide (25 g a.i ha^{-1}) as farmers' practice, which had 45.25% fruit damage. Similar trend was also observed at ten days after the second treatment. BIPM plots recorded 41.22% fruit damage which was on par with plots treated with chemical insecticide (48.61%). BIPM plots continued to record lowest mean fruit damage at both 5 and 10 days after second spray as well, with 54.41 and 41.95% fruit damage, respectively. Fifteen days after the second treatment, all the three treatments were on par with each other. Cumulative values for fruit damage were significantly lower in BIPM plots (45.40%) as well as chemical insecticide treated plots (55.69%), as compared to untreated control (70.74 %). Both the treatments were on par with each other.

Mealy bug infestation was observed from April 2020 onwards. No significant differences were observed among the treatments. However, five days after the second spray, in BIPM and chemical insecticide treated plots were recorded negligible mealy bug population and were significantly superior from untreated control plots. A similar trend was also observed at ten days after the second spray, when no mealy bugs were recorded in BIPM and imidacloprid treated plots while untreated control plot had 8.98 mealybugs per leaf.

Data on marketable fruit yield per plot at each harvest was summed and converted into quintals per ha. BIPM recorded yield of 84.67q/ha which was significantly superior to insecticide treated plots (50.52 q/ha). Untreated plots recorded a mean yield of 19.17 q/ha, which was significantly lower than the yield observed in the above two treatments. The cost benefit ratio was 2.64 for BIPM fields as against 1.2 in chemical treatment. The cost benefit analysis revealed that BIPM package can be a viable alternative to farmer's practices.

Fig:68. Plate 15. Experimental plot for validation of BIPM in brinjal

Pooled analysis (2018 -19 & 2019-2020)

The pooled analysis indicated significant difference between BIPM and farmers' practices in terms of fruit damage. The plots treated with insecticides were significantly superior to other treatments with the lowest mean fruit damage of 31.51%. The BIPM plots recorded a mean of 40.05% fruit damage, which however was significantly superior to the mean damage of 58.51% in control plots (Table 248).

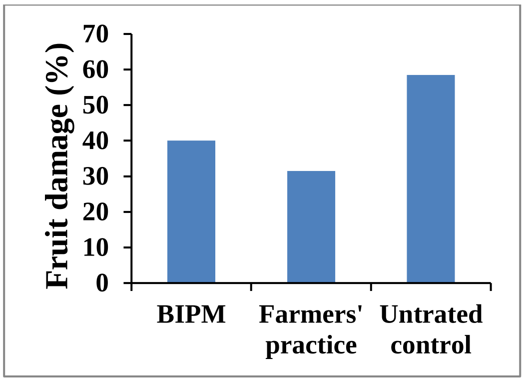
The BIPM and chemical treated plots recorded economic yields of 21.24 and 14.98 q/ha, respectively which were on par with each other. Significantly lower yield of 6.54 q/ha was recorded in untreated plots. Based on these results we conclude that the BIPM package could be a viable alternative to chemical methods.

Table 248. Comparison of BIPM and chemical methods for control of fruit borer

Treatments	Fruit damage (%)	Economic yield (q/ha)
T1- BIPM	40.05 (39.18)^{b}	21.24^{a}
T2- Farmers practice	31.51 (34.07)^{c}	14.98^{a}

T3- Untreated control	58.51 (50.12)[a]	6.54[b]
CD @ 0.05	4.892	6.428
CV	15.23	58.02
SE	2.45	11.82

*Figures in parenthesis indicate arc sin transformed values



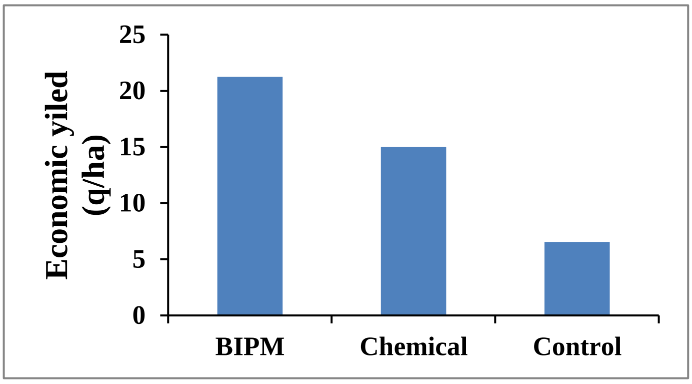


Fig:69. Comparison between BIPM and farmer's practice terms of fruit damage

Fig:70. Comparison between BIPM and farmer's practice in terms of economic yield

24. Biological Control of Okra Pests

24.1 Evaluation of biointensive IPM module against key pests of okra

24.1 .1 AAU, Jorhat

<u>Experimental details:</u>

Targetpests:Jassids/Thrips/Whiteflies/shootandfruitborer

Location: NeulGaon, Jorhat(farmer'sfield).

Season: *Kharif*,2020

Date of Sowing: 25.07.2020

Variety: Arka Anamika

Replication: 10

Area cover: 1 ha

Plot size: 60m x 50m

Treatments:2 (BIPM and farmers practice)

BIPM treatments include:

Yellow sticky traps@20 traps/ha for maintaining of sucking pests.

Rogueout theYVMVaffected plant from time to time.

Application of *Beauveria bassiana* @1×10^8cfu/@5g/lit.

Application of NSKE @5%

5 releases of *Trichogramma chilonis* @ 1,00,000 per ha starting from 35 days after sowing at10 days interval orcoinciding with the emergence of *Earis* sp.

Application of profen of os 50%EC@2ml/per lit.(at2-3sprays as need based)

Farmers practice

Alternate spray of Clorantraniliprole 18.5 SC@0.4ml/lit and lamdacyhalothrin2.5% EC@1.5ml/lit.

Observations:

Sucking pests (leaf hopper and whitefly) from 10 randomly selected plants on each leaves from top, middle and bottom were selected before treatment and 7and 10 daysafter treatment. Number of fruit borer larvae on 5 randomly selected plants was recorded before imposing the treatments and 7 and 10 days after treatments. Percent fruit damaged by borers was recorded. The yield of marketable fruits recorded at the time of harvesting taken from each plot and records of all picking were pooled together.

Table 249. Biointensive insect management in okra

Treatments	Sucking Pest (No./leaf)		Shoot and fruit borer (larvae/ 5 plants)		Fruit Damage (%)	Parasitisation (%) *Trichogramma* sp.	Yield (Q/ha)
	Pretreatment	Post treatment	Pretreatment	Post treatment			
BIPM Package	3.67	1.67	4.92	1.98	8.06	7.4	75.75
Chemical control	4.19	1.87	4.98	1.62	7.27	2.8	68.75
"t" value	1.95	3.67	0.305	2.29	2.42		6.47
Remarks	NS	S	NS	S	S		S

*Mean of two observations

Results: The results indicated a significant difference in between BIPM package and chemical control plot with regard to the mean number of sucking pests /leaf, number of larvae/ 5 plants and per cent fruit damage after treatment. In chemical control plot, six sprays of insecticides at fortnightly intervals contributed maximum protection from infestation of larvae per five plant and per cent fruit damage of 1.62 and 7.27%, respectively as against 1.98% and 8.06% in BIPM plot. However, highest marketable fruit yield of 75.75 q/ha was recorded in BIPM plot, whereas in chemical control plot, the yield was 68.75 q/ha. The per cent parasitisation on *Corcyra* sentinel cards by *Trichogrammatids* species in BIPM plot was 7.4% as against 2.8% in chemical control plot (Table 249).

24.2 Large scale demonstration on bio-intensive pest management in okra

24.2.1 AAU, Anand

Objectives:

To demonstrate the bio-intensive pest management (BIPM) strategies in okra

To create awareness and to train the farmers on BIPM strategies in okra for the management of various insect pests

	Year of commencement	:	*Kharif,* 2020
	Location	:	Farmers' fields, Village - Umreth, District - Anand
	Crop & Variety	:	Okra, F_1- Radhika (UPL Advanta)
	Area	:	10 ha
	Treatments	:	02
	Repetitions	:	10
	Design	:	Large plot sampling CRD

	Spacing	:	60 x 30 cm
	Plot size	:	5 ha for each treatment
	Treatments		
T_1	BIPM module		Installation of pheromone trap for *Helicoverpa armigera* & *Earias vittella* @ 60 traps/ha at 30 DAS. Six releases of *Trichogramma chilonis* @ 50000/ ha at weekly interval with the initiation egg laying of the pest. Two sprays of *Bacillus thuringiensis* NBAIR BTG4 ($2x10^8$cfu/g) 1% WP (50g/ 10 litre water). First spray with the initiation of lepidopteran pest and subsequent spray at ten days interval One spray of Azadirachtin 10000 ppm (1% EC) (20ml/ 10 litre water) with the initiation of sucking pest and subsequent spray with *Lecanicillium lecanii* NBAIR Vl-8 ($2x10^8$cfu/g) 1% WP (50g/ 10 litre water) at ten days interval.
T_2	Chemical module/ Farmers' practice		-
Methodology & observations recorded			Okra crop was raised by adopting standard agronomical practices. Total 10 quadrates were made in each treatment. Each quadrate served as one repetition. Observations on male moth catches of *Helicoverpa armigera* and *Earias vittella* in pheromone trap were recorded at weekly interval from the installation of pheromone trap. The observations on larval population of *H. armigera* and *E. vittella* were recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest. The observations on sucking pest population were recorded from three leaves (upper, middle and lower) of ten randomly selected plants per repetition at weekly interval with the initiation of pest. Fruit damage (%) - The observations on fruit damage on number and weight basis was recorded from each treatment at each picking. Natural enemies – The population of natural enemies was recorded from 10 plants of each quadrate at 15 days interval Fruit yield (healthy marketable fruit) q/ha The data was statistically analysed using suitable transformation.

Table 250. Efficacy of different modules on pest incidence, fruit damage and yield of okra
Note: * Significant at $t_{0.0.5}$

Modules	Moth catches/ trap		*H. armigera* larvae/ plant	*E. vittella* larvae/ plant	Fruit damage (%)		Yield (q/ha)
	Earias vittella	*Helicoverpa armigera*			No. basis	Weight basis	
BIPM Module	2.30	6.20	1.21	3.82	3.08	3.51	136.36
Chemical Module	--	--	0.86	2.88	4.94	4.88	111.21
't'value	--	--	2.26	0.84	2.90*	3.41*	3.21*
Table $t_{0.05}$	--	--	2.78	2.78	2.15	2.15	2.31

Table 251. Efficacy of different modules on incidence sucking pests and natural enemies in okra
Note: * Significant at $t_{0.0.5}$
Results:

The data pertaining to the efficacy of different modules against major insect pests of okra is presented in the Table 250 & 251. In BIPM module, more number of male moth

Modules	No. of whiteflies/ leaf	No. of jassids/ leaf	No. of coccinellids/ plant
BIPM Module	2.03	3.84	3.52
Chemical Module	2.83	3.01	0.92
't'value	1.11	0.60	6.43**
Table $t_{0.05}$	2.57	2.57	2.57

cathes of *H. armigera* (6.20/trap) was recorded as compared to male moth catches of *E. vittella* (2.30/trap). With regard to larval population, the lowest population was recorded in chemical module (*H. armigera* - 0.86/ plant, *E. vittella* - 2.88/plant) and it was found at par with the population documented in BIPM module (*H. armigera* – 1.21 larvae/ plant, *E. vittella*– 3.82/plant). Whereas, the fruit damage was significantly lower in BIPM module (3.08% - number basis and 3.51 % weight basis) as compared to chemical module (4.94% - number basis and 4.88% weight basis). The significant decrease in fruit damage in BIPM module was attributed to the successful integration of different biointensive components and it was reflected in yield of the crop. The BIPM module recorded the significantly higher yield (136.36 q/ha) as compared to chemical module (111.21 q/ha). Further, the population of sucking pest complex *viz*., whitefly and jassids found at par in both the modules, whereas, the population of coccinellids was significantly higher in BIPM module (3.52/plant). This result demonstrates the successful bio-intensive module, which helps in reducing the pest incidence and damage in okra crop with higher yield.

24.3 Management of hoppers, aphids and Whitefly on Okra by oil based formulation of *Metarhizium anisopliae (IIHR Strain)*

24.3.1 IIHR, Bengaluru

Design: RBD, Replication: 4, Plants/replication: 10plants/replication Variety:Arka Anamika

Results:

In okra observed severe incidence of leaf hoppers and the treatments were imposed. The results reveal that there was no significant reductionin the population of leafhoppers among the different doses of *M. anisopliae* after 3 sprays.

Table 252. Effect of oil based formulation of *Metarhizium anisopliae (IIHR Strain)* population of hoppers, aphids and Whitefly on Okra by

	Treatments	Mean no. of Leafhoppers/plant			
		Before spray	After I spray	After II spray	After III spray
T1	*M. anisopliae* (oil based formulation) @ 0.25ml /l	20.35 (4.56)	17.3 (4.21)	17.55 (4.24)	17.3 (4.21)
T2	*M. anisopliae* (oil based formulation)@ 0.5ml/l	20.61 (4.59)	19.3 (4.44)	19.06 (4.42)	19.3 (4.44)
T3	*M. anisopliae* (oil based formulation) @ 1ml/l	17.89 (4.26)	17.1 (4.17)	16.78 (4.13)	16.84 (4.14)
T4	Standard check – Imidacloprid @0.3ml/l	19.53 (4.47)	12.8 (3.63)	13.22 (3.69)	12.95 (3.65)
T5	Unsprayed (control)	18.47 (4.34)	19.26 (4.44)	19.01 (4.41)	18.7 (4.38)
	CD at 0.05 level	NS	0.40	0.35	0.38

Figures in the parenthesis are Sqrt (X+0.5) transformed values

24.4 Efficacy biocontrol agents for management of fruit borer, *Earias vittella* on bhendi (IIVR-Varanasi)

24.4.1 ICAR-IIVR, Varanasi

Plot size 8x5m = 40 m^2; Replication = 04; Design: RBD; Variety = Kashi Pragati

Treatments

T1: *Metarhizium anisopliae* (NBAIR) 1×10^8 spores/ g @ 5g/lt

T2: *Beauveria bassiana*(NBAIR) 1×10^8 spores/ g @ 5g/lt

T3: *Trichogramma chilonis*@50,000 parasitoids/ha, 6 releases at weekly interval.

T4: *Bacillus thuringiensis* @ 1 kg/ha

T5: Azadirachtin 1500 ppm@ 2 ml/lit

T6: University recommended insecticide (Emamectin benzoate 5 SG)

T7: Untreated control

Table 253. Bio-efficacy of different biocontrol agents against major insect pests of okra

Treatments	Damage fruit (%)			Jassid/leaf			Whitefly/ leaf		
	Before spray	After spray	PROC#	Before spray	After spray	PROC#	Before spray	After spray	PROC#
T1	13.59	7.16^{bc}	53.02	4.98	2.36^{a}	50.63	2.26	0.64	65.59
T2	15.67	6.73^{c}	55.84	4.18	2.94^{a}	38.49	2.49	0.69	62.90
T3	17.58	7.44^{bc}	51.18	5.08	4.55^{d}	4.81	2.17	1.78	4.30
T4	15.43	5.65^{b}	62.93	4.68	3.89^{c}	18.62	2.31	1.13	39.25
T5	14.36	7.89^{d}	48.23	4.77	2.52^{a}	47.28	2.09	0.59	68.28
T6	13.58	4.37^{a}	71.33	5.22	1.99^{a}	58.37	2.21	0.81	56.45
T7	14.56	15.24^{e}	--	5.19	4.78^{d}	--	2.11	1.86	--
SEm(±)	--	0.37	--	--	0.42	--	--	0.19	--
LSD (5%)	--	0.84	--	--	0.96	--	--	0.41	--

#PROC= Per cent reduction over control; Means followed by same letters in a column are not significantly different at P@ 0.05

Efficacy of different biopesticides against major insect pests of okra was studied under field conditions at ICAR-IIVR, Varanasi during kharif season of 2020-21. Amongst the tested biopesticides, treatment 4 *i.e.*, spraying of *Bacillus thuringiensis* @ 1 kg/ha was found most promising against okra fruit borer (*Earias vittella*) with maximum (62.93) per cent reduction over control (PROC). In case of okra jassids (*Amrasca biguttula biguttula*), spraying of *Metarhizium anisopliae* (NBAIR)1×10^{8} spores/ g @ 5 g/lit and Azadirachtin 1500 ppm@ 2 ml/lit were found superior with 50.63 and 47.28 PROC, respectively, over other biopesticidesand untreated control. However, in case of whitefly (*Bemisia tabaci*), treatment 5 *i.e.*, Azadirachtin 1500 ppm @ 2 ml/lit was found most effective followed by treatment 1 *viz*., *Metarhizium anisopliae* (NBAIR)1×10^{8} spores/ g @ 5 g/lit.

24.5 Evaluation of *Neoseiulus indicus* for the management of spider mites on okra24.5.1KAU, Thrissur

OKRA

A field experiment to evaluate *Neoseiulus indicus* for the management of spider mites on okra was laid out at farm of CoA, Vellanikkara. But the spider mites were not established in the field even after four inoculations. The experiment will be taken up next year.

Experimental design was RBD , Variety: Arka Anamika, Treatments: 4 with five replications

Treatments:

T1: Release of predatory mites @10 mites/plant

T2: Release of predatory mites @20 mites/plant

T3: Release of predatory mites @30 mites/plant

T4: Spiromesifen 100 g a.i/ha
T5: Control

Fig:71. Plate 16. Experimental plot for evaluation of *Neoseiulus indicus* for the management of spider mites on okra at CoA, vellanikkara

25. Biological Control of Cabbage Pests

25.1 Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage apid (*Brevicoryne/Myzus*) and *Plutella xylostella* (DBM)

25.1.1 CAU (Imphal),

Objective: To study the field efficacy of entomopathogenic strains for the management of cabbage aphid (*Brevicoryne/Myzus*) and *Plutella xylostella* (DBM)
Crop and Variety: Cabbage,Kaneko Cross Rare ball
Spacing: 45×45 cm
Plot size: 4×4 m=16 m^2
Treatments: 06
Replications: 04
Design: RBD
Season: Winter 2020-21
Treatments
1. Bb-5a isolate of *Beauveria bassiana*
2. Bb-45 isolate of *Beauveria bassiana*
3. Ma-4 isolate of *Metarhizium anisopliae*
4. Vl-8 isolate of *Lecanicillium lecanii*
5. Recommended Insecticide application (Alternative spraying of Imidacloprid 17.8 SL@0.5ml and Indoxacarb14.5 SC@1 ml/lit water)
6. Control (Untreated)

Methodology:

Three rounds of foliar sprays of oil formulations of entomopathogenic fungi at the spore dose of 1×10^8cfu/ml (5ml/liter) have given at 15 days interval. Observation

Pre (one day before first spray) and post count (7 and 14 days after spraying) of aphids (nymphs and adults) and DBM larvae were recorded by observing five randomly selected plants from each subplot.

Natural enemies/ plant: The population of natural enemies' *viz.*, coccinellids and syrphid fly was recorded in randomly selected five plants in each subplot.

Table 254. Bio-efficacy of different entompathogenic strains against cabbage DBM and coccinellid predators

Yield (healthy marketable cabbage heads) - kg/plot

Treatments	No. of DBM larvae/plant								Coccinellids/ Plant
	Before Spray	1st Spray		2nd Spray		3rd Spray		Pooled over periods over sprays	
		7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS		
T_1	3.93* (2.09)	3.50 (1.99)	3.47 (1.99)	3.44 (1.98)	3.23 (1.93)	3.26 (1.93)	3.23 (1.93)	3.36 (1.95)	2.20 (4.34)*
T_2	3.82 (2.07)	2.97 (1.86)	2.83 (1.85)	2.61 (1.76)	2.38 (1.68)	2.15 (1.61)	1.85 (1.53)	2.47 (1.70)	1.23 (1.01)
T_3	3.80 (2.06)	3.21 (1.92)	3.17 (1.91)	3.13 (1.90)	3.05 (1.88)	2.87 (1.83)	2.65 (1.77)	3.01 (1.86)	1.84 (2.89)
T_4	3.70 (2.03)	2.56 (1.74)	2.41 (1.69)	2.28 (1.65)	2.04 (1.45)	1.96 (1.55)	1.64 (1.45)	2.15 (1.61)	1.46 (1.63)
T_5	3.61 (1.98)	1.75 (1.49)	1.70 (1.47)	1.46 (1.39)	1.20 (1.30)	0.84 (1.15)	0.71 (1.09)	1.28 (1.32)	1.14 (0.80)
T_6	3.94 (2.09)	4.07 (2.13)	4.19 (2.16)	4.24 (2.13)	4.44 (2.22)	4.00 (2.11)	3.85 (2.08)	4.13 (2.14)	2.34 (4.98)
S. Em ±	0.18	0.09	0.08	0.09	0.09	0.10	0.08	0.12	0.05
C.D. at 5 %	NS	0.27	0.25	0.26	2.27	0.29	0.24	0.36	0.15

* Figures in the parenthesis are √x + 0.5 transformed values, NS: Non significant DAS: Days After Spray

Table 255. Bio-efficacy of different entompathogenic strains against cabbage aphids and its influence on cabbage yield

Treatments	No. of Aphids/plant							Pooled over periods over sprays	Yield (t/ha)
	Before Spray	1st Spray		2nd Spray		3rd Spray			
		7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS		
T_1	5.78 (2.49)*	4.21 (2.16)	3.46 (1.98)	3.21 (1.92)	2.42 (1.68)	1.96 (1.55)	3.21 (1.90)	3.97 (2.09)	18.50
T_2	5.23	4.78	4.23	3.48	3.14	2.45	1.87	3.33	20.30

	(2.38)	(2.29)	(2.17)	(1.98)	(1.90)	(1.70)	(1.52)	(1.94)	
T_3	5.60 (2.44)	4.66 (2.26)	4.47 (2.21)	3.54 (1.99)	3.45 (1.96)	3.03 (1.87)	2.93 (1.83)	3.68 (2.04)	19.60
T_4	5.41 (2.41)	4.81 (2.29)	3.81 (2.06)	3.04 (1.86)	2.66 (1.75)	2.08 (1.59)	1.34 (1.34)	2.96 (1.83)	22.19
T_5	5.43 (2.41)	3.84 (2.07)	3.44 (2.97)	2.52 (1.92)	2.18 (1.60)	1.50 (1.11)	0.97 (1.19)	2.41 (1.68)	24.68
T_6	4.70 (2.27)	5.38 (2.42)	5.58 (2.44)	6.64 (2.66)	7.73 (2.76)	6.36 (2.61)	5.88 (2.50)	6.26 (2.58)	15.09
S. Em ±	0.18	0.13	0.14	0.10	0.11	0.10	0.15	0.16	0.24
C.D. at 5 %	NS	0.39	0.42	0.31	0.33	0.30	0.45	0.48	0.71

* Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values, NS: Non significant DAS: Days After Spray

Among different entomopathogenic fungi evaluated for their bio efficacy against cabbage aphids and DBM the data on population pooled over periods over sprays depicted that, T_5–alternative spraying of Imidacloprid and Indoxacarb (3.70 thrips/plant) was the first effective treatment with lowest number of DBM (1.28 larvae/plant) followed by T_4–*Lecanicillium lecanii* Vl-8 (2.15 larvae/plant) which was followed by the next best treatment T_2– Bb-45 isolate of *Beauveria bassiana*(2.47 larvae/plant).The pooled data on aphids population after three sprays indicated the lowest population was in treatment T_5–chemical insecticides(2.41 aphids/plant) followed by T_4–Vl-8 isolate of *L. lecanii*(2.96 thrips/ plant) and T_2-Bb-45 isolate of *B.bassiana* (3.33 aphids/plant). Whereas, significantly the higher aphids and DBM population was reported in T_1–Bb-5a isolate of *B.bassiana* (3.36DBM larvae/plant and 3.97 aphids/plant) followed by T_3–Ma-4 isolate of *Metarhizium anisopliae* (3.01 DBM larvae/plant and3.68 aphids/ plant) and these two treatments were found statistically at par with each other (Table 254 and 255). However, the untreated control treatment recorded the highest DBM and aphids population of 4.13 and 6.26/plant, respectively. Except for the insecticidal treatment (1.14 coccinellids/plant) remaining biopesticides were not found to have negative impact natural enemies.

The efficacy of biopesticide treatments in reducing the DBM and aphids population was reflected in head yield of cabbage. Among the different biopesticides evaluated, T_4-Vl-8 isolate of *L.lecanii* was found promising in getting higher cabbage yield (22.19 t/ha), followed by T_2– Bb-45 isolate of *B. bassiana* (20.30t/ha). The highest (24.68 t/ha) and lowest (15.09 t/ha) cabbage head yield was respectively recorded in recommended Insecticide application and untreated control.

	
Experimental plot view	Cabbage DBM, Butterfly and Aphids

Fig:72.

25.2 Frontline demonstration on biointensive pest management in cabbage

Objectives:

To demonstrate the bio-intensive pest management (BIPM) strategies in cabbage

To create awareness and promotion of adopting eco-friendly pest management by conducting field day

Year of commencement: 2020-21

Location: Farmers field, Jampani village, East Siang district, Arunachal Pradesh

Crop and Variety: Cabbage, Kaneko Cross Rare ball

Area: 1 ha

Treatments: 02

Repetitions:10

Design: Large plot sampling CRD

Spacing: 60×45 cm

Plot size: 01acrefor each treatment

Treatment details:

Treatment 1: BIPM Module: Raising of mustard as trap crop, 5 releases of *Trichogramma chilonis*@ 100,000/release against *Plutella xylostella*, at 30 days after transplanting, spraying of *L. lecanii*-1×10^{8} spore/ ml @ 5ml/lt against cabbage aphid and three sprays NBAII BtG4 2% against lepidopteron pests or *Beauveria bassiana*/*Metarhizium anisopliae* @0.05% and alternative sprays with Neem oil (1500 ppm) @2 ml/lt water based on availability of bioagents.

Source of Technology:ICAR-NBAIR Bengaluru, TNAU Coimbatore and AAU Jorhat

Treatment 2: Farmers' practice (Chemical control) *i.e.*Imidacloprid 17.8 SL @0.5 ml/lit water against aphids and Spinosad 45 SC @0.4 ml/lit water alternative with Indoxacarb 14.5 SC @ 1ml/lit water against DBM at 10 days interval.

Methodology and observations recorded:

Cabbage crop was raised by adopting standard agronomical practices. Total 10 quadrates were made in each treatment. Each quadrate served as one repetition.The observations on larval population/plant of lepidopteron pest (DBM) were recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest.

The observations on aphid population/plantwere recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest.

Natural enemies–coccinellids, syrphid flies and parasitized larvae were recorded from each treatment at 15 days interval.

Yield (healthy marketable cabbage heads): t/ha

The data was statistically analysed using paired‘t’ test.

Table 256. Efficacy of different modules on pest incidence, head damage and yield of cabbage

Modules	No. of Aphids/Plant	No. of DBM larvae/Plant	Cabbage head damage (%)	Natural enemies/Plant	Yield (t/ha)
BIPM Module	24.46	3.24	4.75	3.91	20.47
Farmers practice	19.92	2.98	3.38	0.92	23.52
‘t’value	1.86	1.14	3.67*	12.12*	3.21*
Table $t_{0.05}$	2.78	3.18	2.36	2.78	2.27

*Significant at $t_{0.0.5}$

Results:

The data pertaining to the efficacy of different modules against major insect pests of cabbage is presented in the Table256. Although, the chemical module documented the lowest population of DBM (3.24 larvae/plant) and aphid (24.46/ plant), it was found statistically at par with the pest population recorded in BIPM module (DBM – 3.24/plant, aphid – 19.92/ plant). Further, BIPM module recorded the significantly higher cabbage head damage (4.75 %) as compared to chemical module (3.38%). Due to significantly lower head damage, the chemical module recorded the highest yield (23.52 t/ha) than the yield of BIPM module (20.47 t/ha). With regard to the population of natural enemies, BIPM module documented with highest coccinellids and syrphids (3.91/ plant) which were significantly higher than the population observed in chemical module (0.92/plant).

Cabbage DBM larva

Gregarious caterpillars of *S. litura*

Cabbage butterfly larva

Cabbage Aphids

	
Painted bug incidence on Cabbage	Field day at Farmers field, Jampani

Fig:73.

25.3 Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid (*Myzus persicae*) and *Plutella xylostella* (DBM)

25.3.1 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 257. 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	10.75	5.91^{b}	41.54	16.21	9.53^{c}	38.24	0.23	0.54
T2	10.53	5.29^{ab}	47.68	16.39	8.19^{ab}	46.92	0.31	0.49
T3	9.89	4.44^{a}	56.08	16.66	8.73^{b}	43.42	0.27	0.53
T4	11.05	4.89^{a}	51.63	15.49	7.80^{a}	49.45	0.35	0.61
T5	10.67	4.11^{a}	59.34	15.82	6.88^{a}	55.41	0.14	0.31
T6	10.42	10.11^{c}	--	16.54	15.43^{d}	--	0.39	0.64
SEm(±)	--	0.54	--	--	0.53	--	--	--
LSD (5%)	--	1.07	--	--	1.17	--	--	--

#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 2020-21 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 56.08per 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 (49.45 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 46.92 PROC. However, amongst the all treatments, Indoxacarb 14.5 SCat its recommended dose @ 0.75ml/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 (0.14 and 0.31 per plant, respectively), and were relatively higher in untreated control and entomopathogens treated plots.

25.4 Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Brevicoryne brassicae* (L.) and *Plutella xylostella* (L.).

25.4.1 MPKV, Pune

In evaluation of ICAR-NBAIR entomopathogenic strains studies, four sprays of Cynantraniliprole 10.26% OD@ 1.50 ml per litreof water effectively suppressed the population of aphids (57.03 aphid /plant) and Diamond back moth (1.09 larvae /plant) with increase in yield of 120.73 q/ha. The next best treatment was Bb-5a isolate of *Beauveria bassiana*@ 5.00gm per liter of water which recorded population of aphids (74.92 aphids /plant) and that of DBM (1.04 larvae /plant) with cabbage yield of 108.60 q/ha. It was followed by the treatment with Ma-4 isolate of *Metarhizium anisopliae* @ 5.00 gm per litre of water with aphids population of 72.04 aphids /plant and 1.45 DBM larvae /plant and recorded yield of 106.80 q/ha. The population of aphid was 91.31 aphids /plant, DBM was 1.99 larvae /plant and yield of 84.20 q/ha was recorded in untreated control. :

Experimental details:

The experiment was laid out on Research Farm of Agril. Entomology Section, College of Agriculture, Pune. Cabbage var Golden Acre was planted on 03.12.2020, having plot size of 2.40 × 4.5 m with spacing 60.00 × 45.00 cm in RBD with 6 treatments replicated 4 times. Four sprays of ICAR-NBAIR entomopathogenic strains and chemical insecticides were given on 08.01.2021, 20.01.2021, 02.02.2021 and 13.02.2021

Method of recording observations:

Aphids, *Brevicoryne brassicae*: Three plants of cabbage were randomly selected from each plot and tagged. Total number of aphids on three plants were counted visually with the help of magnifying lens 10 after each spray and converted into aphids per plant. For recording the aphid population at early plant stage, leaves were grasped at the petiole by thumb and four fingers and twisted until entire underside of the leave clearly visible. In the advance plant stage, these observations were recorded on outer leaves only.

Diamond back moth, *Plutella xylostella*: Five plants were selected randomly from each plot and the total larval population of the pest was counted at 10 days interval.

Results:

The data on field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Brevicoryne brassicae* (L.) and diamond back moth, *Plutella xylostella* (L.) arepresented in Table 258 and pooled mean are given in Table259. It is revealed from Table 258, that, aphid population per plant was ranged from 79.51 and 88.94 and Diamond

Back Moth (DBM) 1.41 and 1.50 larvae in pre count. No significant differences were observed in all the treatments before application of spray. However, post count observations of aphid population /plant and DBM larvae /plant showed significant differences amongst all the treatments.

Aphids /plant:The aphid count after four sprays are pooled and pooled mean was worked out. Mean aphid population was ranged from 57.03 to 91.31 aphids /plant. The lowest 57.03 aphid /plant was recorded in Cynantraniliprole 10.26% OD @ 1.50 ml per litre / water which is significantly superior over the rest of the other treatments except Vl-8 isolate of *Lecanicillium lecanii*5 g/ per litre / water which recorded 62.01 aphids /plant. All the remaining biopesticides treatments are at par with each other.

Diamond back moth/plant: Pooled mean of DBM larvae/plant was ranged from 1.09 to 1.99 larvae /plant. The lowest 1.09 DBM larvae/plant was recorded in Cynantraniliprole 10.26% OD @ 1.50 ml per litre/ water which was significantly superior over rest of the treatments except Bb-5a isolate of *Beauveria bassiana* @ 5.00 g per litre of water which recorded 1.04 lavae/plant and Bb-45a isolate of *Beauveria bassiana* @ 5.00gm per liter of water with 1.05 lavae/plant

Cabbage yield: The efficacy of insecticide and entomopathogenic strains treatments reflected on yield of cabbage heads. Cabbage yield was ranged from 84.20 to 120.73 q/ha. Highest yield of 120.73 q/ha was recorded in Cynantraniliprole 10.26% OD @ 1.50 ml per litre/ water which is at par with Bb-5a isolate of *Beauveria bassiana* @ 5.00gm per litre of water, Ma-4 isolate of *Metarhizium anisopliae* @ 5.00 gm per litre of water and Bb-45 isolate of *Beauveria bassiana*@ 5.00gm per litre of water and recorded yield (108.60, 106.80and 103.67q/ha), respectively.

Table 258. Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Brevicoryne brassicae* (L.) and diamond back moth, *Plutella xylostella* (L.)

Tr. No.	Treeatment Details	Dose g, ml/l.	Mean aphid population/plant					Diamond Back Moth (DBM) larvae/plant				
			10 days after each spray									
			Pre count	First	Second	Third	Fourth	Pre count	First	Second	Third	Fourth
T1	Bb-5a isolate of *Beauveria bassiana*	5.00	86.85^{a} (9.35)	74.92^{b} (8.68)	64.42^{e} (8.06)	46.38^{d} (6.85)	32.01^{d} (5.70)	1.44^{a} (1.39)	1.34^{a} (1.36)	1.21^{a} (1.31)	0.92^{a} (1.19)	0.68^{a} (1.09)
T2	Bb-45 isolate of *Beauveria bassiana*	5.00	88.56^{a} (9.44)	76.16^{b} (8.76)	62.16^{d} (7.92)	44.76^{c} (6.73)	29.99^{d} (5.52)	1.41^{a} (1.38)	1.34^{a} (1.36)	1.21^{a} (1.31)	0.93^{a} (1.20)	0.73^{a} (1.11)
T3	Ma-4 isolate of *Metarhiziumanisopliae*	5.00	88.94^{a} (9.46)	72.04^{b} (8.52)	53.04^{c} (7.32)	37.13^{c} (6.13)	19.31^{c} (4.45)	1.43^{a} (1.39)	1.34^{a} (1.35)	1.50^{b} (1.41)	1.04^{b} (1.43)	0.89^{b} (1.19)
T4	Vl-8 isolate of *Lecanicillium lecanii*	5.00	79.51^{a} (8.94)	62.01^{b} (7.91)	40.01^{b} (6.37)	26.01^{b} (5.15)	12.22^{b} (3.57)	1.60^{a} (1.45)	1.58^{b} (1.44)	1.52^{b} (1.42)	1.48^{b} (1.41)	1.40^{c} (1.39)
T5	Cynantraniliprole 10.26% OD	1.50	83.87^{a} (9.19)	57.03^{a} (7.58)	25.03^{a} (5.05)	14.52^{a} (3.88)	6.68^{a} (2.68)	1.44^{a} (1.39)	1.09^{a} (1.26)	0.85^{a} (1.16)	0.68^{a} (1.09)	0.46^{a} (0.98)
T6	Untreated Control	Nil	85.81^{a} (9.29)	91.31^{c} (9.58)	109.66^{f} (10.50)	130.66 (11.45)	92.66^{e} (9.65)	1.50^{a} (1.41)	1.99 (1.58)	2.19^{c} (1.64)	2.39 (1.70)	2.46^{d} (1.72)
SE±			0.19	0.23	0.16	0.23	0.25	0.05	0.05	0.05	0.04	0.06
CD at 5%			N.S.	0.69	0.48	0.69	0.75	N.S.	0.15	0.16	0.13	0.17
CV (%)			4.05	5.36	4.24	6.80	9.53	7.67	7.10	7.87	6.63	8.94

Figures in parenthesis are ($\sqrt{x+0.5}$) transformed values)50

Table 259. Efficacy of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Brevicoryne brassicae* and diamondback moth *Plutella xylostella* L. (Pooled Mean)

Tr. No.	Treeatment Details	Dose gm ml/l.	Aphid/plant		DBM larvae/Plant		Yield (Qt./ha)
			Pre count	Pooled Mean	Pre count	Pooled Mean	
T1	Bb-5a isolate of *Beauveria bassiana*	5.00	86.85^{a} (9.35)	74.92^{b} (8.68)	1.44^{a} (1.39)	1.04^{a} (1.24)	108.60^{a}
T2	Bb-45 isolate of *Beauveria bassiana*	5.00	88.56^{a} (9.44)	76.16^{b} (8.76)	1.41^{a} (1.38)	1.05^{a} (1.25)	103.67^{a}
T3	Ma-4 isolate of *Metarhizium anisopliae*	5.00	88.94^{a} (9.46)	72.04^{b} (8.52)	1.43^{a} (1.39)	1.45^{b} (1.40)	106.80^{a}
T4	Vl-8 isolate of *Lecanicillium lecanii*	5.00	79.51^{a} (8.94)	62.01^{a} (7.91)	1.60^{a} (1.45)	1.50^{b} (1.41)	92.47^{b}
T5	Cynantraniliprole 10.26% OD	1.50	83.87^{a} (9.19)	57.03^{a} (7.58)	1.44^{a} (1.39)	1.09^{a} (1.26)	120.73^{a}
T6	Untreated Control	Nil	85.81^{a} (9.29)	91.31^{c} (9.58)	1.50^{a} (1.41)	1.99^{b} (1.58)	84.20^{c}

SE±		0.19	0.23	0.05	0.03	6.88
CD at 5%		N.S.	0.69	N.S.	0.08	20.74
CV (%)		4.05	5.36	7.67	4.16	13.59

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

25.5 Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Brevicoryne brassicae* and dimond back moth, *Plutella xyllostella*

25.5.1 AAU, Jorhat

Experimental details:

Location : Horticultural Orchard, AAU, Jorhat

Target pests : Cabbage aphid and DBM

Plot Size : 6m× 5m

Design : 4RBD

Variety : Asha F1

Treatments : 6

Fertilizer dose: N: P: K=80:60:60

Date of Planting : 19.12.2020

Treatment details:

T_1= Bb-5a, isolate of *Beauveria bassiana*@ (1×10^8 spores/ml)

T_2= Bb-45, isolate of *Beauveria bassiana* @ (1×10^8 spores/ml)

T_3= Ma-4, isolate of *Metarhizium anisopliae*@ (1×10^8 spores/ml)

T_4= Vi-8, isolate of *Lecanicillium lecanii*

T_5= Alternate spray of Malathion 50EC @ 1.5 ml/litre / indoxacarb 14.5 SC @ 0.5 ml/litre

T_6= Untreated control

The field experiment was carried out to evaluate the efficacy of different entomopathogenic fungi against cabbage aphid and DBM during *rabi*, 2020-21. 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 (nymph and adult) 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 aphid, 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 260. Bio-efficacy 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	7.50	3.50[a]	62.96	9.20	6.50[b]	33.67	176.95[b]
T_2	7.70	3.40[a]	64.02	9.10	4.80[b]	51.02	190.65[c]
T_3	7.65	4.15[b]	56.08	8.40	6.35[a]	35.20	179.15[c]

T_4	7.60	3.20 [a]	66.14	8.75	4.15 [a]	57.65	214.50 [a]
T_5	7.70	3.10 [a]	67.20	8.60	4.85 [a]	50.51	211.58 [a]
T_6	7.55	9.45 [c]		8.90	9.80 [c]		137.13 [d]
CV%	6.10	7.77		5.48	7.87		8.22
CD= 0.05	NS	0.52		NS	0.72		2.95

Results: The results showed that, among the different biopesticides *L. lecanii* (V1-8 isolate) @ 5 ml/litre was the best treatment in reducing the mean population of aphid, *B. brassicae* (3.20/plant) and *P. xyllostella* (4.15/plant), with 66.14 and 57.65% reduction over control followed by the next best treatment of ICAR-NBAIR strains of *B. bassiana* (Bb-45 isolate) with 64.02 and 51.02% reduction over control of aphid (3.40/plant) and DBM (4.80/plant), respectively. In case of yield, maximum of 214.50 q/ha was obtained in *L. lecanii* (V1-8 isolate) treated plot. However, amongst the all treatments, four alternate sprays of chemical insecticides could significantly reduce the mean population of aphid (3.10/plant) and DBM (4.85/plant) in cabbage. It was also observed that all the EPF of ICAR-NBAIR strains (Bb-5a, Bb-45, Ma-4 and Vl-8) were very much effective to reducing the insect pests in comparison to untreated control.

Plate 2: View of Experimental plot of Cabbage

Fig:74.

25.6 Influence of habitat manipulation on incidence and severity of pest damage in cabbage

25.6.1 AAU, Anand

Objective: To assess the influence of habitat manipulation on incidence of major insect pests of cabbage **Table 261.**

	Year of commencement	:	*Rabi*, 2020-21
	Location	:	Agronomy farm, AAU, Anand
	Crop & variety	:	Cabbage, Golden Acre
	Treatments	:	05
	Replications	:	04
	Design	:	Randomized block design (RBD)
	Spacing	:	60 x 60 cm
Treatments			
T_1	Cabbage intercropped with mustard and cowpea (5:1:1)		
T_2	Cabbage intercropped with mustard and oats as border crop (5:1)		
T_3	Cabbage intercropped with cowpea and oats as border crop (5:1)		

T_4	Cabbage with oats as border crop
T_5	Cabbage as sole crop

Methodology:

Main crop, inter crop and border crop were raised as per recommended agronomic practices. Mustard was sown 15 days before the transplanting of cabbage.

Observations recorded:

Larval population/ plant: Five plants were randomly selected from each subplot and observations on larval population of lepidopteran pests were recorded at weekly interval with the initiation of pest.

Aphid population/ plant: Theobservations on aphid population were recorded at weekly interval with the initiation of pest. Five plants were randomly selected in each subplot. In each plant, three leaves were randomly selected and total number aphid population was recorded.

Natural enemies/ plant: The population of natural enemies*viz*., coccinellids and syrphid fly was recorded in randomly selected five plants in each subplot.

Yield (healthy marketable cabbage heads) - kg/plot

Table 262. Influence of habitat manipulation on incidence and severity of pest damage in cabbage

Treatments	No. of aphids/plant (After week)						No. of larvae of DBM/plant (After week)						No. of coccinellids / plant	Yield (t/ ha)
	1	2	3	4	5	Pooled	1	2	3	4	5	Pooled		
T_1	2.94* (8.14)	3.33 (10.59)	2.91 (7.97)	3.21 (9.80)	2.31 (4.84)	2.94 (8.14)	1.31 (1.22)	1.65 (2.22)	1.48 (1.69)	1.65 (2.22)	1.73 (2.49)	1.56 (1.93)	1.92 (3.19)	22.75
T_2	3.54 (12.03)	4.02 (15.66)	3.79 (13.86)	3.40 (11.06)	2.91 (7.97)	3.53 (11.96)	1.92 (3.19)	2.15 (4.12)	1.85 (2.92)	1.64 (2.19)	1.40 (1.46)	1.79 (2.70)	1.84 (2.89)	21.00
T_3	3.77 (13.71)	4.75 (22.06)	4.44 (19.21)	4.58 (20.48)	3.72 (13.34)	4.25 (17.56)	1.40 (1.46)	1.31 (1.22)	1.48 (1.69)	1.23 (1.01)	1.23 (1.01)	1.33 (1.27)	1.56 (1.93)	25.75
T_4	4.32 (18.16)	4.65 (21.12)	4.52 (19.93)	4.27 (17.73)	4.64 (21.03)	4.48 (19.57)	1.72 (2.46)	2.22 (4.43)	1.89 (3.07)	1.70 (2.39)	1.79 (2.70)	1.86 (2.96)	1.56 (1.93)	16.25
T_5	4.21 (17.22)	5.17 (26.23)	5.53 (30.08)	5.55 (30.30)	5.03 (24.80)	5.10 (25.51)	2.43 (5.40)	2.68 (6.68)	2.27 (4.65)	2.23 (4.47)	2.12 (3.99)	2.35 (5.02)	1.31 (1.22)	15.75
S. Em ±(T)	0.29	0.29	0.31	0.35	0.31	0.14	0.13	0.14	0.09	0.13	0.09	0.05	0.14	1.52
Period (P)	--	--	--	--	--	0.14	--	--	--	--	--	0.07	--	--
T x P	--	--	--	--	--	0.31	--	--	--	--	--	0.12	--	--
C.D. at 5 % T	0.90	0.90	0.96	1.07	0.97	0.40	0.40	0.43	0.28	0.41	0.27	0.23	NS	4.68
Period (P)	--	--	--	--	--	0.42	--	--	--	--	--	0.21	--	--
T x P	--	--	--	--	--	NS	--	--	--	--	--	0.33	--	--
C. V. (%)	15.58	13.26	14.75	16.48	16.91	15.37	14.57	13.96	10.20	15.60	10.51	13.22	16.98	14.97

Note: * Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values,NS = Non –significant

Results:

The data on the influence of habitat manipulation on incidence and severity of pest damage in cabbage is presented in the Table 262. The data reveals that the intercropping of cabbage crop with mustard and cowpea has significant influence on incidence of aphid and DBM infesting cabbage. The data on number of aphids/plant in cabbage depicts that the treatment T_1 – cabbage intercropped with mustard and cowpea recorded the lowest aphid population (8.14/ plant) and which was followed by the treatment T_2 – cabbage intercropped with mustard and oats as a border crop (11.96/ plant). The lowest number of aphid population in these two treatments was attributed to the presence of more number of coccinellids/plant due to intercrops *viz*., mustard and cowpea. The treatment T_1 recorded the coccinellid population of 3.19/ plant which was followed by the treatment T_2 (2.89 coccinellids/ plant). The highest population of aphids was documented in the treatment T_5- cabbage as a sole crop (24.80/ plant) and this treatment recorded the lowest number of coccinellids/ plant (1.22). With regard to the data on larval population of DBM, the treatment T_3 – cabbage intercropped with cowpea and oats as border crop recorded the lowest population (1.27/ plant) which was statistically at par with the treatment T_1- cabbage intercropped with mustard and cowpea (1.93/plant). The next best treatment in terms of reduced DBM infestation was T_2 – cabbage intercropped with mustard and oats as border crop (2.70/ plant). The sole cabbage treatment T_5 recorded the highest DBM larval population of 5.02/ plant.

The influence of intercrops in reducing the pest incidence was reflected in yield of the crop. The highest yield of 25.75 q/ha was recorded in the treatment T_3- cabbage intercropped with cowpea and oats as border crop and which was followed by the treatment T_1 – cabbage intercropped with mustard and cowpea (22.75 q/ha) and these two treatments found statistically at par with each other. The lowest yield of cabbage was recorded in the treatment T_5 – cabbage as sole crop (15.75 q/ha) and this was attributed to more incidence of pest and low population of natural enemies in sole crop. Hence, it can be concluded that the intercropping of cabbage with cowpea and oats as border crop helps in reducing the pest incidence with higher yield.

25.7 Large scale demonstration on bio-intensive pest management in cabbage

Objectives:

To demonstrate the bio-intensive pest management (BIPM) strategies in cabbage

To create awareness and to train the farmers on BIPM strategies in cabbage for the management of various insect pests **Table 263.**

	Year of commencement	:	*Rabi*, 2020
	Location	:	Farmers' fields, Village -Navli, Dist. Anand
	Crop &variety	:	Cabbage, F_1- Super Express (Welcome crop science)
	Area	:	10 ha

	Treatments	:	02
	Repetitions	:	10
	Design	:	Large plot sampling method (CRD)
	Spacing	:	60 x 60 cm
	Plot size	:	5 ha for each treatment
	Treatments		
T_1	BIPM module		Installation of pheromone trap for male moth cathes of *Plutella xylostella* @ 12 traps/ha at 30 DAT Eight releases of *Trichogramma chilonis* @ 100000/ ha at weekly interval with the initiation of egg laying of the pest. Two sprays of *Bacillus thuringiensis* NBAIR *Bt*G4 ($2x10^8$cfu/g) 1% WP (50g/ 10 litre water). First spray with the initiation of lepidopteran pest and subsequent spray at ten days interval One spray of Azadirachtin 10000 ppm (1%EC) (20ml/ 10 litre water) with the initiation of sucking pest/aphid and subsequent spray with *Lecanicillium lecanii* NBAIR Vl-8 ($2x10^8$cfu/g) 1% WP (50g/ 10 litre water) at ten days interval.
T_2	Chemical module/ Farmers' practice		-
	Methodology &observations recorded		Cabbage crop was raised by adopting standard agronomical practices. Total 10 quadrates were made in each treatment. Each quadrate served as one repetition. Observations on male moth catches of *Plutella xylostella* in pheromone trap was recorded at weekly interval from the installation of pheromone trap. The observations on larval population/plant of lepidopteran pest were recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest. The observations on aphid population/plantwas recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest. Fruit damage (%) - The observations on fruit damage on number basis was recorded from each treatment at each picking.

		Natural enemies – Per cent parasitization by *Diaeretiella* sp. and other natural enemies *viz.*, coccinellid and syrphid fly was recorded from each treatment at 15 days interval. Yield (healthy marketable cabbage heads) t/ha The data was statistically analysed using suitable transformation.

Table 264. Efficacy of different modules on pest incidence, fruit damage and yield of cabbage

Modules	Larvae of DBM/ Plant	Aphids/ plant	Fruit damage (%)	No. of coccinellids/ Plant	Yield (t/ha)
BIPM Module	3.08	21.94	4.25	3.41	25.01
Chemical Module	2.83	18.92	3.00	0.82	28.00
‘t’value	0.69	0.86	2.76*	6.90*	6.09*
Table $t_{0.05}$	1.58	2.78	2.37	2.78	2.26

Note: * Significant at $t_{0.0.5}$

Results:

The data of the efficacy of BIPM module in reducing the pest population in comparison to chemical module is presented in the Table 264. Although, the chemical module documented the lowest population of DBM (2.83/ plant) and aphid (18.92/ plant), it was found statistically at par with the pest population recorded in BIPM module (DBM – 3.08/plant, aphid – 21.94/ plant). Further, BIPM module recorded the significantly higher fruit damage (4.25%) as compared to chemical module (3.00%). Due to significant low fruit damage in chemical module, it recorded the highest yield (28 t/ha) which was significantly higher than the yield of BIPM module (25.01 t/ha). With respect to the population of natural enemies, BIPM module witnessed highest coccinellids (3.41/ plant) which were significantly higher than the population observed in chemical module (0.82/plant) and in both the modules, the parasite *Diaeretiella* sp. was not observed during the demonstration period.

26. Biological Control of Chilli Pests

26.1 Management of thrips, aphids and whitefly on chilli by oil based formulation of *Metarhizium anisopliae* (IIHR Strain)

26.1.1IIHR

Design: RBD, Replication: 4, Plants/replication: 10 plants/replication Variety:Arka Meghana

Results:

The results reveal that there was no significant reduction in the thrips population among the different doses of *M. anisopliae* after 3 sprays. Significant reduction of thrips was observed in standard check.

Table 265. Effect of oil based formulation of *Metarhizium anisopliae* (IIHR Strain) thrips, aphids and whitefly population on Chilli

Treatments		Mean no. of Adult thrips/plant			
		Before spray	After I spray	After II spray	After III spray
T1	*M. anisopliae* (oil based formulation) @ 0.25ml /l	27.27 (5.26)	17.3 (4.15)	18.35 (4.33)	17.13 (4.18)
T2	*M. anisopliae* (oil based formulation) @ 0.5ml/l	24.31 (4.97)	19.3 (4.39)	19.3 (4.44)	19.3 (4.44)
T3	*M. anisopliae* (oil based formulation) @ 1ml/l	21.4 (4.67)	19.7 (4.47)	19.7 (4.49)	19.7 (4.49)
T4	Standard check – Imidacloprid @ 0.3ml/l	23.39 (4.87)	12.8 (3.59)	13.26 (3.70)	14.19 (3.83)
T5	Unsprayed (control)	24.22 (4.95)	19.4 (4.43)	19.43 (4.46)	19.43 (4.46)
	CD at 0.05 level	NS	0.22	0.22	0.24

Figures in the parenthesis are Sqrt (X+0.5) transformed values

26.2 Screening of promising isolates of entomopathogenic fungi for management of mites in chilli

26.2.1 RARS, Kumarakom

Table 266.

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

Table 267. Efficacy of isolates of entomopathogenic fungi for management of mites in chillies (RARS, Kumarakom, 2020-2021)

Treatments	Mean number of mites*																	
	First spray						Second spray						Third spray					
	Pre count	1st day	3rd day	5th day	7th day	9th day	Pre count	1st day	3rd day	5th day	7th day	9th day	Pre count	1st day	3rd day	5th day	7th day	9th day
T1	8.00 (3.11)	7.46 (3.25)	7.21 (3.00)	9.41 (3.08)	7.67 (3.17)	8.44 (3.27)	9.65 (3.26)	9.62 (3.25)	8.96 (3.15)	8.02 (2.99)	10.60 (3.36)	8.64 (3.08)	8.00 (2.99)	7.46 (2.89)	7.21 (2.85)	9.41 (3.19)	7.67 (2.89)	8.44 (3.05)
T2	8.54 (2.78)	7.48 (3.06)	7.00 (2.94)	6.48 (3.49)	8.35 (3.14)	7.71 (3.30)	8.52 (3.08)	7.62 (2.92)	7.79 (2.96)	6.69 (2.76)	10.14 (3.30)	8.23 (3.01)	8.54 (3.07)	7.48 (2.91)	7.00 (2.81)	6.48 (2.70)	8.35 (3.03)	7.71 (2.95)
T3	8.29 (3.10)	9.41 (3.10)	6.46 (2.55)	10.69 (3.05)	7.04 (3.19)	8.44 (3.27)	10.69 (3.41)	9.94 (3.29)	9.48 (3.23)	8.87 (3.13)	9.94 (3.30)	8.90 (3.14)	8.29 (3.02)	9.41 (3.16)	6.46 (2.71)	10.69 (3.40)	7.04 (2.80)	8.44 (3.06)
T4	9.14 (3.09)	7.73 (3.20)	8.06 (2.67)	7.10 (3.03)	7.33 (3.23)	7.69 (3.25)	8.56 (3.03)	8.62 (3.07)	8.00 (2.99)	10.58 (3.39)	10.60 (3.39)	9.26 (3.15)	9.14 (3.17)	7.73 (2.94)	8.06 (2.97)	7.10 (2.78)	7.33 (2.83)	7.69 (2.94)
T5	6.54 (3.22)	1.02 (2.94)	0.00 (1.14)	0.14 (1.00)	0.00 (1.15)	0.00 (1.16)	7.96 (2.98)	1.69 (1.62)	0.12 (1.06)	0.00 (1.00)	0.02(1.01)	0.02 (1.01)	6.54 (2.74)	1.02(1.31)	0.00 (1.00)	0.14 (1.06)	0.00 (1.00)	0.00 (1.00)
T6	8.52 (2.93)	9.81 (3.17)	8.52 (3.18)	12.46 (3.19)	9.12 (3.14)	10.48 (3.07)	9.38 (3.22)	8.79 (3.12)	10.96 (3.44)	10.81 (3.41)	12.06 (3.58)	13.44 (3.76)	8.52 (3.04)	9.81 (3.25)	8.52 (3.08)	12.46 (3.66)	9.12 (3.17)	10.48 (3.38)
CD (0.05)	NS	NS	0.59	0.52	0.63	0.60	NS	0.56	0.39	0.52	0.70	0.67	NS	0.78	0.56	0.61	0.74	0.43
CV	8.66	10.10	14.99	12.10	14.68	13.75	10.71	12.79	9.04	12.40	15.43	15.39	11.74	18.61	14.31	14.25	18.65	10.30

Values in parantheses are square root transformed.T1: *Beauveria bassiana* Bb – 5a;T2: *Metarhizium anisopliae* Ma – 4;T3: *Metarhizium anisopliae* Ma – 6;T4: *Lecanicillium lecanii* Vl– 8;(Population of fungal agents is 1×10^{8} cfu/ml) T5: Spiromesifen 22.9 SC @ 96 g ai ha^{-1};T6: Untreated control

Population of chilli yellow mite, *Polyphagotarsonemus latus*, was recorded from upper, middle and lower leaf of four plants each, selected from each of the plot. Mean population of mites per replication was recorded then, for all the six treatments. Three foliar sprays were carried out and infestation was recorded @ 1st, 3rd, 5th, 7th and 9th day after each spray (DAS) and expressed as mean number of mites per treatment Table 267. The treatment with Spiromesifen 240 SC was noticed with better performance in controlling mite in all sprays. This could cause significant reduction in pest population after each of the three sprays.

Among the bioagents, treatment with Ma – 6 isolate of *Metarhizium anisopliae* was observed to cause significant reduction in mite infestation (36.39%) at 3rd day after first spray. However, after the second spray, both Ma – 4 isolate of *M. anisopliae* and VI – 8 isolate of *Lecanicillium lecanii* showed significant reduction in mite infestation at 3rd day after spray where they produced per cent reduction of 28.92 and 27.03, respectively over control. Both the treatments were found to be on par with each other. Ma – 4 isolate of *M. anisopliae* was also observed to produce significant reduction in pest population after the chemical check at 5th (38.15%) and 9th (38.81%) days after spray as well, where the chemical check brought 100% and 99.85% reduction respectively over control.

As far as the third spray is considered, observations proved that Ma – 4 isolate of *M. anisopliae*and VI – 8 isolate of *L. lecanii* were able to produce significant reduction in mite attack on both 5th and 9th days after spray, where both these treatments were found on par. As against the chemical check which was noticed with 98.84 % reduction, Ma – 4 isolate of *M. anisopliae* resulted in 48.01% and VI – 8 isolate of *L. lecanii* caused 43% reduction in mite infestation at 5th DAS. However, on 9th DAS, 26.41% and 26.63% reduction over control was noted with respect to Ma – 4 isolate of *M. anisopliae* and VI – 8 isolate of *L. lecanii* respectively. These two bioagents were found to be the best after the chemical check, which was noticed with the highest per cent reduction in pest attack after each of the spray.

27. Biological Control of Cucumber Pests

27.1 Evaluation of BIPM against fruit flies *Deccaus bactrocera* sp. against cucumber

27.1.1 AAU, Jorhat

<u>Experimental details:</u>

Location:Experimentalfarm, Dept.of Horticulture

Season: *Kharif*,2020

Date of sowing: 18.07.2020

Variety: Siara 934-F1

Treatments: 3 (BIPM, Conventional and farmer practice)

Experimental design: 4RBD

Plot size: 400m^2

Treatments:3(BIPM, conventional and farmer practices)

BIPM practices

Good agricultural practices (racking, weeding)

Installation of cuelure @ 15/ha for monitoring

Destruction of damaged fruits
Spray of neem based insecticides (NSKE 5%@5ml/lit)
Spray of spinosad 45 SC@ 0.3ml/lit
Conventional practices (Chemical Control)
Jaggary1%+malathion 50 EC@2mlper litre of water
Untreated control practice

Observations: For pre and post treatment observation 10 plants were randomly selected from each plotsto assess the percent damaged fruits after imposing the treatment sat35, 45and 55 days after sowing. Spray schedule was made on the basis of flowering of the plant as well as fruit flies trapped in pheromone lure. Average number of fruit flies trapped during the cropping season was 57.43. The marketable fruit at each harvest was pooled together to get the average yield.

Results: It was observed from the table 269 that the BIPM package revealed minimum per cent damaged fruits (16.36%) which was significantly different from chemical control where the per cent damaged fruit was 28.37 after 65 Days after treatment (DAT). The marketable fruit yield was also significantly different in case of BIPM package with that of conventional practices where 86.89 q/ha yield was recorded in BIPM package as against 59.00 q/ha in conventional package. The maximum damaged fruits (35.46%) caused by *Deccaus bactrocera* was recorded in untreated control plot with minimum yield of 44.82 q/ha.

Table 269. Incidence of fruit fly on cucumber

Treatments	Post treatment count (% damaged fruit/10 plants)*			
	35 DAS	45 DAS	65 DAS	Yield (Q/ha)
BIPM practices	24.18 (11.42)	18.68 [a] (10.06)	16.36 [a] (9.42)	86.89 [a]
Conventionalpractices	25.42 (11.74)	28.54 [b] (12.43)	28.37 [b] (12.39)	59.00 [b]
Untreatedcontrol	28.50 (12.45)	31.39 [c] (13.06)	35.46 [c] (13.86)	44.82 [c]
CV %	13.13	13.62	19.29	3.17
CD (=0.05)	NS	4.15	6.00	2.35

*Mean of 10 plants with 3 observations.
Data in parenthesis de notes square root
Means followed by the same letter in a column are not significantly different


Plate 3: View of Experimental plot of Cucumber

Fig:75.

28. Biological Control of Capsicum Pests

28.1 Evaluation of entompthogenic fungi, *Beauveria bassiana* (NBAIR-Bb-5a) and *Lecanicillium leccani* (NBAIR-VL 15) against sucking insect pests of capsicum in open field condition (UAS Raichur)

28.1.1 UAS, Raichur

Table 270.

Treatments Details	
T_1	*Beauveria bassiana* (ICAR- NBAIR-Bb-5a) @ 1×10^8 @ 5 gm/l
T_2	*Lecanicillium leccani* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-8) @ 5.0 g/l
T_3	*Lecanicillium leccani* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l
T_4	*Metarhizium* anisopliae @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-Ma 4) @ 5.0 g/l
T_5	*Isaria fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l
T_6	Azadirachtin 1500ppm @ 2 ml/lit
T_7	Untreated control

In each treatment five plants were randomly selected and from each plant top, middle and bottom leaves were observed to record the number of thrips and mite population and later expressed as number per leaf at a day before spray, seven and ten days after each spray and subjected for square root transformation and analyzed statistically. At each picking (Total 10 pickings) total fruit yield was recorded in each treatment converted to quintals per hectare.

Results: A day before spray the trips population ranged from 5.62 to 6.38 per leaf and it was statistically non- significant. Among the biocontrol agents lowest thrips population of 2.62 per leaf was noticed in *L. leccani* @ 1×108 @ 5 gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l which recorded 3.04 thrips per leaf while untreated control recorded 6.26 thrips per leaf and similar trend was noticed on ten days after spray. Highest per cent reduction of thrips population over control was noticed in *L. leccani* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l (64.72%) and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l (60.16%). Similarly, mite population ranged from 9.86 to 10.56 per leaf at a day before spray. On seven days after spray, lowest mite population of 5.36 per leaf was noticed in *L. leccani* @ 1×108 @ 5 gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l which recorded 5.68 mites per leaf while untreated control recorded 10.26 mites per leaf and similar trend was noticed on ten days after spray. Among the biocontrol agents per cent reduction of mite population over control was highest in *L. leccani* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l (63.17 %) and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l (61.29%). Highest fruit yield of 24.56 q/ha was noticed in *L. leccani* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l which recorded 24.18 q/ha while untreated control recorded lowest fruit yield of 16.36 q/ha (Table 271).

Fig:76.

Table 271. Evaluation of entompthogenic fungi, *Beauveria bassiana* (NBAIR-Bb-5a) and *Lecanicillium leccani* (NBAIR-VL 15) against sucking insect pests of capsicum in open field condition during 2020-21

Sl. No.	Treatment Details	Dosage (g/l)	No. of thrips/leaf				No. of mites/leaf				Fruit yield (t/ha)
			IDBS	7 DAS	10 DAS	ROC (%)	IDBS	7 DAS	10 DAS	ROC (%)	
T_1	*Beauveria bassiana* (ICAR- NBAIR-Bb-5a)	$1×10^8$ @ 5gm/l	6.38 (2.62)	3.54 (2.01)	2.78 (1.81)	48.62 (44.21)	10.56 (3.33)	7.18 (2.77)	3.56 (2.01)	46.83 (43.18)	21.84
T_2	*Lecanicillium leccani* (ICAR-NBAIR-VL-8)	$1×10^8$ @ 5gm/l	6.04 (2.56)	3.12 (1.90)	2.54 (1.74)	53.98 (47.28)	9.98 (3.24)	6.82 (2.71)	2.94 (1.85)	51.68 (45.96)	22.08
T_3	*Lecanicillium leccani* (ICAR-NBAIR-VL-15)	$1×10^8$ @ 5gm/l	5.88 (2.53)	2.62 (1.77)	1.72 (1.49)	64.72 (53.56)	10.14 (3.26)	5.36 (2.42)	2.08 (1.61)	63.17 (52.63)	24.56
T_4	*Metarhizium anisopliae* (ICAR-NBAIR-Ma 4)	$1×10^8$ @ 5gm/l	5.62 (2.47)	4.16 (2.16)	3.74 (2.06)	35.77 (36.73)	10.06 (3.25)	8.86 (3.06)	4.06 (2.14)	36.04 (36.89)	21.12
T_5	*Isaria fumosorosea* (ICAR-NBAIR strain)	$1×10^8$ @ 5gm/l	6.14 (2.58)	3.04 (1.88)	1.86 (1.54)	60.16 (50.86)	9.86 (3.22)	5.68 (2.49)	2.14 (1.62)	61.29 (51.52)	24.18
T_6	Azadirachtin 1500ppm	2 ml/lit	6.08 (2.57)	4.18 (2.16)	3.86 (2.09)	34.63 (36.05)	10.12 (3.26)	8.94 (3.07)	6.52 (2.65)	23.47 (28.97)	19.78
T_7	Untreated control	-	6.12 (2.57)	6.26 (2.60)	6.04 (2.56)	0.00 (0.00)	10.04 (3.25)	10.26 (3.28)	9.94 (3.23)	0.00 (0.00)	16.36
S Em$\pm$			0.36	0.07	0.05	-	0.41	0.08	0.04	-	0.43
CD (P=0.05)			NS	0.21	0.16	-	NS	0.24	0.12	-	1.29

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

29. Biological Control of Amaranthus Pests

29.1 Efficacy of capsule formulations of *Beauveria bassiana* for the management of amaranthus leaf webber, *Hymenia recurvalis*

29.1.1 KAU,vellayani

The experiment is ongoing, since March 2021 at Palappuru village in an area of 10 cents; Vaiga (KAU) amaranthus variety is used in this study. The experimental plots were laid out in a RBD with seven treatments and each treatment was replicated three times. Each plot size is 5 × 5 m^2. The treatments were as follows; T1- Capsule formulation of *B. bassiana* KAU isolate, T2-Capsule formulation of *B. bassiana* NBAIR isolate (Bb5), T3- Talc formulation of *B.bassiana* (NBAIR isolate) , T4-Talc formulation of *B.bassiana* KAU isolate, T5 -Spore suspension of KAU isolate @10^8 spores mL^{-1}, T6 -Spore suspension of NBAIR isolate @10^8 spores $mL^{-1}$and T7 - Untreated check

Plate 12

Fig:77.

30. Biological Control of Bean Pests

30.1 Large scale demonstration of entomopathogenic fungi, *Metarhizium rileyi* (KK-*Nr-1*) against soybean defoliators in Bidar district.

30.1.1 UAS, Raichur

Demonstration was conducted in 50 ha area with three treatments viz., T1:*Metarhizium rileyi* (KK-Nr-1)1×108 spores/g @ 5.0 g/l, T2:Emamectin benzoate 5 SG @ 0.2 gm/lit and T3: Untreated control. Number of defoliator larvae per mrl - *Spodoptera* and Pod yield were recorded. Results showed that a day before treatment imposition the defoliator larval population ranged from 5.06 to 5.18 per meter row length. On seven days after spray, *M. rileyi* (KK-*Nr-1*)1×10^8 spores/g @ 5.0 g/l recorded 2.36 larvae per mrl and it was significant over untreated control (5.18 larvae/mrl). Similar trend was noticed at ten days after spray. *M. rileyi (*KK-*Nr-1)*1×10^8 spores/g @ 5.0 g/l recorded 11.34% foliage damage while untreated control recorded 28.36%. *M. rileyi*(KK-*Nr-1*)1×10^8 spores/g @ 5.0 g/l recorded 15.82 q/ha grain yield which was superior over untreated control which recorded 11.94 q/ha grain yield (Table 272).

Table 272. Large scale demonstration of entomopathogenic fungi, *Metarhizium rileyi* (KK-*Nr-1*) against soybean defoliators in Bidar district during 2020-21.

Sl. No.	Particulars	Defoliator larvae (No/mrl) *			Foliage damage (%) #	Grain Yield (q/ha)
		1 DBS	7 DAS	10 DAS		
T_1	*Metarhizium rileyi*(KK-*Nr-1*)1×10^8 spores/g @ 5.0 g/l	5.18 (2.38)	2.36 (1.69)	1.68 (1.48)	11.34 (19.68)	15.82
T_2	Emamectin benzoate 5 SG	5.14	1.38	1.06	6.56	18.16

	@ 0.2gm/lit	(2.37)	(1.37)	(1.25)	(14.84)	
T_3	Untreated control	5.06 (2.36)	5.18 (2.38)	4.84 (2.31)	28.36 (32.18)	11.94
S Em+		0.14	0.07	0.03	1.84	0.71
CD (P=0.05)		NS	0.22	0.10	5.53	2.13

*Figures in parentheses are square root transformed values

Fig:78.

#Figures in parentheses are arcsine transformed values

31. Biological Control of Cassava Pests

31.1 Survey for incidence of *Phenacoccus manihoti* the recent invasive mealybug on cassava

31.1.1 TNAU, Coimbatore

Host range of *P. manihoti* across agricultural and horticultural crops

Surveys were conducted to assess the mealybug damage in cassava fields in Erode, Namakkaland Salem Districts (Namagiripettai and Senthamangalam blocks (T.Jedarpalayam, Echampatti, Kalkurichi) of Namakkal district, Panamarathupatty block (vengampatty) of Salem district and Anthiyur block (Chinnamathur, Maathur and Aadhireddiyur) of Erode district on 27.05.2020).The mealybugs were identified as *Phenacoccus manihoti* Matile-Ferrero by Dr.Sunil Joshi of ICAR-NBAIR, Bengaluru. The population of the new species of mealybug decreased during June and July 2020 and it was not seen in cassava fields from August,2020. In Namakal district, about 30-40% of mealy bug damage was observed in fields of villages T.Jedarpalayam, Echampatty and Kalkurichi wherein all fields are under rainfed condition and with very less irrigation. In Salem district about 10-15% infection is observed in Panamarathupatty block of Salem district since the fields were partially irrigated. In Erode district, about 10 fields were inspected in Chinnamathur, Maathur and Aadhireddiyur villages of Anthiyur block. The fields were well irrigated and only 10-15% of damage was observed. The incidence of *Paracoccus marginatus* was observed in cassava from August 2020 to Marcch 2021 (Table 273).

Table 273. Roving survey - Incidence of mealy bug in cassava

Date of suvey	Village/District	GPS Coordinates	Age of the crop	*Paracoccus marginatus*	Natural enemies (per 5 leaflets)		
					Cryptoleamus sp	*Mallada sp*	*Acerophagus papayae*

				incidence (%)			
14.08.2020	Kunnathur/Tirupur	11.2327^0 N, 77.4929^0 E	7 months	5.0	1	-	2
14.08.2020	Alukuli/Erode	11.4481^0 N, 77.3584^0 E	6 months	4.0	2	-	4
02.09.2020	Guthiyalathur/Erode	11.6240^0 N, 77.3272^0 E	1 months	5.0	1	1	1
02.09.2020	Guthiyalathur/Erode	11.6310^0 N, 77.3231 ^{0}E	2 months	6.5	4	-	3
10.09.2020	Andarapatti/Namakkal	11.4079^0 N, 77.9440^0 E	3 months	5.0	1	2	4
10.09.2020	Oduvampalayam/Namakkal	11.3959^0 N, 77.940^0E	5 months	7.5	3	-	2
10.09.2020	Pudupalayam/Namakkal	11.4049^0 N, 77.9297^0 E	6 months	3.0	2	-	1
10.09.2020	Ocaklipatti/Namakkal	11.4127^0 N, 77.9072^0 E	6 months	5.0	-	1	2
10.09.2020	Ocaklipatti/Namakkal	11.4146^0 N, 77.8983^0 E	5 months	7.5	1	1	5
05.02.2021	Guthiyalathur/Erode	11.6240^0 N, 77.3272^0 E	8 months	4.0	2	1	4
05.02.2021	Erahanahalli/Erode	11.6236^0 N, 77.3280^0 E	10 months	10.0	1	-	5

05.02.2021	Iggalore/Erode	11.6231^0 N, 77.3286^0 E	6 months	5.0	1	1	-
05.02.2021	Akkaraithappalli/Erode	11.6243^0 N, 77.3270^0 E	9 months	7.5	3	1	3
10.02.2021	Kappalangarai/Erode	10.7713 N; 77.0918 E	6 months	12.5	1	-	1

32. Biological Control of Onion Pests

32.1 Efficacy of different biocontrol agents against onion thrips, *Thrips tabaci* L.

32.1.1 AAU, Anand

Objective: To evaluate the efficacy of different biocontrol agents against onion thrips, *Thrips tabaci* (L.)

Year of commencement	:	*Rabi*, 2020-21
Location	:	Agronomy farm, AAU, Anand
Scientists involved	:	PI – Dr. N.B. Patel Co-PI- Dr.Raghunandan, B.L.
Crop & variety	:	Onion , GJRO-11
Treatments	:	8
Replications	:	3
Design	:	Randomized block design (RBD)
Spacing	:	15 x 10 cm
Plot size	:	Gross – 1.5 x 2.0 m Net - 1.2 x 1.8 m

Methodology: **Table 274.**

Treatments		Concentration	Quantity required/ 10 litrewater
T_1	*Lecanicillium lecanii*NBAIR Vl8 – 1%WP	2x10^8 cfu/g	50 g
T_2	*Beauveria bassiana*AAU Bb1 - 1%WP	2x10^8 cfu/g	50 g
T_3	*Metarhizium anisopliae*AAU Ma1 - 1%WP	2x10^8 cfu/g	50 g
T_4	*Steinernema carpocapsae* NBAIR strain - 1%WP	20000 IJs/100 g	80 g
T_5	*Pseudomonas fluorescens* NBAIR *Pf*DwD-1%WP	2x10^8 cfu/g	50 g
T_6	Azadirachtin 10000 ppm	0.002 %	20 ml
T_7	Dimethoate 30 EC	0.03	10 ml
T_8	Untreated control	-	-

Onion crop was transplanted during second week of November and raised as per the normal agronomical practices.

First spray was carried out with the initiation of pest and subsequent two sprays were carried out at ten days interval.

For observations, five plants were randomly selected from net plot area and observations were recorded. Number of thrips per plant wasrecorded before treatment application and at 3rd, 7th and 10th day after each spray. The data was statistically analyzed using suitable transformation.

Observations recorded:

No. of thrips/ plant

Bulb yield - kg/plot

Table 275. Efficacy of different bio-pesticides against onion thrips and yield of onion

Treatments	No. of thrips/ plant														Yield (q/ha)
	Before Spray	1st Spray				2nd Spray				3rd Spray				Pooled over periods over sprays	
		3 DAS	7 DAS	10 DAS	Pooled	3 DAS	7 DAS	10 DAS	Pooled	3 DAS	7 DAS	10 DAS	Pooled		
T_1	3.82* (14.09)	3.24 (10.00)	3.19 (9.68)	3.14 (9.36)	3.19 (9.68)	3.08 (8.99)	3.01 (8.56)	2.89 (7.85)	2.99 (8.44)	2.83 (7.51)	2.76 (7.12)	2.65 (6.52)	2.75 (7.06)	2.98 (8.38)	87.33
T_2	3.62 (12.60)	3.18 (9.61)	3.12 (9.23)	3.07 (8.92)	3.13 (9.30)	3.02 (8.62)	2.97 (8.32)	2.86 (7.68)	2.95 (8.20)	2.80 (7.34)	2.74 (7.01)	2.61 (6.31)	2.72 (6.90)	2.93 (8.08)	92.67
T_3	3.70 (13.19)	2.54 (5.95)	2.40 (5.26)	2.18 (4.25)	2.38 (5.16)	2.11 (3.95)	2.02 (3.58)	1.94 (3.26)	2.02 (3.58)	1.86 (2.96)	1.74 (2.53)	1.64 (2.19)	1.75 (2.56)	2.05 (3.70)	113.67
T_4	3.80 (13.94)	3.53 (11.96)	3.48 (11.61)	3.43 (11.26)	3.48 (11.61)	3.38 (10.92)	3.32 (10.52)	3.28 (10.26)	3.33 (10.59)	3.34 (10.66)	3.28 (10.26)	3.23 (9.93)	3.28 (10.26)	3.36 (10.79)	71.33
T_5	3.67 (12.97)	3.58 (12.32)	3.53 (11.96)	3.48 (11.61)	3.53 (11.96)	3.43 (11.26)	3.38 (10.92)	3.34 (10.66)	3.38 (10.92)	3.39 (10.99)	3.34 (10.66)	3.29 (10.32)	3.34 (10.66)	3.42 (11.20)	69.00
T_6	3.93 (14.94)	2.96 (8.26)	2.85 (7.62)	2.60 (6.26)	2.80 (7.34)	2.40 (5.26)	2.33 (4.93)	2.16 (4.17)	2.30 (4.79)	2.06 (3.74)	1.88 (3.03)	1.85 (2.92)	1.93 (3.22)	2.34 (4.98)	108.33
T_7	3.61 (12.53)	1.76 (2.60)	1.68 (2.32)	1.46 (1.63)	1.63 (2.16)	1.34 (1.30)	1.05 (0.60)	0.88 (0.27)	1.09 (0.69)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.14 (0.80)	142.33
T_8	3.94 (15.02)	4.06 (15.98)	4.14 (16.64)	3.98 (15.34)	4.06 (15.98)	3.89 (14.63)	3.89 (14.63)	3.85 (14.32)	3.88 (14.55)	3.89 (14.63)	3.89 (14.63)	3.85 (14.32)	3.88 (14.55)	3.94 (15.02)	45.33
S. Em ± (T)	0.22	0.15	0.15	0.15	0.08	0.14	0.16	0.15	0.07	0.16	0.16	0.18	0.08	0.05	4.28
Period (P)	-	-	-	-	0.05	-	-	-	0.05	-	-	-	0.06	0.03	-

Spray (S)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-
T x P	-	-	-	-	0.15	-	-	-	0.15	-	-	-	0.17	0.09	-
T x S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-
S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-
T x S x P	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16	-
C.D. at 5 % T	NS	0.46	0.47	0.46	0.22	0.41	0.49	0.47	0.22	0.47	0.48	0.55	0.24	0.15	13.00
C. V. (%)	10.23	8.49	8.76	9.08	8.77	8.27	10.12	10.07	9.49	10.38	10.88	12.55	11.27	9.83	8.13

Note: * Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values: NS = Non –significant , DAS = Days After Spray; Significant parameters and its interactions – S, P and S x T

Results:

Thrips population after first spray was depicted in treatment T_3 – *Metarhizium anisopliae* AAU strain Ma1 recorded the lowest thrips population (5.16 thrips/ plant) which was followed by treatment T_6 – Azadirachtin10000 ppm (7.34 thrips/ plant). Thrips population after second spray indicated that the lowest population was recorded in treatment T_3 – *Metarhizium anisopliae* AAU strain Ma1 (3.58 thrips/plant) followed by T_6 – Azadirachtin10000 ppm (4.79 thrips/ plant). After third spray, significantly the lowest thrips population was recorded in T_3 – *Metarhizium anisopliae* AAU strain Ma1 (2.56 thrips/ plant) followed by T_6 – Azadirachtin10000 ppm (3.22 thrips/ plant) and these two treatments were found statistically at par in reducing the population of *T. tabaci*. (Table 275)

Thrips population pooled over periods over sprays depicted that among different biopesticides evaluated, T_3 – *Metarhizium anisopliae* AAU strain Ma1 (3.70 thrips/plant) was the first effective treatment with lowest number of thrips/plant followed by T_6 – Azadirachtin10000 ppm (4.98 thrips/ plant). The third effective treatment was T_2 – *Beauveria bassiana*AAU Bb1 (8.08 thrips/ plant). The treatment T_5 – *Pseudomonas fluorescens* NBAIR *Pf*DWD found least effective in reducing the thrips population. The untreated control treatment recorded the highest thrips population of 15.02 thrips/ plant.

The efficacy of biopesticide treatments in reducing the thrips population was depicted in bulb yield of onion. Among the different biopesticides evaluated, T_3 – *Metarhizium anisopliae* AAU strain Ma1was found promising in getting higher bulb yield (113.67 q/ha), followed by T_6 – Azadirachtin10000 ppm (108.33 q/ha) which were at par with each other. The treatment T_2 – *Beauveria bassiana*AAU Bb1 was found next best biopesticide in assuring the high bulb yield (92.67 q/ha). In the untreated control treatment, the lowest bulb yield of 45.33 q/ha was recorded.

33. Biological control of Polyhouse pests

33.1 Management of spider mite in cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition

33.1.1 KAU, Thrissur

An experiment was laid out during February 2021 for the management of sucking pests in cucumber using the anthocorid predator, *Blaptostethus pallescens* under polyhouse conditions.

Design: CRD Variety: KPCH 1

Plot size: 2×2 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 a soilless medium, comprising of coir pith and vermicompost at a spacing of 2.2×0.4 m. Cucumber plants were trailed vertically on floriculture nets. Fertilizers were applied at the rate of 150: 45: 220 kg NPK, 100 kg Ca and 40 kg Mg per ha in seven split doses at three days interval from seedling to flowering stage of the crop. No lateral branches were allowed up to a height of 1m. The 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 the reproductive stage of the crop. Harvesting of fruits was done twice a week.

Mixed stages of *Tetranychus truncatus* were released by stapling mulberry leaf discs containing mites onto the undersurface of lower leaves of cucumber plants twenty days after transplantation and were allowed to establish. Plots receiving different treatmentswere separated from each other by using garden nets to prevent the movement of predator from one treatment to another.

Treatments were applied after the establishment of spider mites on cucumber plants. Mite population was recorded before as well as 3, 6 and 9 days after treatment application. 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. A number of mites per cm^2 leaf area was recorded *in situ* from three loci/leaf. The observed results are presented in Table 276.

Fig:78.

Plate 1.View of experiment on management of spider mites in cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse conditions

Table 276. Field efficacy of *Blaptostethus pallescens* against *Tetranychus truncatus* on cucumber

Treatments	Number of mites per cm^2				Mean yield (kg)
	Precount	3 DAR*	6 DAR	9 DAR	
B. pallescens @ 10/m row	6.55 (2.54)	6.72 $(2.57)^b$	13.35 $(3.62)^a$	6.37 $(2.41)^b$	15.10^b
B. pallescens @ 20/m row	6.03 (2.44)	2.84 $(1.67)^c$	3.01 $(1.71)^c$	2.42 $(1.55)^c$	17.60^{ab}

Spiromesifen @ 100g.ai ha^{-1}	7.85 (2.77)	0.71 (0.78)[d]	0.64 (0.77)[d]	0.49 (0.69)[d]	22.01[a]
Untreated control	7.98 (2.79)	17.69 (4.16)[a]	9.88 (3.11)[b]	11.13 (3.23)[a]	15.94[b]
CD (0.05)	NS	0.526	0.506	0.737	4.529

*DAR – Days after release

Three days after the first release, the lowest number of 0.71 mites/ cm^2 was recorded in plots treated with spiromesifen at the rate of 100g.ai ha^{-1}, followed by plots that received bugs at the rate of 20/m row, with mite counts of 2.84/ cm^2. Plots in which bugs were released at the rate of 10/m row had 6.37 mites/ cm^2. All the above treatments were significantly superior to untreated control (17.69 mites/cm^2). A similar trend was observed six days after treatment as well, with the lowest incidence of 0.64 mites/ cm^2 in plots treated with spiromesifen. Plots in which *B. pallescens* were released @ 20/m row had 3.01 mites/ cm^2. Both the above treatments were significantly superior to *B. pallescens* released @ 10/ m row, which recorded 13.35 mites/ cm^2 and untreated control (9.88 mites/m^2).

Nine days after the first release, plots treated with the acaricide recorded 0.49 mites/ cm^2, followed by plots treated with *B. pallescens* @ 20m/row (2.42 mites/m^2). Mite population, at 11.13 mites/ cm^2 was the highest in control plots, while plots in which the bugs were released @ 10/ m row had 6.37 mites/ cm^2. All the treatments were significantly different from each other.

Among the treatments evaluated, spiromesifen at the rate of 100 g a.i ha^{-1} was the most effective treatment, with a reduction in the mean mite population from 7.85/ cm^2 to 0.49/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 also significantly lower than that of control plots, indicating the potential of the predator to be a safer alternative to synthetic acaricides in managing spider mites in cucumber under polyhouse conditions.

The difference was also observed in terms of yield (Table 276, Fig.79). Acaricide treated plots recorded a mean yield of 22.01 kg/plot, which was on par plots with that of *B. pallescens* @ 20 m/row (17.6 kg/plot). Untreated plots and *B. pallescens* @ 10m/row recorded lower yield of 15.94 and 15.10 kg/plot respectively. The yield results confirm the potential of anthocorid predator in polyhouse conditions.

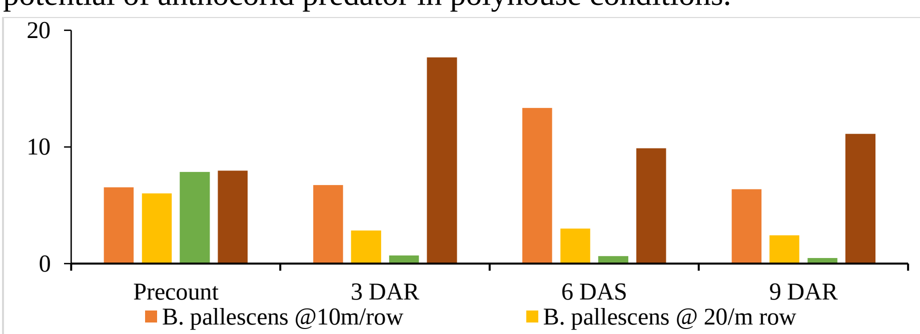


Fig:79. Field efficacy of *Blaptostethus pallescens* against *Tetranychus truncatus* on cucumber

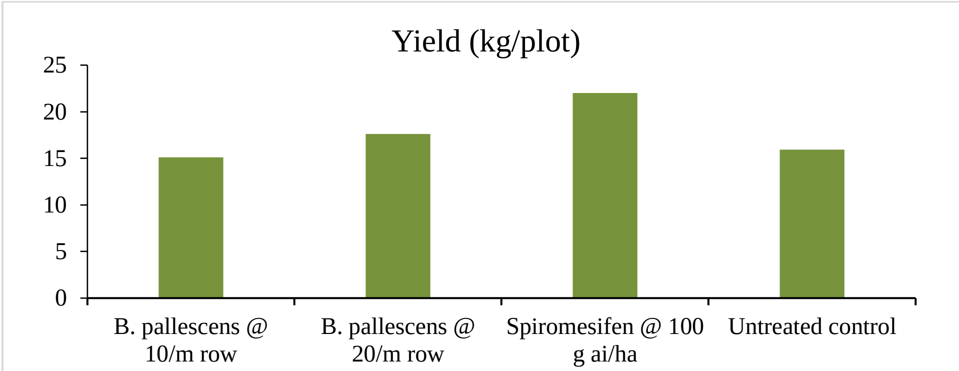


Fig:80. Comparison between different treatments in terms of yield

33.2 Management of sucking pests in tomato under polyhouse condition

33.2.1 PAU, Ludhiana

The tomato seedlings (variety MAHI) were transplanted under protected conditions following agronomic practices recommended by the PAU, Ludhiana on December 17, 2020. The crop was transplanted on raised beds with the plant to row spacing 30 × 90 cm (Plate2). The crop is being monitored for the incidence of sucking pests (aphids and whitefly). To date, a very low population of aphids as well as whiteflies has been recorded. The experiment is in progress and the report will be submitted after the completion of the experiment.

Fig:81.

Plate 2. Tomato seedlings transplanted under protected conditions

33.3 Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse

33.3.1 IIHR, Bengaluru

Variety: Arka Mohini

No. of treatments: 9; No. of replications: Three

Design: RBD

Resutls:The results reveal that there was a significant reduction in the aphid population, all the entomopathogenictreatments were showing a lower mean number of aphids per plant compared to control. But there was no significant difference observedamong 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 277).

Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse **Table 277.**

Sl. No.	Treatments	Mean number of thrips (nymphs & adults)per plant				
		Before spray	After I spray	After II spray	After III spray	Pooled
T1	*Metarhizium anisopliae* (NBAIRMa4) @g/L	110.50 (10.51)	75.86 (8.73)	75.00 (8.68)	70.00 (8.39)	73.62 (8.60)
T2	*Metarhizium anisopliae* IIHR oil @ 1ml/L	120.00 (11.00)	70.49 (8.42)	71.00 (8.45)	68.00 (8.27)	69.83 (8.38)
T3	*Lecanicilium lecanii* (NBAIR Vl8) @ 5g/L	101.00 (10.07)	68.00 (8.27)	66.66 (8.19)	60.00 (7.77)	64.88 (8.08)
T4	*Beauveria bassiana* (NBAIR Bb5a) @ 5g/L	95.67 (9.80)	59.00 (7.71)	57.00 (7.58)	56.00 (7.51)	57.33 (7.60)
T5	*Chrysoperla zastrowii*	120.00 (10.97)	100.00 (10.02)	122.00 (11.06)	120.00 (11.45)	114.00 (10.70)
T6	*Blaptostethus pallescens*	102.00 (10.12)	88.89 (9.45)	88.56 (9.43)	85.00 (9.24)	87.48 (9.37)
T7	Azadirachtin @ 2ml/L	100.50 (10.04)	56.00 (8.15)	57.00 (7.58)	50.65 (7.61)	54.55 (7.41)
T8	Fipronil @1ml/L	102.00 (10.12)	21.60 (4.70)	19.00 (4.41)	15.00 (3.93)	18.53 (4.36)
T9	Control	112.40 (10.62)	142.00 (3.53)	133.00 (11.55)	120.00 (10.97)	131.66 (11.49)
	CD at 0.05%	NS	5.00	5.20	5.14	5.10

Figures in paranthesis are Sqrt (x+0.5) transformed values

33.4 Management of phytophagous mites on cucumber using *Blaptostethus pallescens* and *Neoseiulus longispinosus* under polyhouse

YSPUHF, Solan

An experiment on the management of phytophagous mite, *Tetranychus urticae*s on cucumber by using *Blaptostethus pallescens* and *Neoseiulus longispinosus* was carried out at the experimental farm of the Department of Entomology, YSP University of Horticulture and Forestry Nauni, Solan (HP) under polyhouse conditions in an RBD with 5 replications. *Blaptostethus pallescens* was released at the rate of10 and 20 nymphs per meter row and *N. longispinosus* at 1:30 and 1:20 predator: prey ratio twice at 15 days interval. A chemical control (spiromesifen, 100g a.i./ha) and untreated control were also maintained for comparison. Observations on the number of mites per cm^2 leaf were recorded before and 7 and 14 days after each treatment. Yield data from each plant were recorded at each picking and were pooled to get the total yield.

Results: The results of the experiment reveal that the mite population before treatment varied from 2.5 to 2.8 mite/ cm^2 with no significant differences (Table 278). The mite population in treated plots decreased gradually and was 1.7, 1.4, 1.6, 1.1 and 0.6 mites in plants treated with *B. pallescens* (10nymphs/m row), *B. pallescens* (20nymphs/m row), *N. longispinosus* (1:30), *N. longispinosus* (1:20) and spiromesifen (100g a.i./ha), respectively, after 14 days of the second treatment. In control plants, the mite population increased from 2.6 mites/ cm^2 in the beginning to 9.8 mites/ cm^2 in the end. After 14 days of the second treatment, spiromesifen (100g a.i./ha) was the most effective followed by on par efficacy of *N. longispinosus* (1:20). Other treatments were, although not on par with the chemical treatment, but were on par with *N. longispinosus* (1:20). The yield was significantly higher in all the treatments when compared with untreated control. The highest yield (6.3kg/plant) was recorded in plants treated with spiromesifen (100g a.i./ha) followed by *N. longispinosus* (1:20), *N. longispinosus* (1:30), *B. pallescens* (20nymphs/m row) and *B. pallescens* (10nymphs/m row).

Table 278. Evaluation of *Blaptostethus pallescens* and *Neoseiulus longispinosus* against *T. urticae*in cucumber

Sl. No.	Treatment	Mite count (per cm^2) days after treatment					Yield (kg/plant)
		Pre-count	I- treatment		II- treatment		
			7	14	7	14	
1	*Blastostethus pallescens* (10 nymphs/m row)	2.8	2.7b	2.3b	2.1c	1.7b	3.9c
2	*Blastostethus pallescens* (20 nymphs/m row)	2.7	2.5b	2.2b	1.8bc	1.4b	4.3c
3	*Neoseiulus longispinosus* (1:30 predator: prey)	2.5	2.3b	2.1b	1.9bc	1.6b	4.8bc
4	*Neoseiulus longispinosus* (1:20 predator: prey)	2.6	2.1b	1.7b	1.3b	1.1ab	5.2b
5	Spiromesifen 45SC (100g.a.i ha^{-1})	2.8	0.2a	0.4a	0.3a	0.6a	6.3a
6	Control	2.6	3.8c	5.6c	7.4c	9.8c	1.8d
	CD (p=0.05)	NS	0.9	0.8	0.7	0.6	1.1

33.5 Field evaluation of anthocorid bug, *Blaptostethus pallescens* against spider mite, *Tetranychus urticae* infesting carnation in Kashmir

SKUAST, Srinagar

Due to the failure of maintaining a culture of *B. pallescens* in view of pandemic covid-19, some commercial biopesticides were evaluated against two spotted spider mite, *Tetranychus urticae* infesting carnation in polyhouse of University campus. The allotted experiment shall however be done during 2021.

Field efficacy of some biopesticides against two spotted spider mite, *Tetranychus urticae* in carnation

The present investigation was conducted in the poly house of Division of Floriculture and Landscaping Architecture, FoH, SKUAST-K, Shalimar during 2020. The incidence of two spotted spider mite, *Tetranychus urticae* infesting Red king of carnation on leaves as well as flowers were recorded in an area of 65 m^2 from 3rd week of May till August, on weekly basis during 2020. Data were recorded from randomly selected 10 plants. The incidence of two spotted spider mite on leaves was recorded from five leaves/plant and 3 flowers/plant were examined. Bio-efficacy of biopesticide including azadirachtin (Nimbecidine 300 ppm@ 5.0 ml^{-1}) and entomopathogen (*Lecanicillium lecanii* 1×10^8 CFU ml^{-1}@ 5.0 ml^{-1}) was studied on the same variety of carnation during June when the population of mites tended to increase. The treated area consisted of a bed of 1×16 m divided into 15 plots. Each plot contained 38 plants. The treatments were provided by using a hand sprayer after taking the pre-treatment counts of mites and a subsequent second spray was given after 15 days. Data were recorded on 1 day before and 1, 3, 7, and 15 days after each spray.

Results: The average number of two-spotted spider mite both on leaves as well as flower buds showed a gradual rise from the 3rd week of May till ending June 2020, followed by a steep decline. The maximum occurrence of mites was observed as 44.52/leaf and 67.8/flower bud during the last week of June whereas the minimum number was recorded at the end of August as 3.32/ lead and 2.13/flower bud (Table 279). Difference in number of mites during observation period was found statistically significant both for leaf (F = 435.23; df = 56, 14; P <0.00.1) and flower (F = 412.21; df = 56, 14; P<0.00.1).Cumulative mean population of mites on leaves was found to be minimum (3.85/leaf) when treated with two sprays of propargite 57% EC @ 2.0 ml^{-1} followed by *L. lecanii*(1×10^8 CFU/ml) @ 5.0 m^{-1} + nimbecidine 0.03% @ 5 ml^{-1} > *L. lecanii*(1×10^8 CFU/ml) @ 5.0 ml^{-1} > nimbecidine 0.03% @ 5.0 ml^{-1} > untreated check (Fig. 3). All the treatments were superior over an untreated check and statistically significant (F= 172.75; df = 4, 16; P<0.001). Per cent reduction in number of mites per leaf over pre-treatment (F = 103.60; df = 3, 12; P<0.001) and over control (F= 50.87; df= 3, 12; P<0.001) was found statistically significant. Use of *L. lecanii*(1×10^8 CFU/ml) @ 5.0 ml^{-1}+ Nimbecidine 0.03% @ 5.0 ml^{-1} exhibited statistically non-significant difference with propargite 57% EC @ 2 ml^{-1} in terms of per cent reduction in number of mites over untreated control, hence showed its bioefficacy (Table 280).

An almost similar effect of treatments was also observed in the case of mites on flower buds (Table 281). The average population of mites declined on 1day and 3 days after application of treatments but increased thereafter after 7 and 15 days after application. At the end of experiment, lowest number of cumulative mean population of 11 mites/ flower bud was observed in case of treatment with propargite 57% EC @ 2.0 ml^{-1} which was followed by *L. lecanii*(1×10^8 CFU/ml) @ 5.0 ml^{-1} + nimbecidine 0.03% @ 5.0 ml^{-1} > *L. lecanii*(1×10^8 CFU/ml) @ 5.0 ml^{-1} >nimbecidine 0.03% @ 5.0 ml^{-1} > untreated check. The difference in mite's population in response to treatments was found statistically significant (F= 189.60; df = 4, 16; P= <0.00.1), and all the treatments were found superior over the untreated check. Percent reduction in mites' population over control was found maximum in case of propargite 57%EC @ 2.0 ml^{-1} and differed statistically from the treatment *L. lecanii*(1×10^8 CFU/ml) @ 5.0 ml^{-1} + nimbecidine 0.03% @ 5.0 ml^{-1}. Per cent reduction in mites' population over pre-treatment was found statistically identical in propargite 57% EC and *L.lecanii*+ nimbecidine 0.03%.

Table 279. Numbers of two spotted spider mite, *Tetranychus urticae* on leaf and flower bud of carnation in Srinagar, Kashmir during 2020-21

Period of observation	No. of mites/ leaf	No. of mites/ flower bud
14-20 May	15.2 (3.89)^f	29.4 (5.42)^g
21-27-May	25.32 (5.02)^h	38.6 (6.21)^h
28 May-3rd June	27.32 (5.22)^i	46.2 (6.79)^i
4- 10 June	31.0 (5.56)^j	52.4 (7.23)^j
11- 17 June	35.28 (5.93)^k	57.2 (7.56)^k
18-24 June	40.8 (6.38)^l	63.2 (7.94)^l
25-1st July	44.52 (6.66)^m	67.8 (8.23)
2- 8 July	39.28 (6.26)^l	44.13 (6.64)^i
9- 15 July	24.48 (4.94) ^{h}	37.2 (6.09)^h
16- 22 July	18.68 (4.31)^g	25.4 (5.03)^f
23- 29 July	13.2 (3.63)^e	18.6 (4.31)^e
30- 6 Aug	11.12 (3.33)^d	12.73 (3.55)^d
7- 13 Aug	6.6 (2.56)^c	9.53 (3.07)^c
14- 20 Aug	5.2 (2.27)^b	5.13 (2.22)^b
21- 27 Aug	3.32 (1.81)^a	2.13 (1.44)^a
C.D. (0.05)	0.17	0.32
CV (%)	58.28	61.39

Each observation is mean of 5 replications; figure in parentheses are $\sqrt{n}$; different superscripts in the column indicate the values statistically different.

Table 280. Effect of treatments on the population of two spotted spider mite, *Tetranychus urticae* on carnation leaves in Srinagar, Kashmir during 2020

Treatments	No. of mites after 1st spray					No. of mites after 2nd spray				Cumulative Mean population/ leaf	% Reduction over pretreatment	% Reduction over control
	1 DBS	1 DAS	3 DAS	7 DAS	15 DAS	1 DAS	3 DAS	7 DAS	15 DAS			
T1: *Lecanicillium lecanii*(1x10[8] CFU/ml) @ 5.0 ml[-l]	23.4 (4.81)[a]	11.0 (3.24)[ab]	7.0 (2.56)[ab]	9.6 (3.06)[c]	12.8 (3.56)[c]	5.4 (2.28)[ab]	3.2 (1.76)[b]	4.8 (2.16)[b]	9.2 (3.02)[b]	7.87 (2.78)[c]	66.46 (54.62)[b]	82.16 (65.28)[b]
T2: Nimbecidine 0.03% @ 5 ml[-l]	30.4 (5.51)[a]	22.0 (4.67)[b]	17.2 (4.13)[b]	20.2 (4.48)[c]	24.2 (4.90)[d]	16.2 (4.00)[b]	11.6 (3.39)[c]	15.8 (3.94)[c]	21.0 (4.57)[c]	18.52 (4.29)[d]	41.13 (39.87)[a]	58.73 (50.09)[a]
T3: T1+T2	24.8 (4.94)[a]	8.4 (2.89)[a]	4.2 (2.02)[a]	3.8 (1.94)[a]	7.0 (2.64)[a]	2.4 (1.54)[a]	1.0 (1.0)[a]	3.0 (1.72)[b]	5.0 (2.23)[a]	4.35 (2.08)[b]	82.45 (64.32)[c]	90.36 (71.94)[c]
T4: Propargite 57% EC @ 2 ml[-l] (Standard check)	32.6 (5.71)[a]	5.6 (2.35)[a]	2.4 (1.54)[a]	4.2 (2.02)[b]	8.6 (2.91)[a]	3.2 (1.76)[a]	1.2 (0.96)[a]	1.8 (1.29)[a]	3.8 (1.92)[a]	3.85 (1.94)[a]	88.44 (70.21)[d]	91.57 (73.19)[c]
T5: Control	25.8 (5.04)[a]	31.8 (5.62)[c]	35.2 (5.92)[c]	40.0 (6.31)[d]	46.0 (6.77)[e]	52.8 (7.25)[c]	60.2 (7.75)[d]	66.4 (8.14)[d]	71.4 (8.43)[d]	45.54 (6.73)[e]	-	--
CD (0.05)	0.73	0.61	0.63	0.54	0.48	0.53	0.49	0.51	0.44	0.45	4.00	4.58

Each observation represents mean of 5 replications; Figures in parentheses except last two columns which are asin transformations are √n; similar superscripts in a column indicate values statistically on par

Table 281. Effect of treatments on the population of two spotted spider mite, *Tetranychus urticae* on carnation flower bud after 2 sprays in Srinagar, Kashmir during 2020

Treatments	No. of mites after 1st spray					No. of mites after 2nd spray				Cumulative Mean population/ flower bud	% Reduction over pretreatment	% Reduction over control
	1DBS	1DAS	3DAS	7DAS	15DAS	1DAS	3DAS	7DAS	15DAS			
T1: *Lecanicillium lecanii*(1x10^8 CFU/ml) @ 5.0 ml^{-l}	56.4 (7.50)^{ab}	30.8 (5.54)^{ab}	22.2 (4.70)^c	28.6 (5.34)^c	35.0 (5.90)^c	20.0 (4.44)^c	11.4 (3.37)^c	15.0 (3.86)^c	23.0 (4.79)^c	23.25 (4.81)^c	58.77 (50.05)^b	60.27 (50.92)^b
T2: Nimbecidine 0.03% @ 5 ml^{-l}	60.2 (7.75)^b	39.2 (6.24)^b	29.8 (5.45)^d	39.4 (6.26)^c	50.6 (7.10)^d	29.6 (5.43)^d	21.4 (4.62)^d	29.2 (5.40)^d	41.4 (6.42)^d	35.07 (5.91)^d	41.41 (44.91)^a	39.42 (38.80)^a
T3: T1+T2	52.0 (7.20)^a	27.6 (5.23)^a	15.4 (3.90)^b	19.6 (4.41)^b	25.4 (5.03)^b	11.2 (3.33)^b	6.0 (2.42)^b	9.8 (3.12)^b	14.0 (3.73)^b	16.12 (4.00)^b	62.44 (64.32)^c	72.17 (58.22)^c
T4: Propargite 57% EC @ 2 ml^{-l} (Standard check)	59.0 (7.67)^{ab}	23.6 (4.84)^a	10.2 (3.15)^a	13.4 (3.60)^a	17.0 (4.08)^a	7.00 (2.60)^a	3.4 (1.75)^a	5.6 (2.27)^a	8.6 (2.88)^a	11.1 (3.29)^a	81.25 (64.50)^c	81.24 (64.46)^d
T5: Control	48.2 (6.93)^a	51.4 (7.16)^c	58.6 (7.65)^e	65.8 (8.11)^e	70.0 (8.36)^e	52.6 (7.24)^e	56.0 (7.47)^e	61.2 (7.81)^e	71.2 (8.42)^e	60.85 (7.79)^e	-	--
CD (0.05)	0.47	0.50	0.37	0.40	0.40	0.33	0.35	0.38	0.44	0.01	3.21	3.76

Each observation represents mean of 5 replications; Figures in parentheses except last two columns which are asin transformations are √n; similar superscripts in a column indicate values statistically on par

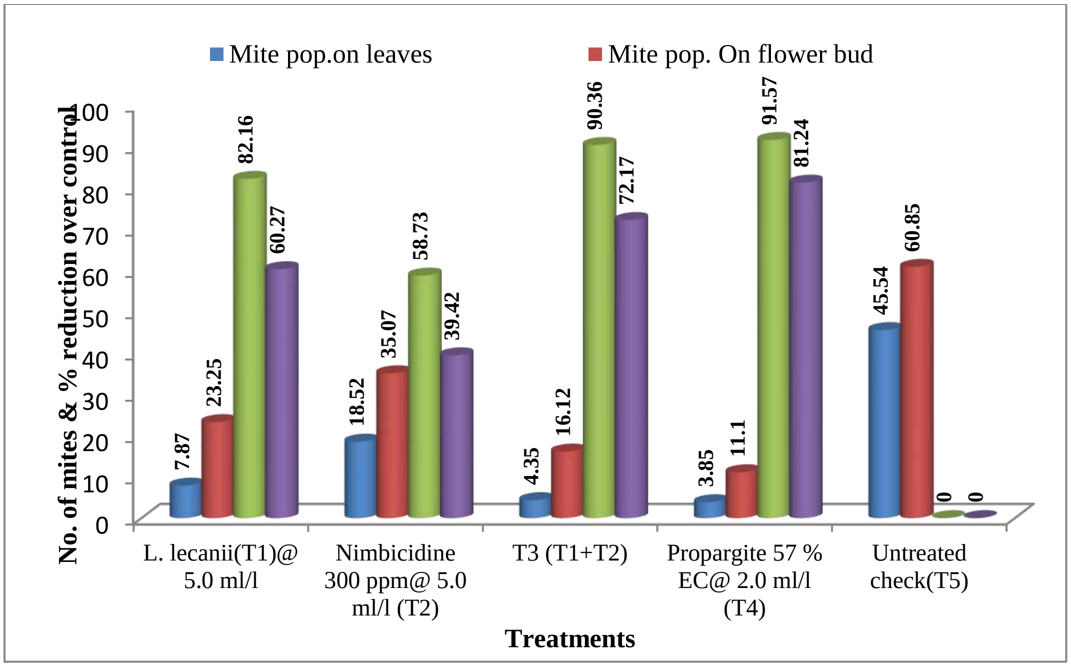


Fig:82. Effect of treatments on two spotted spider mites infesting leaves and flower buds of carnation in Kashmir during 2020

34. TRIBAL SUB PLAN

34.1 AAU, Jorhat Center

Name of the village:

Phase-I: A total of 200 farmers from four villages (Sekuria, Neulgaon, Dangdhora and Solguri) of Jorhat district have been selected under the programme due to BTAD election and Covid-19 pandemic. The programme was performed during September,2020.

Materials distributed to the TSP farmers **Table 282.**

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

Phase-II: A total of 50 nos. farmers from two villages (LahangKachari and Sekuria) of Jorhat district have been selected under the programme.

Materials distributed to the TSP farmers **Table 283.**

Sl. N.o.	Name of the item	Specification	Quantity
1	Falcon Kit	Falcon	50 Nos.
2	Rain Coat	Duckback	50 Nos.
3	Biopesticides	*Beauveria* (Biosona)	50kgs
4	Biopesticides	*Metarhizium* (Biometa)	50kgs

Phase-III: A total of 150 nos. farmers were benefited from these programmes.

Materials distributed to the TSP farmers **Table 284.**

Sl. N.o.	Name of the item	Specification	Quantity
1	Falcon Kit	Falcon	50 Nos.
2	Rain Coat	Duckback	50 Nos.
3	Back Peck sprayer	v-2007	75 Nos.
4	Neem oil	Best quality	75 litrs
5	Biopesticides	*Beauveria* (Biosona)	150kgs
6	Biopesticides	*Metarhizium* (Biometa)	150kgs

Glimpses of the TSP training programme

Table 285.

<table>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Training cum material distribution at Sekuria, Titabor, Jorhat on 23.09.2020</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Training cum material distribution at Neulgaon, Allengmora, Jorhat on 24.09.2021</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Training cum material distribution at Dangdhora, Jorhat on 04.10.2020</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Training cum material distribution at Solguri, Bampothar, Jorhat on 14.10.2020</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Training and material distribution at LahangKachari, Jorhat, on 19.02.2021</td></tr>
</table>

	
Training and material distribution at Chekuria, Dangdhora, Jorhat, on 20.02.2021	

34.2 ANGRAU, RARS

Biointensive pest management in paddy, maize, groundnut, rajmah, millets, turmeric and ginger Organic farming; Encouraging Bee keeping

Techniques adopted:

Technology transferred: Organic farming in paddy, ginger, turmeric and vegetables; Encouraging Bee keeping in Tribal areas

Villages covered: 4 hamlet villages Kollapu, Kothavalasa, Arakuvalley; Kothapalli, Chinthapalli, Visakhapatnam district, Andhra Pradesh.

Farmers benefitted: 52 tribal farmers of Arakuvalley and Chinthapalli divisions, Visakhapatnam district, Andhra Pradesh

Area covered: 40 acres

Frontline demonstrations:

Organic farming paddy, ginger, turmeric and vegetables in acres benefitting tribal farmers of hamlet villages of arakuvalley and Chinthapalli divisions, Visakhapatnam district, Andhra Pradesh.

Distribution of inputs :

Biocontrol agents, Trichocards-104 No.; Biopesticides: *Pseudomonas fluorescence*(52kg) ;*Trichoderma viridae* (52kg); Botanical pesticide :Neem oil (20 lts) ; Biofertilizers : Azospirillum, Phosphobacterria, potash releasing bacteria (each 52 no.of 1/2 lt)

Ecovibes- Araku Tribal Women Apiary unit :

10 Honey bee keeping boxes with Honey extractor given to 8 Tribal women farmers of Kothavalsa, Araku valley

Farmers training programmes:

TSP programme on Biointensive pest management in paddy, maize, groundnut, rajmah, millets, turmeric and ginger; Encouraging Bee keeping was done in Araku valley and chinthapalli division, Visakhapatnam district, Andhra Pradesh .

Conducted awareness programme on organic farming in vegetables at Kothapalli, Chinthpallimandal on10.12.2020; at Kollaput, Dumbrigudamandal on 17.12.2020.

Conducted Training programme on Bee keeping at Kollaput on 17.12.2020 at Kollaput, Dumbriguda and issued Apiary units (10 No.) to a group of women farmers and established Ecovibes Apiary unit for empowering Arakuvalley tribal women

Executive Summary :

During 2020-21, Conducted awareness programme on organic farming in vegetables at Kothapalli, Chinthpallimandal on10.12.2020; at Kollaput, Dumbrigudamandal ,araku valley on 17.12.2020. Conducted Training programme on Bee keeping at Kollaput on 17.12.2020 at Kollaput, Dumbriguda and established established Ecovibes Apiary unit for empowering Arakuvalley tribal women with Apiary units-10 No. and issued to a group of 8 women farmers. ICAR-Tribal sub plan programme created awreness on Biological control in organic cultivation by 52 tribal farmers of 4 hamlet villages in Araku valley and chinthapalli .

A Summary of Achievements :

Tribal farmers benefitted with the adoption of biocontrol in cultivation of rice, vegetables, turmeric, ginger and increased income with honey bee keeping apiary units

Fig:83.

34.3 AAU, Anand

AICRP demo trial 5: Biological interventions to enhance the crop production and productivity of tribal farmers of Narmada district in Gujarat

1. Selection of tribal farmers.

Tribal farmers (125 No.) were selected from Dediapada, Nandod and Garudeshwar tehsils of Narmada district. Area covered was ~1 acre/farmer.

2. KhedutShibir and training programmes

In association with Krishi Vigyan Kendra (KVK), Dediyapada, Navsari Agricultural University, khedutshibir and training programmes were organized in the month of September 2020 & March 2021 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*)*

Table 286.

Date: 29.09.2020 Kit components/ farmer (Total no. of farmers - 50)	Date: 09.03.2021 Kit components/ farmer (Total no. of farmers - 25)	Date: 16.03.2021 Kit components/ farmer (Total no. of farmers - 50)

Seeds (Indian bean & Bottle gourd) – 100g each Van-guard (Azadirachtin 10000 ppm) – 1 litre Pheromone trap (funnel type) – 5 Nos Lure (*Helicoverpa armigera*) – 10 No. Yellow sticky trap - 5 strips *Trichoderma harzianum* (ICAR-NBAIR strain Th-3) – 2 kg *Pseudomonas fluorescens* (ICAR-NBAIR strain PFDWD) – 2 litre *Bacillus thuringiensis* (ICAR-NBAIR strain *Bt*G4) – 2 litre Literature pertaining to biocontrol of crop pests and diseases	Knapsack sprayer PPE kit *Metarhizium anisopliae* (ICAR-NBAIR strain Ma-4) – 2 kg *Trichoderma harzianum* (ICAR-NBAIR strain Th-3) – 2 kg Literature pertaining to biocontrol of crop pests and diseases	Seeds (Vegetable cowpea and Bottle gourd) – 100g each PPE kit Pheromone trap (funnel type) – 5 Nos Lure (*Helicoverpa armigera*) – 10 No. Van-guard (Azadirachtin 10000 ppm) – 1 litre *Pseudomonas fluorescens* (ICAR-NBAIR strain PFDWD) – 2 litre *Bacillus thuringiensis* (ICAR-NBAIR strain *Bt*G4) – 2 litre Literature pertaining to biocontrol of crop pests and diseases

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 beneficiaries. Significant reduction (25-30%) in use of chemical pesticides was documented with the use of bio-inputs provided.

34.4 CAU, Imphal

Tribal Sub Plan (TSP) activities

One day awareness cum inputs distribution programmes to tribal farmers were carried out at different villages. The details are mentioned below.

Table 287.

Sl. No.	Date	Venue	No. of tribal farmers	Inputs distributed	Remarks
1	06th Feb 2021	Jampani, East Siang, Arunachal Pradesh	60	Talc based formulations of *Beauveria bassiana*, *Lecanicillium lecanii*, *Trichoderma harzianum* and *Pseudomonas fluorescence*, Pen and Writing pad (60 each)	Farmers from Sille village were also involved in the programme
2	08th March 2021	Ditchik, Nafracircle, West Kameng,	30	Talc based formulations of *Metarhizium anisopliae*, *Beauveria bassiana,* Pen and Writing pad (30 each)	For the first time the CAU-Pasighat centre has conducted TSP activities in West Kameng district

		Arunachal Pradesh			
3	09th March 2021	Nachibon, Nafra circle, West Kameng, Arunachal Pradesh	35	Talc based formulations of *Metarhizium anisopliae*, *Beauveria bassiana,* Pen and Writing pad (35 each)	-do-
4	10th March 2021	Lower Dzoung, Nafra circle, West Kameng, Arunachal Pradesh	25	Talc based formulations of *Metarhizium anisopliae*, *Beauveria bassiana,* Pen and Writing pad (25 each)	-do-
5	19th March 2021	Taki Lalung, East Siang, Arunachal Pradesh	30	Talc based formulations of *Bacillus thuringiensis*, *Metarhizium anisopliae*, *Trichoderma harzianum* , and writing pad and pen (30 each)	Awareness programme on FAW in Maize was also conducted

Table 288.

TSP Progarmme at Jampani, East Siang, Arunachal Pradesh

TSP Progarmme at Ditchik, West Kameng, Arunachal Pradesh

TSP Progarmme at Nachibon, West Kameng, Arunachal Pradesh

TSP Progarmme at Lower Dzoung, West Kameng, Arunachal Pradesh

TSP Progarmme at Taki Lalung, East Siang, Arunachal Pradesh

34.5 DYS PUHF, Solan

Name of the project proposal: Eco-friendly management of insect-pests of temperate fruits and vegetables

Details of the location of tribal area where TSP was implemented: District Kinnaur of Himachal Pradesh

No of village covered: 2 and number of farmers benefitted: 40

Table 289.

SN.	Village	District	Date of training/ demonstration	No of farmers
1	Pooh	Kinnaur	23-10-2020	20
2	Urni (Tapri)	Kinnaur	24-10-2020	20
	Total			40

Crops covered:

Apple, almond, apricot, peas, cauliflower and cabbage

Area covered: **Table 290.**

Crop	Area (ha)

Apple	15
Almond	2
Apricot	2
peas	3.5
Cauliflower & cabbage	5.5
Total	28

Objective of the Project

To manage the insect-pests and diseases of important cash crops through eco-friendly methods to minimize the use of chemical pesticides on these crops.

IPM technologies demonstrated/ implemented

Use of *Metarhizium anisopliae*, *Beauveria bassiana* and azadirachtin for the management of apple root borer and apple stem borer.

Use of *Trichoderma* far the management of diseases in apple and vegetable nursery.

Use of azadirachtin and mechanical control in cabbage and cauliflower for the management of cabbage caterpillars.

Avoidance of indiscriminate use of insecticides for the conservation of parasitoids of apple woolly aphid and other natural enemies.

Use/conservation of predatory mites against phytophagous mites.

Inputs supplied to the farmers **Table 291.**

Sr. No.	Material	Number/ quantity
1	*Metarhizium anisopliae*	80 Kg
2	*Beauveria bassiana*	40L
3	Neem Baan	40L
4	*Trichoderma viride*	80Kg
5	Literature (Kisan diary)	40

Training/ demonstration conducted

Trainings and demonstrations were organized at villages Pooh and Urni of district Kinnaur, Himachal Pradesh in which 40 farmers participated. Farmers were trained and demonstrated regarding the use of bio-pesticides for the management of insect and mite pests of apple, almond, peas, cauliflower and cabbage. The farmers of the area were exposed to the use of bio-pesticides for the management of crop pests for the first time..

Expenditure:

Total amount allocated for the year : Rs. 1,00,000/-

Amount received: Rs. 82,000/-

Amount spent till date: Rs. 48300/-

Outcome of the project:

Forty farmers of Pooh and Urni villages of districts Kinnaur, Himachal Pradesh were benefited from the trainings/demonstrations. These farmers were exposed to the use of bio-pesticides for pest management for the first time. In peas, cauliflower and cabbage there was a reduction of 2-3 sprays of chemical pesticides. In case of apple, farmers saved about Rs 17000/- per hectare by avoiding chemical treatment for the control of apple root borer.

TSP photographs

Fig:84.

a)  b)  c) 

a) Farmers participating in training programme at Pooh, Kinnaur (HP)
b) Farmers participating in training programme at Pooh, Kinnaur (HP)
c) Farmers participating in training programme at Urni, Kinnaur (HP)

Fig:85.

a)  b) 

a)Farmers participating in training programme at Urni, Kinnaur (HP)

b) Scientists participating in live phone-in programme at Doordarshan Shimla

Tribal Sub Plan Programme (TSP) proposed for 2021-22

Title: Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests

Locations: Villages Keylong and Udaipur of district Lauhal and Spiti, Himachal Pradesh

Crops to be covered: Apple, apricot, peas, cauliflower, beans

Inputs to be supplied: Entomopathogenic fungi, neem products, predatory mite, yellow and blue sticky traps, light traps, Bt products, literature and other miscellaneous training material.

Approximate funds: Rs 1.0 lakh

34.6 GBPUAT, Pantnagar

Tribal Sub-Plan (Pantnagar Centre)

Under Tribal Sub-Plan (TSP) project, demonstrations on bio-control technologies were conducted amongst tribes in district Udham Singh Nagar in Uttarakhand State at Bajpur block in two villages namely, Vijayrmpura and Sheetpuri covering 200 farmers (with average land holding 0.5-20 acre).

For Kharif Season: Crop-Rice

Demonstrated Soil Solarization technology to200 farmers for the application of polysheet (2x10m) (Nos.400) on nursery beds of paddy. It is a low-cost technique to reduce losses due to soil borne insect pests and diseases of the nursery. Under the technique, nursery beds were prepared 5-8 weeks in advance of seed sowing, irrigated and covered with a transparent polythene sheet (50-100 u thick) which was removed 3-4 days ahead of the seed sowing. The techniques gives a green-house effect whereby sun rays are trapped underneath the polythere sheet. As a result, temperature of the soil increases to a level that is injurious to the soil microorganisms. Besides, it reduces weed population, improve physical and chemical properties of the soil and increases population of useful micro flora in the soil.

A total of 20q of Pant BiocontrolAgent 3, which is a mixture of *Trichoderma harzianum*-14(Th) and*Psuedomonas fluorecens*173(Psf), was distributed to the farmers for soil treatment, seed treatment, seedling treatment and foliar spray.

Use of PBAT-3 by the farmers was as under:

Seed treatment@10 g/kg seed.

Seedlings root dip treatment withPBAT-3 @ 10g/l for 30 min. prior to transplanting.

Foliar spray of PBAT-3 @ 10g/l at 15 days interval from transplanting.

Value addition of compost@1kg/q for soil treatment.

Biocontrol agents offer a better alternative by virtue of being environment friendly, cost effective, safe for humans and animals and improving soil health. At the Biocontrol Laboratory of Department of Plant Pathology, G. B. Pant University of Agriculture and Technology, Pantnagar mass multiplication of four *Trichoderma* and *Pseudomonas* spp. based powder formulated bioagents is being done and distributed to farmers for popularization under the AICRP on Biological Control Project.

In general, following methods of the application of use of Bioagents were advised:

Seed treatment through Biopriming:Seeds to be mixed with the formulated BCAs @10g/kg and incubate under moist conditions for 24 to 48h before sowing.

Rhizome treatment: Rhizomes dipped in solution of bioagent @ 10 g/ liter water for 30 minutes, dried in shade and planted.

Seedling treatment: Before transplanting roots of seedlings to be dipped in solution of bioagents @ 10 g/ liter for about 30 minutes.

Spray: @ 8-10 g/ liter on standing crop at 10-12 days intervals.

Drench: @ 8-10 g/ liter in soil in the nurseries from time to time.

Value addition of compost: Before the use of compost, it is to be supplemented with bioagents @ 1kg/q. This increases the nutritive value of the compost and provides opportunity to the bioagent to grow faster on the compost so that it can compete well with plant pathogens in the soil. Further, it facilitates rapid spread of bioagents in the soil.

Seed Biopriming

A seed biopriming method was developed for the application of *Trichoderma* and *Pseudomonas*. This method enhances efficacy of biocontrol agents against root and seed borne diseases. Seeds are mixed with the formulated BCAs at the rate of 10g/kg. Drops of water are sprinkled while mixing bioagents.Treated seeds are then placed on plastic sheet as a heap and covered with moist sacks for incubation under moist conditions for 24 to 48h before sowing. Bioagents adhered to the seed grow on the seed surface under moist condition to form a protective layer all around the seed coat.

Improved method for mass multiplication of bioagents (at farmer's level)

Colonization of FYM, poultry manure, press mud by *Trichoderma* and/or *Pseudomonas* at farmers level. Such compost acts both as biofertilizer&biopesticide. Content of water solublehumic matter, phosphorus and micronutrients is higher in colonized compost than non-colonized.

1kg of bioagent formulation is mixed with about 100 kg of FYM.

It can be prepared in pits (with variable dimensions as per convenience and use) filled with animal dung and other waste material available on farm / Mixture can also be spread as approx. 6-10 inch layer under shade.

Covered with polythene sheet/ sugarcane leaves or rice straw.

Incubated for 2 to 3 weeks at 25-32ºC at the farmer's place.

Water sprayed regularly to maintain moisture.

FYM gets decomposed within four months.

This colonized FYM is ready for use as it contains very high population of bioagents.

For the control of insect pest Neem oil (30 litre) wasdistributed for the control of stem borer in rice.

Rabi Season:

Distribution of vegetable kit:

As per experienced gained by the farmers through the introduction of vegetable cultivation forkitchen garden, this year farmers were very much keen to grow vegetables. But, due to the costly seed, they were unable to purchase it and requested us to provide vegetable seed under this programme. Accordingly, a vegetable seed kit was prepared containing following seeds produced at Vegetable Research Centre, GBPUA&T, Pantnagar, and treated withPant Bioagent 3.

Table 292.

S. No.	Name of Vegetable	Quantity (kg)	Number of farmer
1.	Vegetable Pea	100	200
1.	Coriander	200	200
2.	Radish	20	200
3.	Fenugreek	20	200
4.	Spinach	20	200

Table 293. Training organised under Tribal Sub-Plan (TSP) -2020-21

S.No.	Topic	Place	No. of Farmers
1.	Use of Polythene sheet for nursery soil solarization of Rice	Block- Bajpur Village- 1.Vijayrampura 2.Sheetpuri	200

2.	Use of Biocontrol agent for soil treatment	Block- Bajpur 1.Vijayrampura 2.Sheetpuri	250
3.	Use of Biocontrol agents for seed treatment	Block- Bajpur 1.Vijayrampura 2.Sheetpuri	175
4.	Use of Biocontrol agents for seedling root treatment and foliar spray	Block- Bajpur 1.Vijayrampura 2.Sheetpuri	300
5.	Organic Vegetable cultivation for kitchen garden	Block- Bajpur 1.Vijayrampura 2.Sheetpuri	200
6.	Use of Bioagents in vegetables like Pea, Corriander, Spinach, Fenugreek and Raddish.	Block- Bajpur 1.Vijayrampura 2.Sheetpuri	200

Bioagent Supplied: 20q Pant Bioagent 3 (Trichoderma+Pseudomonas)200 Polysheet (10x2m^2 each), Neem oil 30 L

ACTIVITIES

Training, distribution of inputs and monitoring of farmers field






Fig:86.

34.7 IGKV, Raipur

TSP under IGKV, Raipur, Chhattisgarh conducted during 2019-20

This year *ie*during 2020-21, Rs. 10.00 Lacs was allotted to IGKV, Raipur, Chhattisgarh under TSP from ICAR, vide letter F. No. 3-3[AICRP/BC]2020-21/467 dated 15/05/2020. Three tribal centres were chosen for conducting trainings. These centres were, Kondagaon, Ambagarh Chowki and Jagdalpur (Bastar).

The first training of TSP under the session 2020-21 was taken up at Village- Dhondra, Pharasgaon, under KVK, Kondagaondistrict(Bastar) on 16th Oct'2020. Large number of tribal farmers gathered, who were first given awareness and benefits of biocontrol agents through a lecture in hindi. Sr.Scientist& Head, KVK, Kondagaon, Dr. Om Prakash along with staff members. About 73 farmers participated in the training. This was followed by live demonstrations of the various bioagents being reared in the laboratory such as., Trichocards, reduviid bugs, Coccinellid beetles and *Zygogramma* beetles. Low cost candle based light traps were also displayed and distributed. Application method of Trichocards was also demonstrated on a model plant. Trichocards 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. It seemed that lady farmers were more interested to learn and receive the bioagents being distributed. There was demand for more bioagents which was supplied after a week from the Biocontrol laboratory, Raipur

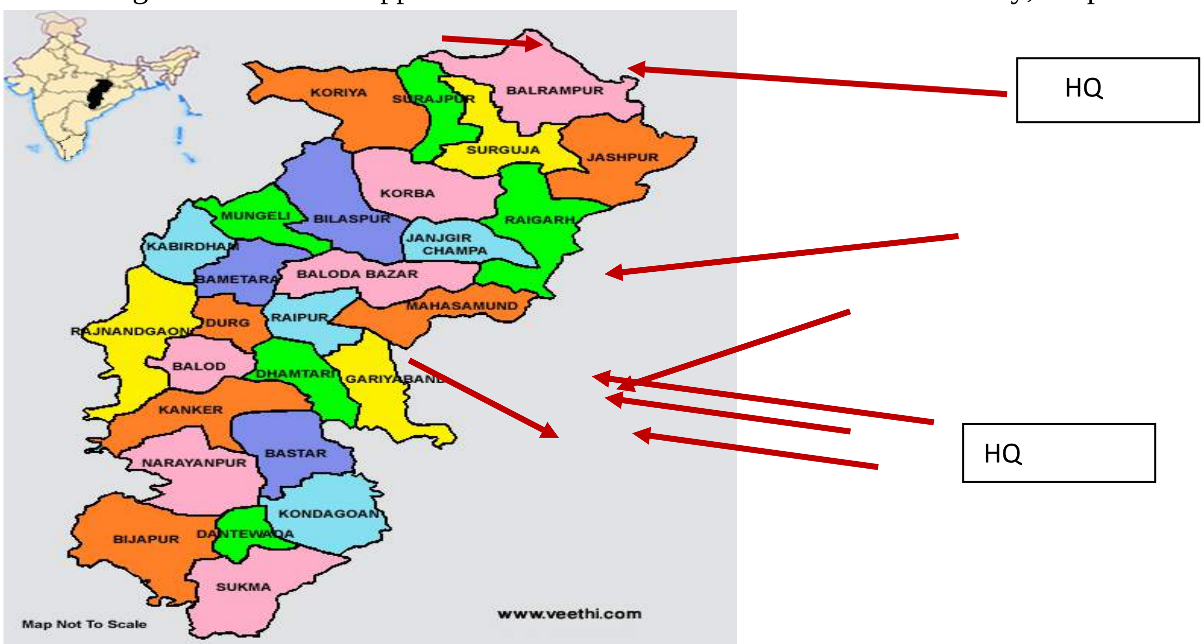


Fig:87.

The second training under TSPwas organized at Village- Muretitola, AmbagarhCowki, district Rajnandgaonon 25/11/2019. Under this 50 tribal farmers wereselected under ST category belonging to Village- Muretitola Block-Ambagarh Chowki, District Rajnandgaon, participated. Initially lecture 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 in good numbers to the tribal farmers. Lady farmers also participated actively in the training programme. Distribution of the above bioagents along with knap sack sprayers, vermibed and live application of Trichocards and Bracocards were done in the nearby farmer's field.

The thirdtraining"Hands on Training on production of Trichocards" under TSP was organized at Village- Devarsur, Ambagarh Chowki, Rajnandgoan (C.G.) on 23/12/2020, which was planned and co-ordinated by Dr.Vinamrata Jain, Assoc. Prof., CoA &Res.Stn, Rajnandgaon.. Sr. Sci. & Head, KVK, Rajnandgaon, Dr.B.S.Rajput, was also present. At first live demonstration of preparation of Trichocards was shown to the farmers and then farmers themselves prepared the cards.(Photobraphs enclosed). Large number of tribal farmers keenly observed the live bioagents and learnt their utility in insect pest management.

The fourth training was organized at Village-Fupgaon , under district Kondagaon (Bastar) on 26/02/2021. Lecture in hindi was delivered about the importance and safety about bio-agents and live samples were demonstrated. Lady Sarpanch, along with lady Agril. Engg, from State Govt., Chhattisgarh and large number of tribal farmers also attended the training. Distribution of Trichocards, Bracocards, *Zygogramma* beetles, Coccinellid beetles, hand sprayers, pheromone traps and irrigation cans were distributed to the tribal farmers.

The fifth training under TSP was organized at Village- Badekadma, Jagdalpur (Bastar). Initially importance and eco-friendly role of biocontrol agents was explained to the Tribal farmers in an easily understandable hindi language. Then live bioagents such as Trichocards, Bracocards, Reduviid bugs, Coccinellid beetles, *Zygogramma* beetles, hand sprayers, pheromone traps and irrigation cans were and distributed to the farmers including lady farmers who showed great interest in the programme. The farmers of the village- Badekadma are practicing organic mode of farming using cow dung, compost etc. as manure and using extracts of certain plants for plant protection. The training demonstrating the use of bioagents was really helpful, knowledge full and worth adopting.

(List of farmers and Photographs enclosed)

Fig:88. 1st Training under TSP on AICRP on Biocontrol, Krishi Vigyan Kendra, Kondagaon (C.G.) on 16/10/2020

Fig:89. Distribution of low cost light trap, hand sprayer and Knapsack sprayer to the tribal farmers of Village- Dhondra, Kondagaon (C.G.)


आयोजन जैविक नियंत्रण कृषक प्रशिक्षण कार्यशाला

Fig:90. 2nd Training under TSP on AICRP on Biocontrol, at Village- Muretitola, Ambagarh Chowki, Rajnandgaon, (C.G.) on 23/11/2020

Fig:91. Delivering lecture and demonstrating Trichocards and Wota-T trap
Distribution of low cost light trap, pheromone traps and Wota T traps to the tribal farmers of Ambagarh Chowki, Rajnandgaon

Fig:92. Live demonstration of the application of Trichocards and Bracocards at farmer's field of Village- Muretitola, Ambagarh Chowki, Rajnandgaon (C.G.)
List of tribal farmers selected under TSP, from Village- Muretitola, Ambagarh Chowki, Rajnandgaon (C.G.)


मुरेटीटोला में रखी गई कृषक संगोष्ठी

रिपोर्ट-हरदीप छाबड़ा

अंबागढ़ चौकी(अमर स्तम्भ)। ब्लाक के ग्राम मुरेटीटोला में भारतीय कृषि अनुसंधान परिषद के नेतृत्व में एक दिवसीय कृषक संगोष्ठी का आयोजन किया गया ।जिसमें भारी संख्या में क्षेत्र के किसान उपस्थित हुए ।उपस्थित किसानों को मित्र किट,कीटो का नियंत्रण तथा जैविक किट नाशक दवाओं के बारे में विस्तार से जानकारी दी गई।जया लक्ष्मी गांगुली (किट वैज्ञानिक)ने उपस्थित किसानों को प्रभावशाली किट और बहुपयोगी परजीवी किट के बारे में विस्तार से जानकारी दी। इसके अतिरिक्त जैविक खाद निर्माण ,बीज उपचार ,जैविक बीज उपचार इत्यादि के बारे में अच्छी जानकारी इस कृषक संगोष्ठी के माध्यम से किसानों को मिली।यह सभी जानकारी पाकर किसान बहुत खुश हुए।इस कृषक संगोष्ठी में जया लक्ष्मी गांगुली किट वैज्ञानिक, डॉ विनम्रता जैन कृषि वैज्ञानिक, डॉ. मोनीष जंघेल किट वैज्ञानिक, रश्मि गौर कार्यक्रम सहायक, कृष्णकांत रजक विरिष्ठ अनुसंधान अध्येयता आदि लोगो ने किसानों को इस संगोष्ठी के माध्यम से किसानों महत्वपूर्ण जानकारियां दी। इस एक दिवसीय कृषक संगोष्ठी में किसानों को लाईट ट्रैप, फिरो मेन ट्रैप, वर्मी कंपोस्ट खाद ,मित्र किट तथा वर्मी बैड भी प्रदान किया गया। इस कृषक संगोष्ठी का मुरेटीटोला में आयोजन डॉ. विनम्रता जैन फारमर्स फर्स्ट परियोजना प्रभारी व डॉ. वी. के.दुबे अधिष्ठाता कृषि महाविद्यालय सुरगी राजनांदगांव के मार्गदर्शन में किया गया।

Fig:93. 3rd training in the form of "Hands on training on preparation of Trichocards" was conducted under TSP at Village- Devarsur, Ambagarh Chowki, Rajnandgoan (C.G.) on 23/12/2020

Fig:94. Inaugurating the programme with Dr.Vinamrata Jain & PC, KVK, Rajnadgaon and Farmers preparing Trichocard themselves

Fig:95. Distribution of sprayers to the tribal farmers

4th training programme conducted under TSP at Village- Fupgaon, District-Kondagoan (C.G.) on 26/02/2021

Delivering lecture and demonstrating pheromome trap to tribal farmers

Fig:96. Demonstrating symptoms of dead heart and distributing Knapsack sprayer to a farmer

Fig:97. Distributing Wota -T trap, mushroom production packet and pheromone trap to tribal farmers

5th Training under TSP on AICRP on Biocontrol, at Village-Badekadma, Jagdalpur (C.G.) on 06/03/2021

Fig:98. Display and distribution of Pheromone traps, biocontrol agents like Trichocard, Bracocard, Coccinellid beetles etc.

Fig:99. Distribution of sprayer and Vermi-bed to lady farmers of Village -Badekadma

34.8 KAU, Thrissur

TRIBAL SUB PLAN 2020-21

Activities under tribal sub plan (TSP) for the year 2020-21 of AICRP on BCCP, College of Agriculture, Kerala Agricultural University, Vellanikkara were carried out at Wayanad and Thrissur districts.

The project activities in Wayanad district were undertaken in collaboration with Krishi Vigyan Kendra, Wayanad and National Seeds Corporation. The tribal hamlet of Thirunelli was adopted and National Seed Corporation, GoI distributed seed kits that comprised seeds of vegetables, millets and pulses. AICRP on BCCP, KAU, Thrissur provided biocontrol agents and biofertilizers to promote organic farming. The bioinputs distributed included *Trichoderma viride*, *Pseudomonas flourescens*, *Lecanicillium lecanii*, *Purpureocillium lilacinum*, *Azospirillum*, biopotashand arbuscular mycorhizal fungi (AMF). As the tribal farmers had expressed non availability of sprayers as a major constraint, 15 knapsack sprayers were also distributed for proper application of bioagents. The bioinputs were distributed to the farmers on the same day through Kudumbasree mission. As part of this programme, a total of 216 farmers of Thirunelli panchayat were benefitted. Hon. Vice Chancellor, Dr. R. Chandrababu inaugurated the programme.

TSP activities in Thrissur district were carried out with the help of Department of Tribal development and Department of Agriculture. Vegetable seeds (cowpea, brinjal, amaranth, chilli, bitter gourd and bhindi) and bioagents were provided to 41 farmers (121 family members) in the Kallichithra colony of Thrissur district. Training programme was also conducted for the farmers on proper use of biocontrol agents in organic vegetable cultivation. Details of training programmes conducted, number of beneficiaries, bioinputs distributed, *etc.* are given in Table 16.

Table 294. Details of activities under Tribal sub plan for the year 2020-21

Sl. No.	Place	Village	Taluk	No. of beneficiaries	No. of women tribal farmers	Date of supply	BC agents/other items supplied to farmers	Area covered (ha)
1	Varantharappalli, Thrissur district, Kerala	Varantharappalli	Chalakkudi	41 (121 family members)	11	9-9-20	Vegetable seeds – 75 pkts *Pseudomonas*– 140kg *Trichoderma*–140kg	175
2	Thirunelli, Wayanad district, Kerala	Thirunelli	Mananthavadi	216	216	22-2-21	*Pseudomonas* – 430 kg *Trichoderma*–285kg *Lecanicillium* – 155 kg *Purpureocillium*– 150 kg *Azospirillum* -150kg Biopotash – 150 kg AMF – 150 kg Sprayers – 15 nos.	
		Total number of farmers benefitted – 257 Total number of women tribal farmers – 227						

Fig:100.

കേരളകൗമുദി

Fig:101. Plate 19. Distribution of biocontrol agents, biofertilizers and seed kit to tribal farmers of Thirunelli panchayat, Wayanad on 22-2-21
Plate 20.Trainingprogramme at Varantharappalli on 9-9-2020

Fig:102. Plate 21: Distribution of bioinputs and leaflets under tribal sub plan (TSP) at Kallichithra ST colony in Thrissur District

34.9 SKUAST (Srinagar)

Tribal sub plan on Integrated management of Codling moth, *Cydiapomonella* in Ladakh (2019-20):

Since Tribal Sub Plan (2019-20) was allotted to the center during May 2019' which could not be initiated due to unavoidable circumstances in Kashmir during 2019-20 and was therefore taken up late during 2nd week of October' 2020 when inter UT movement was permitted. Further, the plan was executed in Kargil sub division of Ladakh only due to official restrictions on movement.

The outline of the project has been summarized in Table 295. Inputs in kinds (Table 296) were given to seventy five farmers belonging to 28 villages of subdivision Kargil (34° 33' 27.54" N and 76° 07' 34.39" E). Distribution of inputs was done in presence of Scientist I/C Mountain Agriculture Research & Extension station, SKUAST- Kargil and PC KVK, SKUAST-K, Kargil. Before distribution of inputs the farmers were given a complete know-how for effective and timely management of Codling moth through a pictorial chart prepared by the P.I. Biocontrol. A thorough scientists- farmers' interaction also took place both at MAR&ES and KVK- Kargil, maintaining all SOPs for Covid- 19. A list of beneficiaries (Table 297) with complete address and phone numbers was also maintained. Receipts of inputs, from beneficiaries were also taken, for record. Visits were also made at villages like Trespone, Mingy and Saliskot and the inputs were distributed to some progressive farmers on sharing basis. Dr.Faizan Ahmad, Scientist I/C MAR &ES, Kargil and Dr. Mahdi, PC KVK- Kargil took active part in arranging the events, interacting with farmers as well as distribution of items at their stations (Plates 5-8).

Impact of Tribal sub plan: Since the distribution of inputs was meant for use during upcoming season in 2021, the impact will therefore be recorded during the said year and sent to the Director, NBAIR, Bengaluru.

Table 295. Summarized outline of Tribal Sub Plan (2019-20)

S. No.	Particulars	Details
1.	Title of TSP Project	Tribal sub plan on Integrated management of Codling moth, *Cydia pomonella* in Ladakh (Kargil&Leh) (2019-20)
2.	Year of implementation	2020
3.	Location	Kargil
4.	Crop	Apple
5.	Budget	7.26 lakh
6.	Expenditure	7,17,855.00
7.	No. of villages covered	28
8.	No. of beneficiaries	75
9.	Area covered	Approx. 25- 30 ha.

Table 296. List of items distributed in Kargil during 2019-20

S. No.	Name of inputs	No./ Qty
1.	Foot sprayer	75 No.
2.	Quinalphos 25 EC	75 lit.
3.	Delta traps	1300 No.
4.	Cod lure Pheromone	1700 No.
5.	Sticky liner	1400.No.
6.	*B. bassiana*	75.0 Kg.
7.	Bucket (17 lit.)	75 No.
8.	Protective gear (Uniform, goggle, mask, glove)	75 sets
9.	Yellow metallic plate	100 No.
10.	Management chart	100 No.
11.	Gunny bags	15,00 meter
12.	Trichocards*	300 cards

To be given during May- August' 2021

Fig:103. I/C Scientists MARES- SKUAST, Kargil, and KVK- SKUAST-K, Kargil addressing farmers at Kargil under Tribal Sub Plan (2019-20) for the Integrated Management of Codling moth during October' 2020

Plate 5

Fig:104.

Fig:105. P.I. Biocontrol interacting with farmers regarding Integrated management of Codling moth,*Cydia pomonella* infesting apple in Ladakh at KVK- SKUAST, Kargil on 12th October' 2020

Plate 6

Fig:106.

Fig:107. P.I. Biocontrol explaining the strategy of managing the Codling moth through pictorial chart and use of inputs at KVK- SKUAST, Kargil on 12th October' 2020

Plate 7

Fig:108. Distribution of TSP inputs to farmers of Kargil by the I/C Scientist, MARES & KVK- SKUAST, Kargil and P.I.
Biocontrol on 10 th& 11th October' 2020

Plate 8.

Tribal sub plan on Integrated management of apple fruit borers in tribal areas of Baramullah, Kashmir

Under approved Tribal Sub Plan (Table 296), purchase of inputswas done as per codal formalities of the State Government of Jammu& Kashmir and University. The outline of the project has been summarized in Table 297. Inputs in kinds (Table 298) were given to seventy five farmers belonging to villageBrandub of sub division Rafiabad of district Baramulla. Distribution of inputs was done in presence of Prof. G.M. Lone, Prof. & Head, Division of Entomology, SKUAST-K, Mohammad Yousuf Shah, Chief Agriculture Officer ,Baramullah, Dr. Malik Mukhtar, Co P.I. Biocontrol, Division of Entomology, Mr. Gurdeep Singh, Sub Divisional Agriculture Officer, Rohama and Mr. Hilal Ahmad, AEO, Sub division Rohama. Before distribution of inputs the farmers were given a detailed strategy of the management of fruit borer of apple in their villages. Techniques including safe use of pesticides, time and frequency of uses of pheromone traps and Trichogrammacacoeciae, use of trunk banding to trap and kill 2nd generation as well as overwintering fruit borer were explained through chart, photographs, samples of Tricho cards and trunk bands (Plates 9-12).

A list of beneficiaries (Table 299) with complete address and phone numbers was also maintained. Receipts of inputs, from beneficiaries were also taken, for record (Table 300).

Impact of Tribal sub plan: Impact of TSP (2021) shall be recorded during and after the harvest of crop and communicated to the Director, NBAIR, Bengaluru.

Table 297. Proposed and approved program of Tribal sub Plan (2020-2021)

1.	Name of the Project Proposal	:	Integrated Management of apple fruit borers in tribal areas of Baramullah, Kashmir
2.	Name of the center	:	Division of Entomology Sher-e- Kashmir University of Agricultural Sciences & Technology, Kashmir (J&K)
3.	Name of P.I Name of Co P.I.	:	Dr. Md. Jamal Ahmad Dr. Malik Mukhtar
4.	Details of locations of Tribal areas/STs where TSP is going to be executed	:	District Baramullah (34° 12' 7.310" N and 74° 20' 53.2422" E)

5.	a. No of Villages	:	01
	b. No of Farmers	:	75
	c. Area under coverage	:	100 ha.
6.	Crops to be dealt	:	Apple
7.	Budget allotted	:	7.0 Lakh
8.	Materials to be supplied to the TSP farmers with clear financial details.	:	(see table below)

Materials (per year)	No.	Rate (INR) Unit price	Total (Rupees)
Foot sprayer	75 No..	5050.00	378750
Protective gear	75 No.	1320.00	99000
Tub	75 No.	850.00	63750
Chlorpyriphos 20 EC	75 lit.	425.00	31875
Delta trap	1500 No.	40.0.00	60000
Liner	1500 No.	20.00	30000
Pheromone	1500 No.	30.00	45000
Tricho cards	750 No.	25.00	18750
Gunny bags	1500 meter	Available in the Division	-
Total			727125

9.	IPM technologies to be implemented for pest management	:	Use of light trap Essential use of insecticide Use of pheromone Use of Tricho cards Use of trunk banding and killing of borer Field sanitation
10.	Target proposed and expected Achievements	:	Reduction in fruit borer 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. However, current problem of fruit borer in Baramullah district has caused significant loss of marketable yield. By supporting the farmers from tribal areas of district Baramullah through necessary inputs the farmers may be able to manage the pest and help boost the economy.
12.	Training/ Demonstrations to be given to tribal farmers	:	Training regarding Management of Insect pests and diseases of apple Training regarding identification of pests Demonstration regarding use of light trap, Pheromone trap, trunk banding and Tricho card Timing of management

13.	Target proposed and expected Achievements	:	Reduction in fruit infestation Increase in yield
14.	Anticipated impact of TSP Project on economic improvement of the tribal of the Tribal people and wealth creation in Tribal areas	:	The present effort will help manage the pest problem in given area through timely supply of inputs. Proper training for the management of borers and awareness camps will provide an up-to-date information regarding effective management of the pest. Moreover, an all inclusive approach of IPM including chemicals/ pheromone/ biocontrol agents and other cultural practices will benefit the farmers through reduction in fruit damage by the fruit borers.

Table 298. Summarized outline of Tribal Sub Plan (2020-21)

S. No.	Particulars	Details
1.	Title of TSP Project	Integrated Management of apple fruit borers in tribal areas of Baramullah, Kashmir
2.	Year of implementation	2020-21
3.	Location	Rafiabad, (*Rohama Latitude* 34.31089 and *Longitude* 74.2422), Baramullah
4.	Crop	Apple
5.	Approved Budget	7.00 lakh
6.	Sanctioned budget	5.30 lakh
7.	Expenditure	6.50 lakh
8.	No. of village covered	01
9.	No. of beneficiaries	75
	Area covered	Approx. 100 ha.

Table 299. List of items distributed to farmers in Rafiabad, Baramullahduring 2021.

S. No.	Name of inputs	No./ Qty
1.	Foot sprayer	75 No.
2.	Chlorpyriphos20 EC	75 lit.
3.	Delta traps	1500 No.
4.	Cod lure Pheromone	1500 No.
5.	Sticky liner	1500.No.
6.	Tub (50 lit.)	75 No.
7.	Protective gear (Long apron,hat, goggle, mask, glove, gum boot)	75 sets
8.	Gunny bags	15,00 meter
9.	Trichocards	300 cards

Table 300. Proforma of receipt of TSP items from the farmers of Rohama, Baramullah

Details of inputs received under TSP (2020-21)

Received following items under ICAR- NBAIR sponsored Tribal sub plan (2020-21) from Dr. Jamal Ahmad, P.I. Bio control, Division of Entomology, SKUAST-K, Srinagar (J&K) today, for the management of Apple fruit borer in Rafiabad, Baramullah.

S. No.	Items	Qty (No.)	Purpose
1.	Foot sprayer (Shakti)	1.0 No.	For spray against 1^{st} generation of Codling moth
2.	Chlorpyriphos 20 EC	01 lit.	-do-
3.	Tub (50 lit. capacity)	01	For dilution of insecticide
4.	Water proof apron	1.0 No.	For protection during spray
5.	Gum boot	1.0 pair	-do-
6.	Mask, gloves, hat and goggle	1.0 set	-do-
7.	Pheromone traps (Yellow trap, liner and lure)	10 sets	For mass trapping of adult Codling moth
8.	Tricho cards*	5 cards	For management of Codling moth at egg stage
9.	Trunk bands**	10 meters	For trunk banding to trap overwintering larvae

*Will be supplied during May- July' 2021** will be supplied during September' 2021

Name of beneficiary : ……………………………………
Adhar Card No. : ………………………………………
Contact No. ………………………………………
Address ………………………………………………
Age of trees : ……………………..
No. of trees : ……………………..

Dated : Signature……………………

Fig:109. Top: L to R. Mr. Mohammad Yousuf Shah, Chief Agriculture Officer, Baramullah, Prof. Jamal
Ahmad, P.I. Biocontrol, Prof. G.M. Lone, Prof. & Head, Division of Entomology, SKUAST-K, Mr.
Gurdeep Singh, Sub Divisional Agriculture Officer, Rohama and staff of Agriculture station Rohama during TSP (2020-21) at Rohama, Bottom :Beneficiaries listening to P.I. Biocontrol

Plate 9

Fig:110. Chief Agriculture Officer ,Baramullah(Top) and Prof. & Head, Division of Entomology, SKUAST-K (Below) addressing the beneficiaries before distribution of TSP (2020-21) items at Rohama

Plate 10

Fig:111. Top &Bottom : P.I. Bio control detailing the IPM techniques of the management of apple fruit borer at Rohama on 27.04.2021.

Plate 11

Fig:112. Distribution of TSP (2020-21) inputs to farmers at Rohama on 27.04.2021.

Plate 12

34.10 UBKV, Pundibari

Under TSP programme two training programmes were conducted with 75 tribal farmers of Turturi, Dhamsibad and Nurpur villages under GP Shamuktala, Dist. Alipurduar-II of West Bengal in the month of November, 2020. Besides, 5 farmers were selected to whom training was provided on 'Beekeeping for upliftment of rural livelihood'. The objective was to enhance the expertise of the farmers, so that they can become self-sufficient as well as equipped with the scientific beekeeping and honey production. Programmes were also conducted for different kinds of input distribution like seed, fertilizers, herbicide, insecticides and bio-pesticides, knapsack sprayer, beehive with colony and other accessories and honey extractor among tribal farmers.

Title of the programme: Cultivation of crops through biological intervention and promotion of bee-keeping under AICRP on Biological Control for livelihood improvement of the tribal people.

2. Objective:

(i) Providing training on proper cultivation techniques necessary inputs for cultivation of mustard to the tribal farmers so that they can utilise their fallow land after harvesting of kharif rice and can increase cropping intensity.

(ii) Upliftment of rural livelihood of tribal farming community by providing necessary training and inputs for beekeeping.

3. Location of the tribal area where TSP was implemented:

Villages: Turturi, Dhamsibad and Nurpur under GP Shamuktala, Dist. Alipurduar-II (West Bengal)

4. Selection of farmers: Total 80 tribal farmers were selected during 2020-21 from the aforementioned location.

5. Training Programme: **Table 301.**

Sl. No.	Date of training	Topic of training	No. of tribal farmers attended
1.	17.11.2020	Recommended cultivation practice of mustard	75
2.	24.11.2020	Pest and disease management of mustard using botanicals and microbials	75
3.	08.01.2021	Beekeeping for upliftment of rural livelihood	5

6. Distribution of inputs: **Table 302.**

Sl. No.	Inputs	Quantity
1.	Mustard seed	1 kg/ farmer
2.	Herbicide	-----
3.	Fertilizers	Urea- 90 kg/acre, SSP- 120 kg/acre, 30 kg/acre
4.	*Trichoderma viridi*	500 gm/farmer

5.	Azadirachtin 3000 ppm	250 ml/farmer
6.	Knapsack sprayer	75 sprayers (1 sprayer/farmer)
7.	Beehive with colony and other accessories	15 box for selected 5 farmers @ 3box/farmer
8.	Honey extractor	1 for the entire group

7. Expenditure Incurred:

Allotted fund during 2020-21under TSP head: 3 lakhs

Amount spent till date: approximately total fund was spent.

8. Outcome of the project/ Achievements:

(i) Training programme on proper cultivation techniques of mustard was given and all essential inputs for cultivation were distributed among the tribal farmers. The farmers used to keep their land as fallow after harvesting of kharif rice. Providing the necessary inputs and training on cultivation of rabi crops like mustard helped them to utilize their fallow land which increased the cropping intensity and provided scope for additional income. A total of 75 bigha (i.e. 25 acre) lands were included under mustard cultivation with technical and financial support from the project AICRP- Biological control under sub-head Tribal Sub Plan (TSP). The seed yield ranged from 50-70kg/bigha. Harvested mustard seeds were used by the tribal community mainly for oil extraction and also for domestic consumption.

(ii) Increase in yield due to replacement of local variety: 30% increase in yield

(iii) Number of tribal farmers benefitted: 80

(iv) Replacement of area under fallow land with introduction of mustard crop: 25 acre

(v) The distributed beehives were maintained with utmost care by the group of farmers and a good amount of honey was extracted and sold in the local market.

9. Activity Photographs: **Table 303.**

	
Distribution of seed and fertilizers	Distribution of biopesticides
	
Mustard cultivation using given inputs	Distribution of bee hives and honey extractor

	 মধু ও সর্ষে চাষে লাভের মুখ দেখছে নুরপুর
Distribution of sprayer machine	Newspaper coverage of the event

35. GENERAL INFORMATION

35.1 Functioning of the co – ordinated project

35.1.1 Scientific staff position

Table 304.

Centres	Name of the Scientist/s	Phone number	E-mail ID
Regular centres			
AAU, Anand	Dr. Nainesh B. Patel	09998960525	nainesh@aau.in
	Dr.B.L. Raghunandan	09972842619	raghumic2@gmail.com
AAU, Jorhat	Dr. D. K. Saikia	09954410068	dilip.kr.saikia@gmail.com
	Dr. R. N. Borkakati	07002955996	rnbk.agri@gmail.com
ANGRAU, Anakapalle	Dr. M. Visalakshi	09618061963	visalamahanthi@yahoo.co.in
GBPUAT, Pantnagar	Dr. Roopali Sharma	07830355250	roopalibiocontrol@gmail.com
	Dr. Manju Sharma	07088510595	manju_sharma9917@yahoo.co.in
KAU, Thrissur	Dr.Madhu Subramanian	09447100151	madhu.s@kau.in
	Dr. Smitha M.S.	09846493554	smitha.ms@kau.in
MPKV, Pune	Dr. Sharad Galande	09422986630	smgbiol@gmail.com
	Dr. Santosh More	08329513891	suatharv@rediffmail.com
PAU, Ludhiana	Dr. Neelam Joshi	08146996976	neelamjoshi_01@yahoo.co.in
	Dr P.S. Shera	09872205425	psshera@pau.edu
PJTSAU, Hyderabad	Dr. G. Anitha	09949997830	saicrpbiocontrol@gmail.com
SKUAST, Srinagar	Dr. Jamal Ahmad	09596013043	ahmadj1964@gmail.com
	Dr. Malik Mukhtar	09906726920	drmalikmukhtar@yahoo.com
TNAU, Coimbatore	Dr. Jeyarajan Nelson	09442051229	sjn652003@yahoo.co.in
YSPUHF, Solan	Dr. P. L. Sharma	09418401842	sharma.pl@rediffmail.com
	Dr. S. C. Verma	09418828036	scvermaento@gmail.com
Contingency centres			
CAU, Pasighat	Dr. Ajaykumara K.M	07252027083	ajaykumarakmath@gmail.com
	Dr. R.C. Shakywar	07085505874	rcshakywar@gmail.com
MPUAT, Udaipur	Dr. M. K. Mahla	09829219205	mkmahla@yahoo.co.in
OUAT, Bhubaneswar	Dr.T.Samal	09438073235	tribikram.samal@gmail.com

UAS Raichur	Dr. Arunkumar Hosamani	09449762175	arent23@gmail.com
ICAR-CISH, Lucknow	Dr. Shiv Kant Singh	09450277360	singhskkanpur@gmail.com
	Dr. P.K. Shukla	09451290652	pksmush@gmail.com
ICAR-CPCRI, Kayangulam	Dr. Chandrika Mohan	09495316960	chandrika.mohan@icar.gov.in
	Dr. Joseph Rajkumar	09447978662	joseph.rajkumar@icar.gov.in
	Dr K M Anes	08606381982	anes.meerasahib@icar.gov.in
ICAR-IIHR, Bangalore	Dr.B.R.Jayanthi Mala	08861767095	jayanthimala@iihr.res.in
	Dr.Radha T.K.	08792392781	Radha.K@icar.gov.in
ICAR-IIMR, Hyderabad (Millets)	Dr. G. Shyam Prasad	09866431157	shyam@millets.res.in
ICAR-IIRR, Hyderabad	Dr. Chitra Shanker	09441866612	chitrashanker@gmail.com
	Dr. C. Kannan	09425865057	agrikannan@gmail.com
ICAR-IIVR, Varanasi	Dr. Jaydeep Halder	09453653467	jaydeep.halder@gmail.com
ICAR-NCIPM, New Delhi	Dr. Anoop Kumar	08588090462	anooptiwariento@gmail.com
	Dr Jitendra Singh	8743005643	drjsbsingh@gmail.com
DRYSRUH, Ambajipeta	Dr.N.B.V.Chalapathi Rao	09849769231	chalapathirao73@gmail.com
	Mrs B. Neeraja	08985435304	neeru.boddepalli@gmail.com
IGKV, Raipur	Dr. Jayalakshmi Ganguli	09827891566	jayaganguli@yahoo.com
KAU, Kumarakom	Dr.Sible George Varghese	09497647830	sible.gv@kau.in
KAU, Vellayani	Dr Reji Rani, O.P	09446378182	rejiniop@gmail.com
UBKV, Pundibari	Dr. S. K. Sahoo	09647255868	shyamalsahoo@gmail.com
	Dr.Anamika Debnath	09474827173	dr.anamikadebnath@rediffmail.com
	Debanjan Chakraborty	09647800589	debanjan.ubkv@gmail.com
	Moulita Chatterjee	09679350517	moumita.2014@gmail.com
	Biswajit Patra	09547152202	biswa.kris@gmail.com
Voluntary Centres			
Sun Agro, Chennai	Dr. S. Sithanantham	09884104036	sithanantham@yahoo.com
PDKV, Akola	Dr. D.B Undirwade	09850819992	hdentomology@gmail.com
SKUAST-Jammu	Dr. Reena	09419153105	bkreena12@gmail.com
Nagaland University	Dr. M. Aleminla Ao	09436004739	aleminla@nagalanduniversity.ac.in
	Dr. Daiho	09436004490	daiho_2004@yahoo.co.in
UHAS, Shivamogga, Karnataka	Dr. S..Pradeep	09663977455	drpradeepent@rediffmail.com
	Dr.Ravindra	09900300245	ravindranema@gmai.com
DRYSRUH, Tirupati	Dr.Srinivasa Reddy	09440572070	dsr2020@gmail.com
ICAR-SBI, Coimbatore	Dr. N.Geetha	09442076920	mvsbi@yahoo.com
	Dr.P.Malathi	09487022404	emalathi@yahoo.com

WNC-ICAR-IIMR , Hyderabad	Dr.J.C.Sekhar	09908600340	jcswnc@rediffmail.com
NIPHM, Hyderabad	Ms.N.Lavanya	08978778708	16lkiran@gmail.com
	Dr. S. Jesu Rajan	09704514603	sjrajan83@gmail.com
ICAR- NRRI, Cuttack	Mr.Annamalai M	08695241420	annamalaiagriento@gmail.com
	Dr. Aravindan S	09337997597 07538995223	aravindgobi@gmail.com

35.2 Budget of AICRP for 2020-2021

Table 305.

Item of Expenditure	Sanctioned and allotted grants (Rs. in lakh)	Grants released during 2020-21 from ICAR (Rs. in lakh)	Total expenditure (Rs.)
Pay and allowances	205.81	205.81	205.81
Rec. Contingencies	318.35	318.35	318.35
T.A	50.65	50.65	50.65
TOTAL	**574.81**	**574.81**	**574.81**

35.3 PROBLEMS ENCOUNTERED DURING THE YEAR (2020-2021)

AAU, Anand

1. Survey and collection of natural enemies from different Agro-ecological zone, demonstration and field trials on farmers' fields were partially affected by different protest and corona pandemic and assembly election of the state.

CPCRI

1. Problems encountered during the year: COVID-19 lockdown and subsequent setbacks. Permission is hereby sought for procuring room conditioner for successful maintenance of insect culture in the laboratory.

KAU, Thrissur

1. The increasingly unpredictability in monsoon has been hindering timely conduct of field experiments for the last three years.
2. The vehicle available with the programme is two decades and is not roadworthy.

MPKV

1. Problems encountered during the year (MPKV, Pune).
2. Sufficient grants may be allotted for pay and allowances. Non recurring Contingencies may be provided.

TNAU

1. Mealybugs damage in cassava was high in Salem and Namakkal Districts from May,2020 to July,2020.
2. Rugose spiraling whitefly and bonders nesting whitefly were seen coconut trees in various districts of Tamil Nadu. The advantages of 'Conservation biological control and trapping of whiteflies with yellow sticky traps were explained to the Department officials and farmers. *Chrysoperla zastrowi silemmi* is being supplied to farmers for the management of this invasive pest.
3. In the maize growing areas in Tamil Nadu, fall army worm damage was observed and IPM measures were recommended to the farmers.
4. Sugarcane woolly aphids were observed in Thoppampatti and Ambarampalayam villages in Coimbatore District and recommended conservation of natural enemies.

35.4 Visitor

ANGRAU

1. Sri. M. Nagireddygaru, Vice chairman, Andhra Pradesh Agriculture Mission visited Biological laboratory of AICRP Biocontrol on 25.11.2020 , observed biocontrol agents production and interacted on utilizxation of biocontrol agents and Biopesticides in crop protection.
2. Dr.Vishnuvardhana Reddy garu, Hon'ble Vice Chancellor, ANGRAU visited AICRP Biocontrol laboratory on 14.12.2020 , observed the biocontrol agents production and interacted on new local strains of biocontrol agents and gave direction for laboratory studies, field studies and registration / licencing of technologies

DYSPUHF, Solan

1. Incharge, State Biocontrol Laboratory, Shimla visited Biocontrol Research Laboratory of Dept. of Entomology, UHF, Nauni on 11-06-2020.
2. Managing Director, Industries (HP) visited Biocontrol Research Laboratory of Dept. of Entomology, UHF, Nauni on 10-02-2021.
3. MPKV
4. Dr. S. D. Masalkar, Associate Dean, College of Agriculture, Pune visited took review of biological control laboratory on 19.8.2020.
5. Dr. J. P. Dhange, Former Secretary of Govt. of Maharashtra visited and took review of biological control laboratory activities on 18.09.2020.
6. Dr. S. D. Masalkar, Associate Dean, College of Agriculture, Pune visited biological control laboratory on 18.09.2020.
7. Dr. D. S. Pokharkar, Ex. Head, Department of Agril. Entomology, MPKV, Rahuri visited and reviewed research activity on 15.10.2020.
8. Dr. S. S. Jadhav, Ex. Head, Deptt. of Entomology, MPKV, Rahuri visited biological control laboratory on 10.11.2020.
9. Dr. S. M. Galande delivered lecture on white grub management at Lonikand on 7.9.2020.
10. Dr. S. A. More delivered lecture on IPM of sugarcane as resource person for farmers in Pune district organized by REC, Pune 18.10.2020.

11. Dr. S. M. Galande delivered lecture on gram pod borer management at Ohawhalwadi on 12.1.2021.
12. Hon, Dr. Ashok Dhawan, Vice Chancellor, MPKV, Rahuri visited and took review of biological control laboratory on 01.01.2021 and appreciated the work of mass production of bioagent and biopesticdes.
13. Dr. S. D. Masalkar, Associate Dean, College of Agriculture, Pune visited biological control laboratory on 01.01.2021.
14. Dr. A. L. Pharande, Dean Faculty of Agriculture visited and took review of biological control laboratory on 18.02.2021.
15. Dr. S. D. Masalkar, Associate Dean, College of Agriculture, Pune visited and took review of biological control laboratory on 18.02.2021.

PJTSAU

1. Dr. V. Avil Kumar, Associate Director of Research, Regional Agricultural Research Station, Palem, Nagarkurnool dt. for an office inspection on 19 Sep, 2020
2. Dr. Ch. Damodar Raju, Associate Director of Research Regional Agricultural Research Station, Palem, Nagarkurnool dt. for an office inspection on 12 December, 2020
3. Dr. V. Anitha, Dean – P.G.Studies, PJTSAU, for discussions on Black Soldier Fly project for submission to NAHEP Wealth to Waste on 5 January, 2021.
4. Dr. V. Anitha, Dean – P. G. Studies, PJTSAU, for discussions on Black Soldier Fly project for submission to NAHEP 12 February, 2021.
5. As a trainer to impart training to input dealers of the state in the handling and use of bioagents and biopesticides as part of the Diploma in Argrl. Extension Services (DAESI) organized by MANAGE, Hyderabad at Horticultural Research Station, Kondamallepalli, Nalgonda dt.
6. "Basics of Entomology and Pest Management" on 2.2.2021 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
7. "Integrated Pest Management in different Crops" on 9.2.2021 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
8. "Basics of Entomology and Pest Management" on 9.3.2021 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
9. "Integrated Pest Management in different Crops" on 12.3.2021 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
10. "Basics of Entomology and Pest Management" on 24.3.2021 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
11. "Integrated Pest Management in different Crops" on 28.3.2021 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
12. As member of the village adoption programme of the University, visited the adopted village Sheriguda Bhadraipally, Kothur Mandal, Rangareddy dt and took up two trials in farmers fields in *rabi* 2021.
13. Integrated Pest Management on Rice using *Pseudomonas flourescens* for seed treatment at sowing and also soil application at 30DAT, foliar sprays at 30,45 and 60DAT. Supply of pheromone traps and lures for yellow stem borer.

14. Integrated Pest Management of shoot and fruit borer in brinjal in rabi 2021.
15. Regular monitoring of various crops to know pest situation in the village.
16. Conducted an interactive session cum awareness programme on "Use of bioagents and biopesticides in pest management" on 5 February, 2021 in the village
17. Exposure visit of farmers of the village to the scheme on 25 February,2021.

TNAU

Table 306.

S.No.	DATE	VISITORS	PURPOSE
1	16.06.20	Mr.Ranjith Kumar, Parry AgroPvt.Ltd Vaalparai	To know Mass culturing of *Corcyra cephalonica.*
2	07.07.20	Mr.Hariharan Eco-care Bio-Solutions Pvt.Ltd, Trichy	To know about mass culturing of *Corcyra cephalonica.*
3	20.07.20	Mr.Bala Krishnan Sree Ramakrishna Kudil, Trichy	To get *Acerophagus papaya* for control of mealybug.
4	05.03.21	Mr.RamaKrishnan Cryptox Bio-solutions, Kanyakumari	To know about C*hrysoperla* rearing

35.5 Awards/Honours/Recognition

AAU, Anand

1. Raghunandan, B. L., N. A. Bhatt and N. B. Patel awarded the best poster award (second position) for the paper entitled 'Bio-efficacy of different formulations of entomopathogenic fungi against leaf eating caterpillar *Spodoptera litura* (Fab.) under laboratory condition' in 'National Symposium on Plant Health Management' organized by Dept. of Plant Pathology and Entomology, College of Agriculture, Navsari Agriculture University, Bharuch campus during 2-4th November 2020

KAU, Vellayani

1. Received best poster presentation award and best oral presentation awards in National seminars.

CPCRI

1. Dr A. Joseph Rajkumar, Principal Scientist is bestowed with Prof. T.N. Ananthakrishnan Award for Senior Scientist 2018-2019 (Third position) in recognition for the outstanding research contributions in the field of coconut entomology. The award carried a citation and a cheque for Rs 10000/-. Received the prestigious Award from Board of Directors, Prof. T.N. Ananthakrishnan Research Foundation, Entomology Research Institute, Chennai on December 15, 2020 during the National Conference.

DYSPUHF, Solan

1. P. L. Sharma received best oral presentation award in Sixth National Conference on Biological Control: Innovative Approaches for Green India held held at

Bengaluru, 3-5 March, 2021 for the following paper: Sharma, P. L. Verma, S. C. Chandel, R. S. and Nidhi. 2021. Biointensive management of invasive South American tomato leafminer, *Tuta absoluta.* Presented in Sixth National Conference on Biological Control: Innovative Approaches for Green India held held at Bengaluru, 3-5 March, 2021, Abstract Book, p.115.

GBPUAT

1. Best Oral Presentation Award on Bio-intensive Management of Major Diseases in Vegetable Cultivation on Uttarakhand by Bhupesh Chandra Kabdwal, Roopali Sharma and J. Kumar in the Sixth National Conference on Biological Control "Innovative Approaches for Green India", March, 2021, Bengaluru, India.

PAU, Ludhiana

1. Dr. P. S. Shera, got Scientist Award – 2020 from Dr. B. Vasantharaj David Foundation, Chennai.

PJTSAU

1. Dr. G. Anitha was awarded "Mega Records Sevaratna Award" for contribution to organic farming on 25 November, 2020 at Phoenix Open Theatre, Near Lime tree hotel, Hitech City, Hyderabad
2. Dr. G. Anitha was awarded "Best Woman Researcher" award for her contribution to the field of agriculture at International Scientist Award 2021 on Engineering, Science and Medicone on 26-27 February, 2021 at Hyderabad.
3. Dr. G. Anitha received the "Best Poster Award" at "National Web-symposium on "Recent Advances in Beneficial Insects and Natural Resins and Gums" organized by Society for Advancements of Natural Resins and Gums and ICAR – Indian Institute of Natural Resins and Gums, Ranchi , February 25-26, 2021 for work on "Species composition and relative abundance of Egg Parasitoids of Yellow Stem Borer, *Scirpophaga incertulas* in *kharif* rice"

SKUAST, Srinagar

1. Best oral presentation award certificate on Field efficacy of entomopathogenic nematodes against two lepidopteran pests infesting kale, *Brassica oleracea* L. var. k*hanyari*in Kashmir valley by Dr./Mr./Ms. M. Jamal Ahmad, Tarique, H. Askary, JagadeeshPatil, Sajad Mohiudin and Malik Mukhtar at Sixth National Conference on Biological Control: Innovative Approaches for Green India held at Bengaluru, 3 - 5 March, 2021.
2. Acting as P.I. Bio control of SKUAST-K, centerw.e.f. June' 2014.
3. Acting as Major Advisor for Ph.D. student entitled "Use of *Trichogramma* in the management of insect pests of cabbage in Kashmir".
4. As major guide, M.Sc. degree awarded on "Bio efficacy and Biological studies of anthocorid bug, *Blaptostethus pallescens* against two spotted spider mite, *Tetranychus urticae* infesting carnation in Kashmir.
5. Acting as major guide of fresh Ph. D. student, Jasra Bano.
6. Acting as major guide of fresh M. Sc. Student, Kaneez Fatima.

7. As co guide of student of Zoology Department, Kashmir University, Hazratbal, Ph.D. thesis awarded on Taxonomy of family Pteromalidae (Hymenoptera : Chalcidoidea) of Kashmir .
8. Acting as Advisory member of Ms. I frahim Zehra, M. Sc. Division of Entomology, SKUAST- K.
9. Acting as Advisory member of Adil Rasool, M. Sc. Division of Entomology, SKUAST- K.
10. Acting as Advisory member of Baber Pervez, M. Sc. Division of Entomology, SKUAST- K.
11. Acting as committee member for the package of practice in Royal Golf Course, Srinagar.
12. Acting as Dean P.G. nominee of Ms. ArifaGulzar, M.Sc. student of Division of Plant Pathology, SKUAST-K.
13. Acting as Dean P.G. nominee of Ajazul MumtazKhatana, M. Tech. student of College of Engineering, SKUAST-K.
14. Acting as Dean P. G. nominee of Javed Ahmad Dar, Ph. D. student of Division of Plant Pathology, SKUAST-K.
15. Acting as Co P. I. Bio control of SKUAST-K, centrew.e.f. June' 2020.
16. Major Advisor to M.Sc. student with thesis title "Field efficacy of newer insecticides against major insect pests of cauliflower".
17. Acted as Co Advisor to M.Sc. student with thesis title "Studies on Population Dynamics and Spatial Distribution of Insect Pest Complex of Rose with special reference to sucking pests".
18. Acting as Co Advisor to Ph.D. student with thesis title "Dissipation Behaviour of some Fungicides used against scab of Apple under Kashmir conditions".

UAS, Raichur

Table 307.

Sl. No.	Name and designation of Scientist	Name of Award / Recognition / Distinctions	Awarding Institute
1	Arunkumar Hosamani	Best Research Scientist Award - 2019-20	UAS, Raichur

35.6 Education &Training

AAU, Anand

Table 308.

Sr. No	Date	Village & Taluka	No. of farmers attended
1	29/9/2020	Village: Vanaji Ta. Garudeshwar, Dist. Narmada	50
2	9/3/2021	Village: Motiraval Ta. Garudeshwar, Dist. Narmada	25
3	16/3/2021	KVK Dediapada, Dist. Narmada	50

1. Dr. N. B. Patel delivered lecture on "Shakbhaji Pakoma Sanklit Jeevat Vyavasthapan" in State level Webinar on "Shiyalu Shakbhaji Pakoma Pak Sanrakshan" jointly organized by Plant Protection Association of Gujarat (PPAG) and Anand Agricultural University, Anand on 06/10/2020.
2. Dr. N. B. Patel delivered lecture on "Shakbhaji Pakoma Jeevatonu Jaivik Vyavasthapan" in State level Webinar on "Sajeev Khetima Pak Sanrakshan" jointly organized by Plant Protection Association of Gujarat (PPAG) and Anand Agricultural University, Anand on 27/10/2020.
3. Dr. N. B. Patel delivered lecture on "Primary concept and importance of IPM in agriculture" in certificate course on "Diploma in Agricultural Extension Services for Input Dealers (DAESI)" on 08/01/2021.
4. Dr.Raghunandan B. L. delivered lecture on 'Bio-pesticide Use in Organic Farming' in 'seven days online training programme on organic farming'conducted by Regional Centre of Organic Farming (RCOF), Gandhinagar (Guj.) on 24.8.2020, 10.3.2021 and 19.3.2021

AAU, Jorhat

1. Dr. D. K. Saikia has been appointed as OSD, Sericulture College; Professor & Head, Department of Entomology and Professor & Head, Department of Sericulture by honorable VC, AAU, Jorhat.
2. Dr. D. K. Saikia, Principal Scientist was appointed as external question setter for Umroi, UmiamMeghalya for comprehensive examination.
3. Dr. D. K. Saikia, Principal Scientist was appointed as examiner for thesis evaluation of M. Sc. (Ag.) of Nagalang University.
4. Dr.D.K.Saikia, Principal Scientist conducted Ph.D courses on Recent trends in Biological control (ENT-606)),Advanced Insect Ecology (ENT 604), Insect Behavior (ENT- 605) and Advanced IPM (ENT-612)
5. Seven Ph.D students are being carried out P.G. research work under the guidance of Dr.D.K.Saikia,
6. Dr. D. K.Saikia , Principal Scientist act as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) students
7. Dr.D.K.Saikia , Principal Scientist impart coaching to UG students for JRF examination
8. Dr.D.K.Saikia act as a Co- investigator in the Biopesticides programme under DBT –AAU, Centre
9. R. N. Borakakati, Jr. Scientist acted as a course leader of UG course "Pests of crops, stored grain and their management" (Ento- 323). Besides this he also acts as course instructor of PG courses Biological Control (ENT 507) and Integrated Pest Management (ENT-510)
10. R. N. Borakakati, Jr. scientist, act as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) students

Resource Person in Training Programme: **Table 309.**

Sl. No.	Programme	Place	Resource person	Date	Trainee
1	Training programme to extension functioneries	ETC, Naltali, Nagaon	R. N. Borkakati	11.02.2021	ADO and Sr. ADO

Training cum material distribution **Table 310.**

Sl. No.	Date	Topic	Place	Target
TSP programme				
1	23.09.2020	Training cum material distribution under TSP programme	Sekuria, Titabor, Jorhat	Tribal Farmers (50)
2	24.09.2021	Training cum material distribution under TSP programme	Neulgaon, Allengmora, Jorhat	Tribal Farmers(50)
3	04.10.2020	Training cum material distribution under TSP programme	Dangdhora, Jorhat	Tribal Farmers(50)
4	14.10.2020	Training cum material distribution under TSP programme	Solguri, Bampothar, Jorhat	Tribal Farmers(50)
5	19.02.2021	Training cum material distribution under TSP programme	LahangKachari, Jorhat	Tribal Farmers(25)
6	20.02.2021	Training cum material distribution under TSP programme	Sekuria, Titabor, Jorhat	Tribal Farmers (25)
Normal training				
1	15.10.2020	BIPM of Field and Vegetable Crops	Hahchora, Mahuramukh, Golaghat	Progressive farmers (40)
2	16.10.2020	BIPM of Field and Vegetable Crops	Dangdhora, Jorhat	Progressive farmers (40)
3	19.10.2020	BIPM of Field and Vegetable Crops	Neulgaon, Allengmora, Jorhat	Progressive farmers (40)
4	20.10.2020	BIPM of Field and Vegetable Crops	Bohuabheti, Kachamari, Nagaon	Progressive farmers (40)
5	21.10.2020	BIPM of Field and Vegetable Crops	Bamungaon, Kachamari, Nagaon	Progressive farmers (40)
6	06.02.2021	BIPM of Field and Vegetable Crops	Barjan, Choudungpothar, Golaghat	Progressive farmers (30)
7	08.02.2021	BIPM of Field and Vegetable Crops	2 No. Butalikhowa, Khumtai, Golaghat	Progressive farmers (30)
8	09.02.2021	BIPM of Field and Vegetable Crops	Solguri, Majgaon, Titabor, Jorhat	Progressive farmers (32)

Glimpses of the Training programme

Training, summer institute, winter school, seminar, conference, symposium etc. attended during the year:

Scientist: R. N. Borkakati **Table 311.**

Topic/theme of the training etc.	Duration		Venue	*Nature of participation
	From	To		
National Webinar on "Advances on Disease and Pest Management for Sustainable Banana Industry" by Assam Agricultural University, Jorhat-13	July 4, 2020.		Online platform	Active Participation
International Webinar on the theme "HORTICULTURE INDUSTRY UNDER COVID-19 PANDEMIC" jointly organized by Department of Horticulture and College of Horticulture, Assam Agricultural University, Jorhat in association with NAHEP.	27th August , 2020	28th August , 2020	Online platform	Active Participation
IYPH Web Series – "'Bio-Security Strategies for Sustainable Plant Health: Protect Domestic Plant Health, Promote Export'" organized by NIPHM Rajendranagar, Hyderabad - 500 030	29th August, 2020	29th August, 2020	Online platform	Active Participation
Technical Webinar cum training on 'Integrated Pest Management for Maize Crop with special reference to fall armyworm in NEH region" organized by FAO India(11.00-13.30hrs) and ICAR-IIMR	4th September, 2020	4th September, 2020	Online platform	Active Participation
IYPH Web Series – "Plant Health Management for Sustainable Agriculture" organized by NIPHM Rajendranagar, Hyderabad - 500 030	4th September, 2020	4th September, 2020	Online platform	Active Participation

Training on “Impact of climate change on insect pests” organized by NIPHM Rajendranagar, Hyderabad - 500 030	7th September, 2020	11th September, 2020	Online platform	Active Participation
Training on “Fruit-fly Surveillance and Management” organized by NIPHM Rajendranagar, Hyderabad - 500 030	21st September, 2020.	25th September, 2020.	Online platform	Active Participation
Training on “Stored Grain Pest Detection, Identification and Management” organized by NIPHM Rajendranagar, Hyderabad - 500 030	5th October, 2020.	9th October, 2020.	Online platform	Active Participation
Training on “Introduction to Plant Biosecurity & Plant Quarantine” organized by NIPHM Rajendranagar, Hyderabad - 500 030	12th October, 2020.	16th October, 2020.	Online platform	Active Participation
Training on “Pesticide application methods and safety measures” organized by NIPHM Rajendranagar, Hyderabad - 500 030	19th October, 2020.	23th October, 2020.	Online platform	Active Participation
Training on “RS & GIS applications in Agriculture” organized by NIPHM Rajendranagar, Hyderabad - 500 030	26th October, 2020.	28th October, 2020.	Online platform	Active Participation
Training Programme on “Analysis of Experimental Data Using SAS (On-Line)organizedby ICAR-National Academy of Agricultural Research Management Rajendranagar, Hyderabad 500 030	09-11-2020	14-11-2020	Online platform	Active Participation

ANGRAU

Farmers training programmes:

1. TSP programme on Biointensive pest management in paddy, maize, groundnut, rajmah, millets, turmeric and ginger; Encouraging Bee keeping was done in Araku valley and chinthapalli division, Visakhapatnam district, Andhra Pradesh .
2. Conducted awareness programme on organic farming in vegetables at Kothapalli, Chinthpallimandal on10.12.2020; at Kollaput, Dumbrigudamandal on 17.12.2020.

3. Conducted Training programme on Bee keeping at Kollaput on 17.12.2020 at Kollaput, Dumbriguda and issued Apiary units (10 No.) to a group of women farmers and established Ecovibes Apiary unit for empowering Arakuvalley tribal women

Production of Biocontrol agents :

1. Mass multiplication of *Trichogramma chilonis* with new protocol (2010) developed by NBAIR, Bangalore.
2. Mass multiplication of *Trichogramma japanicum, Trichogramma pretiosum* .

Production of Entomopathogenic fungi (EPF) :

1. Mass production of Entomopathogenic fungi, *Beauveria bassiana (ICAR-NBAIR Bb45) and Metarhizium anisopliae(ICAR-NBAIr Ma35)* formaize fall army worm management .
2. Initiated production of Entomopathogenic fungi, *Isaria fumosorosea* (ICAR-NBAIR Pfu-5) as conidiatedrice with protocol of NBAIR, Bangalore for the management of Coconut spiraling whitefly.

Mass production of Biocontrol agents - Revolving fund :

1. Mass production of egg parasitoid,*Trichogramma chilonis* and sale of Trichocards to farmers, Daattcentes, sugar fairies And department of agriculture and Revenue generated with Trichocards and Corcyra eggs was Rs.1,12,250.00 .

Technical guidance to Biocontrol labs at Sugar factories :

1. 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.

Virtual meetings attended :

1. Dr. M. Visalakshi, Principal Scientist (Entomology) participated in Virtual meet on Desert Locust held on 05. 06. 2020 organised by ICAR-NBAIR, Bangalore .

Review meeting of AICRP on Biological control :

1. Dr.M.Visalakshi, Principal Scientist (Entomology) attended Virtual Review meeting on Progress AICRP on Biological control of crop pests organized by Project coordinator and Director, NBAIR and presented the progress of the ongoing programmes and activities of ANGRAU centre through power point on 14.9.2020 .

AICRP on Biological Control EFC meeting :

1. Dr.M.Visalakshi, Principal Scientist (Entomology) attended virtual EFC meeting on 30.9.2020 organised by Project coordinator (biological control) , ICAR-NBAIR.

Distance learning course on Organic farming :

1. Dr.M.Visalakshi, Principal Scientist (Entomology) gave lecture on “Role of Biopesticides and Biocontrol agents in Organic farming” on 26.9.2020 organised by Open and Distance learning Centre, ANGRAU through online for 455 participants of organic farming certificate course.
2. Training Prgrammesorganized :

3. Dr.M.Visalakshi, Principal Scientist (Entomology) organized Farmers training programme on the occasion of World soil day on 05.12.2020 at RARS,Anakapallle, imparted training on Conserving soil biodiversity using biopesticides in pest management for 30 farmers under AICRP on Biological control .
4. Dr.M.Visalakshi, Principal Scientist (Entomology) organized awareness programme on organic farming in vegetables at Kothapalli, Chinthpallimandal on10.12.2020; at Kollaput, Dumbrigudamandal on 17.12.2020 for 25 tribal farmers under TSP-AICRP on Biological control.
5. Dr.M.Visalakshi, Principal Scientist (Entomology) organized awareness programme on organic farming in vegetables at Kollaput, Dumbrigudamandal on 17.12.2020 for 25 farmers under TSP-AICRP on Biological control.
6. Dr.M.Visalakshi, Principal Scientist (Entomology) organized Training programme on Bee keeping at Kollaput on 17.12.2020 at Kollaput, Dumbrigudaand issued Apiary units (10 No.) to a group of ten women tribal farmers under TSP-AICRP on Biological control.
7. TSP programme on Biointensive pest management in paddy, maize, groundnut, rajmah, millets, turmeric and ginger; Encouraging Bee keeping was done in Araku valley and chinthapalli division, Visakhapatnam district, Andhra Pradesh . Conducted awareness programme on organic farming in vegetables at Kothapalli, Chinthpallimandal on10.12.2020; at Kollaput, Dumbrigudamandal on 17.12.2020.
8. Conducted Training programme on Bee keeping at Kollaput on 17.12.2020 at Kollaput, Dumbriguda and issued Apiary units (10 No.) to a group of women farmers.

Trainings participated :

1. Dr. M. Visalakshi, Principal Scientist (Entomology) participated in Training programme on Production Protocols of microbilas and biopesticides organized by NIPHM, Hyderabad from 30.11.2020 to 4.12.2020
2. Dr. M.Visalakshi, Principal Scientist (Entomology) undergone Training on Recent Advances in entomology- New Dimensions to Invigorate the Insect Pest Management organized by Department of Entomology, College of Horticulture, Bidar, Karnataka for 10 days from 07.12.2020 to 18.12.2020
3. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in Training programme on Role of organic farming in plant health management organized by NIPHM, Hyderabad from 22.12.2020 to 24.12.2020
4. Dr. M. Visalakshi, Principal Scientist (Entomology) attended as a external examiner in conducting semester final theory examinations of Diploma course at BeharaAgriculturtal polytechnic, Kotyada, L.Kota, Vizianagaram district on 23.1.2021.
5. M. Visalakshi, Principal Scientist (Entomology) conducted training about biocontrol agents to Agricultural college, Mysore students under RAWEP visited Bioicontrol lab on 18.1.2021.

CAU, Pasighat

1. The AICRP on Biological Control of Crop Pests and Diseases, CAU-Pasighatcentre has organized two farmers' capacity building training programmes on biocontrol under ICAR-NBAIR-NEH Fund. The details are mentioned below.
2. Three days Farmers' Training Programme on 'Biointensive Pest Management in Tomato and Cabbage' conducted during 16th to 18th February 2021 at CHF, Pasighat in on campus mode. With an objective to create awareness and promote on biological control 30 farmers were selected from the Jampani village as the latter is known for vegetables production and using of chemical pesticides. The topics covered and resource persons involved are as follows.
3. Three days Farmers' Training Programme on 'Biological Control of Mustard and Maize Pests' held during 17th to 19th March 2021 at Taki Lalung Village in off campus mode. Around 30 farmers were benefitted from the programme by undergoing training on different aspects of biointensive pest and disease management in field crops with special reference to maize and mustard. The topics covered and resource persons involved are as follows.

CPCRI

1. In the virtual platform held on 03-08-2020, the holistic package on rugose spiralling whitefly was discussed and finalized. Conservation biological control using the aphelinid parasitoid, *E. guadeloupae* and sooty mould scavenger beetle, *L. nilgirianus*, installation of yellow sticky traps, jet water spraying or application of 5% neem oil in severe cases, nutritional management and ecological engineering using intercrops are the major technologies evolved to mitigate the pest successfully.
2. During the AICRP on palms Annual workshop, a special talk on invasive whiteflies infesting coconut was delivered on 11-08-2020 in virtual platform for general awareness and correct diagnosis for holistic suppression.
3. A farmer-scientist interface was conducted virtually on 02-09-2020 with coconut farmers from Anaimalai, Polllachi, Tamil Nadu and highlighted on good agricultural practices and safe use of insecticides on coconut A training session on integrated crop management in coconut to farmers belonging to Devikulankara panchayat was conducted on 23-09-2020 in an open field under tree shade.
4. A skill demonstration programme on crop pluralism and pest management was imparted and this marks the first field training session after COVID lockdown.
5. An online technical session on Pest management in coconut for the farming community of Mullasseri was convened on 24-11-2020 empowering the farmers on advanced pest management solutions in coconut.
6. A *krishipadasala* was convened on 11-02-2001 on palm health management for the benefit of Trikunnapuzha farmers.
7. Training on scientific coconut farming techniques was conducted at Navsakthi Trust, Thazhava on 03-03-2021 organized by State Department of Agriculture Development and Farmer's welfare.

DYSPUHF, Solan

Trainings organized **Table 312.**

SN	Title of training	Place	Date	No of participants
1	Eco-friendly management of insect-pests of crops under TSP	Pooh, Kinnaur	23.10.2020	20
2	Eco-friendly management of insect-pests of crops under TSP	Urni , Kinnaur	24.10.2020	20
3	Conservation of biocontrol agents through Subhash Palekar Natural Farming	Narag, Sirmaur	26.11.2020	25
4	Conservation of biocontrol agents through Subhash Palekar Natural Farming	Dilman, Sirmaur	28.12.2020	25
5	Preparations of formulations on Natural Farming in a training programme on New Vistas in Temperate Fruit Production w.e.f 17-31 December,2020	YSP UHF Nauni	30.12.2020	30 (SMS)
6	Role of biocontrol agents in high density apple plantation	Ser (Rajgarh)	24-03-2021	60
	Total			180

DYSPUHF, Solan

Teaching and Courses taught: **Table 313.**

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	D. 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

Students guided:

Table 314.

SN	Student Name	Degree	Title of thesis	Guide
1	Nidhi	PhD	Studies on the effect of host plants and insecticides on the performance of *Neoseiulus longispinosus* (Evans) against *Tetranychus urticae* Koch	PL Sharma
2	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
3	RiteshJamwal	MSc	Predatory potential of minute pirate bug, *Blaptostethus pallescens* Poppius against *Tuta absoluta* (Meyrick) in tomato	PL Sharma
4	Anamika Walia	MSc	Studies on parasitisation potential of *Encarsia formosa* Gahan against greenhouse whitefly, *Trialeurodes vaporariorum* (Westwoo)	SC Verma
5	Bhisham Dev	MSc	Evaluation of entomopathogenic fungus, *Nomuraea rileyi* Farlow (Samson) against *Helicoverpa armigera* (Hubner)	SC Verma
6	Shikha Katoch	MSc	Studies on spatial distribution of pea leaf miner parasitiods and evaluation of *Diglyhpus horticola* Khan against *Chromatomyia horticola* (Goureau)	PL Sharma
7	Shagun Thakur	MSc	Predatory potential of *Blaptostethus pallescens* Popp against *Tetranychus urticae* Koch and its intraguild predation on *Neoseiulus longispinosus* (Evans).	PL Sharma
8	Tanvi Sharma	MSc	Seasonal abundance and parasitization potential of *Diaeretiella rapae* M'Intosh against *Brevicoryne brassicae*(L.) in cauliflower	SC Verma
9	Pryianka Sharma	PhD	Studies on natural enemy complex of *Macrosiphum euphorbiae* (Thomas) infesting tomato and potato	PL Sharma
10	JashanjitThind	Ph.D	Yet to be decided	SC Verma
11	Vibhuti Sharma	Ph.D	Yet to be decided	SC Verma
12	Nikita Chauhan	Ph.D	Yet to be decided	PL Sharma

13	Shubham Sharma	M.Sc	Yet to be decided	PL Sharma
14	Prajjaval Sharma	M.Sc	Yet to be decided	PL Sharma
15	Shikha Thakur	M.Sc	Yet to be decided	SC Verma

KAU, Vellayani

The centre conducted two awareness programme to farmers on the potential of use of biopestcides in major crops of Kerala at two different panchayaths Vilavoorkkal and Malayinkeezh. The participants were trained on the use of bioagents and EPF formulations and pheromone traps were distributed free of cost to the farmers. The programme was restricted to 30 participants per programme, observing covid protocol.

KAU, Thrissur

Post/under graduate teaching

Scientists of the project have been handling classes on biocontrol and IPM for U.G, P.G. and Ph. D programmes as well as guiding M.Sc and Ph.D students on regular basis

Table 315.

Sl. No	Date of training/class/ interface	Topic	Venue	Beneficiaries	Organised by
1	9-9-20	Biocontrol of crop pests	Kallichithra colony, Varantharappalli	ST farmers	AICRP on BCCP, Thrissur
2	23-6-20	Farmer-scientist interface	Virtual meeting	Farmers of Ollukkara block	KVK, Thrissur
3	28-7-20	Farmer-scientist interface	Virtual meeting	Farmers of Mathilakam block	KVK, Thrissur
4	24-8-20	Farmer-scientist interface	Virtual meeting	Progressive farmers, Thrissur district	KVK, Thrissur
5	27-1-21	Biopesticides	AICRP on BCCP	Pesticide dealers	CTI, mannuthy
6.	16-2-21	Biological control	AICRP on BCCP	DAESI Trainees	KVK, Palakkad
7.		Monthly Technology Advice meetings (MTA)	KVK, Thrissur	Dept. Officials of Thrissur District	KVK, Thrissur

MPKV,Pune

Education and Teaching

Table 316.

1	Dr. S. A. More worked as Associate Dean's representative for course of EXPL ENTO-488 (Sericulture) of VIII semester during 27.05.2020 to 29.05.2020 of AC, Akluj for online Semester end examination.
2	Dr. S.M. Galande and Dr. S. A. More attended online SAC meeting of I year M.Sc. (Agri.) students of entomology discipline on 23.06.2020. All staff members, guides and all students attended meeting on Google meet app.
3	Dr. S. A. More, worked as paper setter, conducted online Semester end theory examination and evaluated answer sheets and submitted results for the course of ENTO-507 (Biological Control of Insect) of II semester of M. Sc. (Agri.) on 13.07.2020.
4	Dr. S.M. GalandeandDr. S. A. More attended Virtual meeting 79th Meeting of Board of studies in Agril. Entomology held at MPKV, Rahurion) 13th and 14th August, 2020 and participated in discussion
5	Dr. S.M. Galandeworked as a ADR for online Village Attachment Examination of RAWE students of Agril. Engineering centre during 19 -20 Oct., 2020.
6	Dr. S. A. More conducted online Semester End Practical examination for the course ENTO 354 (N) during 7.12.2020 to 19.12. 2020.
7	Dr. S.M. Galande conducted online examination of RAWE students for SRP 403 during 23-24th Nov., 2020.
8	Dr. S. A. More worked as Invigilator for State Level MHTCET examination for Ph.D. on 31.10. 2020.
9	Dr. S.M. Galande conducted the Theory and Practical classes of Course No. ENT 510 : Principles of Integrated Pest Management under PG programme.
10	Dr. S.A. More conducted the Theory and Practical classes of Course No. ENT 501 : Insect Morphology, under PG programme.
11	Dr. S.A. More conducted the Theory and Practical classes of Course No, ENT 243 : Insect Ecology and IPM under UG programme.

MPUAT

Two farmer's training were conducted at farmers field in different villages and two trainings were conducted at RCA, Udaipur (On-Campus) to aware the farmers for biological control of crop pests in *Kharif* and *Rabi* seasons 2020-21.

Table 317.

S. No.	Locations	Crop	No. of farmers
1.	Brahmino ki Hunder (Madar)	Tomato	10
2.	Madar	Tomato	10
3.	Chanavada	Gram	20
4.	Karodia	Gram	12
	Total		52

Table 318.

S. No.	Locations	Date of training	No. of Participants
1.	Balewadi (Rishabhdev)	17.10.2020	41
2.	Madar (Badgaon)	29.01.2021	80
3.	RCA, Udaipur	11.02.2021	27
4.	RCA, Udaipur	10.03.2021	44
	Total		192

PAU, Ludhiana

Post/under graduate teaching

Table 319.

Teacher	No. of courses taught	
	PG	UG
Dr Neelam Joshi	3	2
Dr Parminder Singh Shera	2	1
Dr Rabinder Kaur	1	2
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	2
Dr Rabinder Kaur	2	1
Dr Sudhendu Sharma	-	1

Thesis evaluation / Viva-Voce

1. Dr P. S. Shera evaluated M.Sc. thesis and conducted viva-voce as external examiner of M.Sc. student from CSKHPKV, Palampur
2. Dr P.S. Shera acted as external examiner and conducted viva-voce of Ph.D. student from CSIR-IHBT, Palampur
3. Dr Neelam Joshi acted as a reviewer of 'Indian Journal of Entomology'
4. Dr P.S. Shera acted as reviewer ofInternational journals – Pakistan Journal of Agricultural Sciences and Journal of Pure and Applied Agriculture
5. Dr Sudhendu Sharma acted as a reviewer of 'International Journal of Tropical Insect Science'
6. Dr Rabinder Kaur acted as external examiner to evaluate the progress of JRF and SRF from Guru Nanak Dev University, Amritsar.

Table 320.

Training Programme	Venue	Dates
Insect pest management through non-chemical approaches	Birdwal (Patiala)	26.6.2020
Biocontrol on insect pests in *basmati* rice	Sakraudi (Sangrur)	29.7.2020

Biocontrol on insect pests in rice	Dhira Patra (Ferozepur)	14.8.2020
Eco-friendly management of sugarcane borers through biocontrol technology	Chaggran (Hoshiarpur)	20.11.2020
Biocontrol based integrated pest management technology for insect pests	NeelaNaloya (Hoshiarpur)	18.2.2021
Mass production of bioagents and their utilization for the management of major crop pests" for scientists and technical staff	Department of Entomology, PAU, Ludhiana	2.3.2021
Management of wheat insect pests by using non-chemical methods	BhojoMajri (Patiala)	8.3.2021
Validation and dissemination of biocontrol based technology in sugarcane	Garhshankar (Hoshiarpur)	9.3.2021

Table 321.

Sl.No	Exhibitions arranged on bioagents and biocontrol technologies	Date
1.	Farmers' awareness camp on "Biocontrol of insect pests on sugarcane, rice and maize" at village NeelaNaloya (Hoshiarpur)	18.2.2021
2.	Training on "Validation and dissemination of biocontrol based technology in sugarcane" at Garhshankar (Hoshiarpur)	9.3.2021

SKUAST, Srinagar

PG/UG teaching

1. Dr. Jamal Ahmad and Dr. Malik Mukhtarare involved in teaching of 4 different courses of UG and PG classes of Horticulture Courses (Entomology)
2. Prof. M. Yousuf, Dean, Faculty of Life Sciences, Central University of Kashmir, Ganderbal on 28.02. 2021.
3. Training
4. 30 trainees on 6.03.2021 to learn Mass production of *Trichogramma* and their field uses.
5. Senior scientist, Dr. Basheer A. Rather, KVK, HMAARI (High Mountain Arid Agriculture Research Institute) Leh, for construction of Bio control lab in Leh for mass production of *Trichogramma* for management of Codling moth in Leh.
6. Dr. Krishna Kumar, Prof. & Head, Entomology, Bidhan Chandra KrishiVishwaVidyalaya on 17.04.2021.
7. Provided training to farmers of Kargil for the Integrated management of Codling moth, *Cydia pomonella* infesting apple under Tribal Sub Plan in MAR & ES (Kargil) and KVK, Kargil on 8-9 October' 2020.
8. Provided training on 25th March' 2021 to participants of five days skilled training programme entitled, "**Integrated Pest Management in Apple**" conducted by Division of Entomology, on Mass production of *Trichogramma* and its field application for the management of Codling moth, *Cydia pomonella*.

9. Provided training to participants regarding "Survey and monitoring methods and their importance in pest management" on 24th March 2021 during five days skilled training programme entitled, " **Integrated Pest Management in Apple**" conducted by Division of Entomology.

SKUAST, Jammu

Title of the training: Role of beneficial microorganisms on soil health Number of farmers: 50 Location: ACHR Udheywalla.

Title of the training: Biological control in horticultural crop. Number of the farmers: 50. Location: ACHR Udheywalla.

Title of the training: Bio intensive pest management for vegetables and fruit crops. Number of farmers: 60. Location KotheySalehar, Bishnah, Samba

Title of the training: Integrated disease management in vegetables and fruit crops. Number of farmers: 60. Location: KotheySalehar, Bishnah, Samba.

Attending Monthly Training and Visit Workshops as Resource Person Entomology and Delivering lecture regarding Use of Bioagents and other alternative methods of pest management to the Department of Agriculture officials of District Samba – 17/01/2020, 10/02/2020, 05/03/2020, 27/01/2021, 26/03/2021, 06/04/2021.

Amount of biopesticides distributed during 2020 – 21 to various Krishi Vigyan Kendras of the SKUAST-JAMMU, SKUAST-KASHMIR, Department of Agriculture and farmers during various training programs, Kisan Mela etc. - 3.02 quintal

Table 322.

Name of the programme &the place	Date (s)	No. of Lectures	No. of participants (Approx.)
Lecture delivered on 'Bio intensive pest management for vegetables and fruit crops' in a training programme organized by ACRA, Dhiansar at Village KotheySalehar, Bishnah, Jammu	26.03.2021	One	50 (Farmers)
Delivered a lecture on '*Utilizing Entomopathogens for the Management of Insect Pests'* in a training programme on "Role of Biofertilizer in Plant Growth and Soil Fertility" organized by SAMETI, Jammu, SKUAST-J, Main Campus, Chatha	03.03.2021	One	30 (Department of Agriculture officials)
Delivered lecture in a one day training program in the farmer's field, village Jinder Melu, District Jammu, J&K on the topic '*Recent Advances in Use of Biopesticides*', under RKVY Project and also interacted and advised the farmers regarding the entomological problems faced by them.	23.03.2021	One	70 (Farmers)

Delivered lecture in a one day training program in the farmer's field, village Nandpur, District Jammu, J&K on the topic '*Recent Advances in Use of Biopesticides*', under RKVY Project and also interacted and advised the farmers regarding the entomological problems faced by them.	25.03.2021	One	50 (Farmers)

TNAU

UG courses:

EXP401 – Commercial production of biocontrol agents (0+5) – Dr. S. Jeyarajan Nelson and Dr.R.Vishnupriya

AEN 301 Pests of field crops and stored produces and their management (1+1) - Dr.S.Jeyarajan Nelson

Ph.D courses :

ENT 606 Recent trends in biological control (1+1) - Dr.S.Jeyarajan Nelson

Table 323.

Sl.No.	Title of the training /lecture	Beneficiary /participants	Date	Sponsor
1	Mass Production of bio-control agents	Officials from Dept. Biocontrol Unit, Salem -2Nos.	o4.05.20	Dept. of Agriculture, TamilNadu
2	Mass production of bioconrol agents of rugose spiralling whiteflies issues and prospects	one day brain storming webinar on "Coconut whiteflies:Issues, Managemet and Way forward"	09.11.20	TNAU, Coimbatore
3	Mass Production of bio-control agents	Entrepreneurs-40Nos	07.01.21	ICAR-KVK,MYRADA Erode (dt).
4	Mass Production of bio-control agents	Scientist -	05.02.21	PJTSAU, Rajendranagar Hyderabad -30
5	Natural enemies of insect pests and biological control	Students -15Nos.	24.02.21	Institute of Forest Genetics and Tree Breeding, Coimbatore
6	Mass Production of bio-control agents	Students – 15 Nos.	26.02.21	Institute of Forest Genetics and Tree Breeding, Coimbatore
7	Mass Production of bio-control agents	B.Sc.(Horticulture) Students-29 Nos	02.03.21	TNAU, Coimbatore
8	Mass Production of bio-control agents	B.Sc.(Horticulture) Students-31 Nos.	03.03.21	TNAU, Coimbatore
9	Mass Production of bio-control agents	B.Tech. (Bio-tech.) Students-49 Nos.	05.03.21	TNAU, Coimbatore

10	Mass Production of biocontrol agents	Farmers-2 Enterpreneurs-3	05.03.21	Paid training – Venture Capital scheme

UBKV

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

35.7 Radio/TV talk

AAU, Jorhat

1. Hello Krishi darshan (Door Darshan Programme) Episode:3758 [Telecasted on 4.11.2020(5.00-6.00pm)].
2. Live phone in programme(Kishanvani) by AIR JORHAT (Broadcasted on 11.02.2021).
3. Radio programme "SanghataKeetPotangaNiyantran" (AIR DIBRUGARH) (Recorded on 12.03.2021 and Broadcasted on 14.03.2021).
4. Hello Krishi darshan (Door Darshan Programme) Episode:3758 [Telecasted on 31.03.2021(5.00-6.00pm)].

ANGRAU

1. Participated in Review meeting on Status of production of Biofertilizers, Byproducts and biopesticides at ANGRAU, Guntur on 30.3.2021 and presented the Activities of AICRP on Biocontrol nd production of Biocontrol agents and Biopesticides.
2. Attended T&V monthly meeting online through jio meet on 28.8.2020 and interacted on Biocontrol agent usage in current crops (paddy and maize) and will be supplied for demonstrations of polambadi.
3. Attended T&V monthly meeting online through jio meet on 24.9.2020 and interacted on Biocontrol agent usage in current crops (paddy and maize) and will be supplied for demonstrations of polambadi.
4. Attended T&V monthly meeting online through jio meet on 31.10.2020.
5. Participated as resorce person in Review meeting on Convergence activities of KVKs and DAATTCs with RBKs and Delivered talk on Biopesticides and Biocontrol agents in organic farming on 3.4.2021 at RARS,Anakapalle.
6. Attended PRE-ZREAC meeting of RARS, Anakapalle on 8.4.21 and 9.4.21 and presented the work done 2020-21 and proposed technical programme for 2021-22 and also participate in the deliberations.

DYSPUHF, Solan

1. Dr. P. L. Sharma and Dr. S. C. Verma participated in Krishi Darshan Live Phone in Programme on Biocontrol of Horticultural Crop Pests at Doordarshan Shimla on 10-11-2020.
2. Dr. P. L. Sharma and Dr. S. C. Verma participated in live phone in programme of Doordarshan Shimla on 10-11-2020. The programme was focussed on the role and use of biocontrol agents for the management of horticultural pests. Biocontrol

agents of major fruit crops were displayed on TV to make more and more farmers aware about the commonly occurring bioagents in the field. Farmers also interacted through live phone in programme regarding the use of *Metarhizium anisopliae* and light traps for apple root borer management, use of predatory mite and conservation of woolly aphid parasitoids. Farmers also enquired about the harmful effects of chemical insecticides and their safe use. One farmer discussed about the possibility of changes in pest scenario in apple in the context of climate change and shift in apple cultivation from low to high density plantation.

3. Scientists participating in live phone-in programme at Doordarshan Shimla.

SKUAST, Srinagar

1. Acted as External Examiner of M.Sc. students for practical exam and viva in the Central University of Kashmir on dated 31.12.2020.
2. Delivered radio talk on 4th May 2020 regarding "Insect pest management in fruit crops during the month of May".
3. Delivered radio talk on 8th May 2020 regarding "Insect pest management in vegetables during the month of May".
4. Delivered radio talk on 11th May 2020 regarding "Insect pest management in field crops during the month of May".

UAS, Raichur

Table 324.

Sl.No	Activity	No.
1	Field visits	65
2	Diagnostic visits	45
3	All India Radio Programme	03
4	News paper coverage	02
5	Advisory messages	100
6	Phone calls attended	2500
7	Farmers visit to Bio control lab for pest and disease diagnosis and management	500
8	On youtubehttps://www.youtube.com/watch?v=QOHGOYCMd9c mass production is posted	03
9	On Google map visit biocontrol lab https://goo.gl/maps/FAR5PnyXJRB39KGd7	

CPCRI

1. The radio talk on "Integrated Management of rhinoceros beetle, red palm weevil and exotic whiteflies infesting coconut" has been re-broadcast on 22-09-2020, 09-11-2020 and 19-11-2020 during the *VayalumVeedum* programme by *Prasar Bharathi*, Thiruvananthapuram.

UBKV

Table 325.

Newspaper Coverage on Extension activities of AICRP Biocontrol

S.No.	Headline of coverage	Date of release	Name of Newspaper
1.	Nurpur-e Sorshechashebeej o saarbitoron	25.11.2020	Uttar Banga Sangbaad
2.	Modhu o Sorshe Chase GhooreDarachheNurpurgraam	30.01.2021	Volka Samachar

35.8 Post/Under graduate teaching

AAU, Anand

Table 326.

S.No.	Name of Teacher	Courses offered	PG Students Guiding
1.	Dr. N. B. Patel	ENT 606 : Recent Trends in Biological Control (1+1)	2 (M. Sc)
		ENT 513 : Storage Entomology (1+1)	
		ORG PP 502: Biological Control of PestandDisease (2+1)	
		Ag.Ento. 2.2 : Principles of Integrated Pest Management (2+1)	
		Ag. Ento. 4.2 : Principles of Integrated Pest Management (1+1)	
2.	Dr.Raghunandan B.L.	ENT 611 : Molecular Approaches in Entomological Research (1+1)	1 (M. Sc)
		ENT 506 : Insect Pathology (1+1)	
		MICRO 509 : Plant Microbe Interactions (3+0)	
		MICRO 506 : Food and Dairy Microbiology (2+1)	
		Ag. Micro 6.2 : Biopesticides and Biofertilizers (2+1)	

IGKV

Table 327.

S.No	Name of Teacher	Courses offered	PG Students Guiding
1	M.Sc. (Ag.) Prev	ENT-501 - Insect Morphology- (I semester) 2(1+1). ENT-502 - Insect Anatomy, Physiology and Nutrition- (II semester) 3 (2+1).	5
2	Ph.D.	ENT- 606 - Recent Trends in Biological Control - (I semester). ENT- 611 - Molecular Approaches in Entomological Research - (II semester)2(1+1).	5

35.9 LIST OF PUBLICATIONS

AAU, Jorhat

Research papers

1. Buragohain, P. Saikia, D. K. Cardona, P. S. and Srinivasan, R. (2021) Development and validation of an integrated pest management strategy against the invasive South American tomato leaf miner, *Tuta absoluta* in South India. *Crop Protection*, 139: 105348.
2. Saikia, D. K. Borkakati, R. N. Venkatesh, M. R . and Barman, S. (2020) Role of Weather Parameters on Population Build Up of Minor Insect Pests of Brinjal. *International Journal of Current Microbiology and Applied Sciences*, 9(07): 397-402.
3. Pradhan, P. P. Borkakati, R. N. and Saikia, D. K. (2020) Insect pests of mustard and their natural enemies in Assam. *International Journal of Current Microbiology and Applied Sciences,* 9(07): 2785-2790.
4. Saikia, D. K. and Borkakati, R. N. (2020) Evaluation of Anthocorid Predators against Storage Pests of Rice in Assam Situation. *International Journal of Current Microbiology and Applied Science,* 9(8): 3180-3185.
5. Borkakati, R. N. and Saikia, D. K. (2020) Evaluation of IPM for the management of insect pests of Okra. *J EntomolZool Stud*, 8(4): 2197-2200.
6. Borkakati, R. N. and Saikia, D. K. (2020) Effect of Weather Parameters on Population Buildup of Predatory Coccinellids and Spiders Present in Brinjal Crop Ecosystem of Assam. *International Journal of Current Microbiology and Applied Science,* 9(9): 114-117.
7. Borkakati, R. N. Saikia, D. K. and Venkatesh, M. R. (2020) Development of BIPM module against brinjal shoot and fruit borer, *Leucinodes orbanalis* Guenee for North-east India. *Indian Journal of Entomology*, 82(4): 861-863.
8. Saikia, D. K. Mudoi, A. and Borkakati, R. N. (2020) Suppression of Sugarcane Plassey Borer, *Chilo tumidicostalis* Hampson with *Trichogramma chilonis* Ishii in Assam. *Indian Journal of Entomology*, 83(1): 73-75.
9. Borkakati, R. N. Saikia, D. K. and Venkatesh, M. R. (2021) Influence of meteorological parameters on population build-up of brinjal shoot and fruit borer, *Leucinodes orbonalis*Guenee in Assam. *Journal of Agrometeorology,*

Book chapter

1. Borkakati, R.N. (2021) Ecological EngineeringorXuprayugareXashyaraksha. In: Rupantor, National Agri-Horticulture Show. Pp. 138-139

Popular Article

1. Borkakati, R. N. (20.06.2020). Mahabharatatu Ache KakatiPhoringorDhwangsa Leela. AmarAsam: 5.
2. Borkakati, R. N. (29.06.2020). KakatiForing: Covid-19 BibhishikarMajotKrishakorHahakar. AsomiyaKhabor: 9.
3. Borkakati, R. N. (13.07.2020). KakotiForingorBishayoeKichukotha. DainikJanambhumi: 7.

4. Borkakati, R. N. (13.07.2020). TholuaForingokloiAtankaGrastaNohobo. AsomiyaKhabor: 9.
5. Rahman, A. and Borkakati, R. N. (08.09.2020). SaratKalorPotangorBishoyeCharcha. NiyamiyaBarta: 7.
6. Borkakati, R. N. and Saikia, D. K. (05.10.2020). XurPukorBiruddheXajagHouk. AsomiyaKhabor: 9.
7. Borkakati, R. N. (09.10.2020). ApokareePotangorDimbaVakshi "Trichogramma". AmarAsam: 5.
8. Rahman, A. and Borkakati, R. N. (12.10.2020). Aheen Kati MahorSambhabyaKeetPotangorNiyantranByabastapona. DainikJanambhumi: 7.
9. Borkakati, R. N. (12.10.2020). Bharotat Potangor Bishoyeaddhyanor ChamuIteehash. NiyamiyaBarta: 7.
10. Borkakati, R. N. (13.10.2020). Potango JetiaBohurupeeAbhineta. AmarAsam: 5 .
11. Rahman, A. and Borkakati, R. N. (23.11.2020). KrishiKhetratNishiddhaPotangoNashakarBikalpa. DainikJanambhumi: 7.
12. Borkakati, R. N. and Saikia, D. K. (04.01.2021). KolGacharKeetPotangorNiyantranarChinta. AsomiyaKhabor: 9.

ANGRAU, Anakkaplle

Research papers

1. Visalakshi, M. KishoreVarma, P. Chandra sekhar, V. Bharathalaxmi, M. Manisha, B.L and Upendra, S. (2020) Studies on mycosis of *Metarhizium (Nomuraea) rileyi* on *Spodoptera frugiperda* infesting maize in Andhra Pradesh, India. *Egyptian Journal of Biological Pest Control*, 30: 135.
2. Visalakshi, M. Ramanujam, B. and Poornesha. (2020) Management of white grub, Holotrichia consanguinea using biocontrol agents in suagarcane in coastal andhra Pradesh. *Journal of Biological control*, 34(4).

AAU, Anand

Research papers

1. Patel, P. H. Sisodiya, D. B. Raghunandan, B. L. Patel, N. B. Gohel, V. R. and Chavada, K. M. (2020) Bio-efficacy of entomopathogenic fungi and bacteria against invasive pest *Spodoptera frugiperda* (J.E. Smith) under laboratory condition. *Journal of Entomology and Zoology Studies*, 8(6): 716-720.
2. Patel, H. C. Borad, P. K. and Patel, N. B. (2020) Determination of Economic Injury and Threshold Level of *Marucavitrata* (Geyer) in Green Gram. *International Journal of Current Microbiology and Applied Sciences*,9(9): 3211-3215.
3. Patel, N. B. Bhatt, N. A. and Patel, C. C. (2020) Effect of weather parameters on incidence of brinjal mite, *Tetranychus urticae* Koch and its predatory mite, *Amblyseius alstoniae* Gupta. *Journal of Pharmacognosy and Phytochemistry*,9(4): 3095-3099.
4. Patel, N. B. Thumar, R. K. and Patel, C. C. (2020) Efficacy of different bio-pesticides against brinjal mite, *Tetranychus urticae* Koch. *Journal of Entomology and Zoology Studies*, 8(3): 1049-1053.

5. Raghunandan, B. L. Kapadiya, T. B. Patel, N. B. Patel, N. M .and Mehta, D. M. (2020) Efficacy of different entomopathogenic fungi against mango hoppers in middle Gujarat. *International Journal of Current Microbiology and Applied Sciences*,9(8): 2310-2316.

Folders

1. Raghunandan, B.L. Patel, N.B. Mehta, D.M. and Vyas, R.V. (2020) Research accomplishments on microbial biopesticides. No. RES:15:4:2020:1000.
2. Raghunandan, B.L. Mehta, D.M. and Patel, N.B. (2020). Wide area management of white grub in groundnut through bio-agent based IPM module: A success story.No. RES: 15:2:2022:1000.
3. Kapadiya, T.B. Patel, N.M.Raghunandan, B. L.andPatel, N.B. (2020) Biopesticides. No. RES:15:3:2020:5000.

Folders - Vernacular language

1. Patel, N.M.Kapadiya, T. B. Raghunandan, B. L. andPatel, N.B. (2020) Fall armyworm (Poonchde char tapkavalilashkariiyal) nu N.P.V. No. RES:15:1:2020:2000.
2. Patel, N.B.Raghunandan, B.L. Mehta, D.M. and Vyas, R.V. (2020)Sukshmajivanuaadharitjavikkitnashakoangenasanshodhannijhalak. No. RES:15:5:2020:1000

Popular articles – Vernacular language

1. Patel, N.B.andDabhi, M.R. (2020) Soyabean ma sankalitjivatvyavsthapan. Krishi Govidya. 12(1-3): 63-65.

CPCRI, Kayankuam

Research papers

1. Anes, K.M. Merin Babu. Jinu Sivadasan. and Josephrajkumar, A. (2020) Discovery of a new *Steinernema* sp. (Rhabditida: Steinernematidae) with higher shelf life and better efficacy against red palm weevil under laboratory conditions. *Journal of Plantation Crops*, 48 (3): 184-191.
2. Josephrajkumar, A. Chandrika Mohan. Merin Babu. Prathibha, P. S. Vinayaka Hegde and Krishnakumar, V. (2020) Diagnosis of invasive whitefly species co-occurring on coconut. *Current Science*, 119(7): 1101-1105.
3. Merin Babu.Thangeswari, S. Josephrajkumar, A. Krishnakumar, A. Karthikeyan, A. Selvamani, V. Daliyamol. Vinayaka Hegde. Maheswarappa, H. P. and Anitha Karun. (2021) First report on the association of '*Candidatus* Phytoplasmaasteris' with lethal wilt disease of coconut (*Cocos nucifera* L.) in India. *Journal of General Plant Pathology*, 87(1): 16-23.
4. Wankhede, S. M. Shinde, V.V.Ghavale, S. L. Josephrajkumar, A. and Maheswarappa, H.P. (2020) Efficacy of biorationals and chloranthraniliprole against coconut rhinoceros beetle (*Oryctes rhinoceros* Linn.). *Journal of Entomology and Zoology Studies*, 8(6): 483-486.
5. Daliyamol. Merin Babu. Josephrajkumar, A. and Vinayaka Hegde. (2021) Identification of *Leptoxyphium* sp. causing sooty mould on coconut. *Indian Phytopathology*, 74: 257–261.

Technical / popular articles

1. Anes, K.M. Josephrajkumar, A. Chandrika Mohan. and Merin Babu. (2020) ‘Thengilevelleecha, virunnineththunnashathru’ (In Malayalam). *Karshakasree,* 26(4): 36-38.
2. Josephrajkumar, A. Anes, K.M. Merin Babu, Prathibha, P.S. and Chandrika Mohan (2020) Holistic package to mitigate exotic whiteflies on Coconut. *Indian Cocon. J.* 63(5): 9-12.
3. Josephrajkumar, A. Chandrika Mohan. Jijo Paul. Jayalakshmi, T. Rajendran, K. Vinayaka Hegde. Kalavathi, S. and Anitha Karun. (2021) Red palm weevil detector. *Indian Coconut Journal,* 63(10): 16.
4. Josephrajkumar, A. Chandrika Mohan. Jijo Paul, Jayalakshmi, T. Rajendran, K. Vinayaka Hegde. Kalavathi, S. and Anitha Karun. (2021) Red palm weevil detector (Malayalam). *Indian Naalikera Journal*, 12 (1): 26.
5. Jerard B. A., Josephrajkumar, A. Damodaran V., Zamir Ahmed S. K., Singh L. B. and Jaisankar, I. (2021) Invasive whiteflies infesting on Coconut palms in Andaman, *The Echo of India*, Port Blair, March 26, 2021.

Book chapters/Technical Bulletin/Manual

1. Chandrika Mohan, Anes K. M., Josephrajkumar, A., Merin Babu, Abdul Haris, A., Anithakumari, P., Regi Jacob Thomas, Jeena Mathew and Kalavathi. S. (2020) Kerasamrakshanamurakal (Malayalam). Technical bulletin 148. ICAR-CPCRI, Regional Station, Kayamkulam. 32p.

Special compilations/documentation

1. Josephrajkumar, A., Merin Babu, Anes, K.M. and Chandrika Mohan (2020) Molecular characterization of exotic whiteflies infesting coconut palms. *Kalpa Newsletter* 39(1): 3
2. Josephrajkumar, A., Jerard, B.A., Merin Babu, Anes, K.M. and Chandrika Mohan (2020) Sporadic emergence of coconut leaf beetle (*Callispakeram*) along the brackish water region in Kerala. *Kalpa Newsletter* 39(1): 3
3. Josephrajkumar, A., Merin Babu, Anes, K.M. and Chandrika Mohan (2020) Emergence of invasive cassava mealybug in coconut system. *Kalpa CPCRI Newsletter* 39(2): 4
4. Josephrajkumar, A., Chandrika Mohan, Merin Babu and Anes, K.M. (2020) Structural characterization of cement gland in *Aleurodicus rugioperculatus* and *Paraleyrodes bondari* as an identification marker. *Kalpa CPCRI Newsletter* 39(3): 4
5. Thube, S. H., Josephrajkumar, A., Pandian, T. P., Bhavishya, R. and Santhoshkumar, P. (2020) Whitefly complex in arecanut. *Kalpa CPCRI Newsletter* 39(3): 5.

DRYSRHU, Ambajipeta

Research papers

1. Neeraja, B. Snehalatharani, A. Chalapathi Rao, N. B. V. and Ramanandam G. (2020) Studies on different formulations of the bio agent *Trichoderma* in the

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2. Chalapathi Rao, N. B.V. Ramani, B. S. Rakshith Roshan, D. and Bhagavan, B. V. K. (2020) Biocontrol management options for invasive whiteflies on coconut. *Indian Coconut Journal August*, 17 -22.
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GBPUAT, Pantangar

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MPKV, Pune

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MPUAT, Udaipur

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PAU, Ludhiana

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SKUAST, Jammu

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TNAU

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UAS, Raichur

Research papers

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4. Hiremath, R. Ghante, V. N. Hosamani, A.Shivaleela. and Amaresh, Y. S. (2020) Compatibility of entomopathogenic fungus *Beauveria bassiana* (Bals.) with selected chemical insecticides, *Journal of Entomology and Zoology Studies*, 8(6): 1542-1548.
5. Shirwal, S. Veerangouda, M. Palled, V. Sushilendra. Hosamani, A. and Krishnamurthy, D. (2020) Studies on operational parameters of different spray nozzles, *Int. J. Curr. Microbiol. App.Sci*,9(1): 1267-1281.
6. Anusha Hugar, J. M. Nidagundi, N. Yogesh, Muniswamy, Hosamani, A. C. and Patil, J. R. (2020) Combining ability studies for seed cotton yield and fibre quality traits for varietal and hybrid development in cotton (*Gossypium hirsutum* L.), *J. Farm Sci.*, 33(3): 306-30).
7. Anusha Hugar, J. M. Nidagundi, N. Yogesh, Muniswamy, Hosamani, A. C. and Patil, J. R. (2020) Detection of high heterotic crosses for seed cotton yield and fibre quality traits in cotton (*Gossypium hirsutum* L.) J. *Farm Sci*., 33(3): 310-318.
8. Ramanujam, B.Hosamani, A. C. Poornesha, B. and Sowmya, E. (2020) Biological control of white grubs, *Holotrichia serrata* (Fabricius) in sugarcane by two species of entomopathogenic fungi, *Int J Trop Insect Sci*, 41, 671–680.
9. Ravi Biradar, M.Bheemanna, A. Hosamani. Harischandra Naik. Nagaraj Naik. and Kavita Kandpal. (2020) Insecticide Use and Farmers Perception On Cabbage Cultivation In Nine Districts Of Karnataka. *Int.J.Curr.Microbiol.App.Sci*, 9(01): 1461-1467.
10. Technical Leaf folders:
11. Arunkumar Hosamani, Sowmya, E. Nikita, Rajeshwari Hiremath. and Vijaykumar Ghante, (2020) Success story on the management of sugarcane white grub - biocontrol agents, UAS, Raichur 4pp.
12. Arunkumar Hosamani, Vijaykumar Ghante, Nikita, Rajeshwari Hiremath and Sowmya E., 2020, Technical folder on vermiculture, UAS, Raichur 4pp.

UBKV, West Bengal

Research papers

1. Sreedhar, B. K. Hath, T. K. Sahoo, S. K. and Okram, S. (2020) Seasonal incidence of mustard aphid (*Lipaphis erysimi* Kalt.) and its correlation with weather factors under terai zone of West Bengal. *International Journal of Current Microbiology and Applied Science,*10(01): 2556-2561.
2. Polu, P. Sahoo, S. K. and Bhowmick, N. (2020) Year round incidence and preference of cicadellids hoppers on different cultivars of mango in Sub-Himalayan terai zone of West Bengal. *Journal of Entomology and Zoology Studies,*8(2): 1543-1545.
3. Maji, A. Pal, S. Chatterjee, M. and Sahoo, S. K. (2020) Seasonal incidence of aphid and their natural enemies on mustard from terai region of West Bengal. *Journal of Ent. Res.,*44(4): 555-558.
4. Nirmal Sarkar. Raina Saha.Anamika Debnath. Bhattacharya, P. M. and Roy, A. (2020) Improving Seedling Health of Bell Pepper (*Capsicum annum* L.) by Plant Growth Promoting Microorganisms. *Int.J.Curr.Microbiol.App.Sci*,9(4): 231-244.

Associated with teaching:

1. Dr. S.K. Sahoo:ENT-501 (Insect morphology); ENT- 503 (Principle of Taxonomy and classification of insects); ENT-510 (Pests of field, horticultural and plantation crops and storage entomology); ENT- 601 (Immature stages of insects); EXT-103 (Values & Ethics); ENT-151 (Fundamentals of Entomology); ENT-301 (Crop pests and stored grain pests and their management)

35.10 Participation in Seminor/Symposia/Workshops, etc

ANGRAU, Anakkaplle

Name of the Seminar/ Workshop

1. Visalakshi, M., Selvaraj, K., Poornesha, B and Sumalatha, B. V. Biological control of Invasive pest, Rugose spirallying whitefly in Coconut and impact on Environment. International virtual conference on Environmental impact assessment organized by entre for Climate Change Environmental Management & Policy Research Institute (EMPRI) Bangalore. 2020.
2. Visalakshi, M., Jagadish patil and Poornesha, B. Biological control of White grub, *Holotrichia consanguinea* Blanch using entomopathogenic nematode and entomofungus in conserving biodiversity of sugarcane ecosystem " . International Virtual Conference on Biodiversity and Ecosystem services 2020, on 10th & 11th of December, 2020 by entre for Climate ChangeEnvironmental Management & Policy Research Institute (EMPRI) Bangalore. 2020.
3. Visalakshi, M., Suresh, M and Pradeep kumar. Biological Control in Rice Cultivation of Araku Valley, Visakhapatnam District, Andhra Pradesh- A Boost to Organic Farming by Tribal Farmers. 1st Indian Rice Congress to be held on 08-09th December 2020 at ICAR-NRRI, Cuttack. 2020.
4. Visalakshi, M., Richa varshey., Rangeswaran and Poornesha. Efficacy of Biological control agents in the management of new invasive pest, fall army

worm, *Spodoptera frugiperda* in maize. International E - Conference AMIFOST 2020 on “Future Food For Sustainability & Nutritional Security” on 21st Dec, 2020 organised by Amity Institute Of Food Technology, Amity University, New Delhi. 2020.

5. Visalakshi, M and Bhavani B. Storage techniques in the production of egg parasitoid, *Trichogramma chilonis* for Promotion of Biological control in sustainable agriculture. International Web Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2020) On 28-30th Dec 2020 organised by AASTHA foundation, Meerut, U.P. 2020.

Webinars attended:

1. Dr.M.Visalakshi, PS (Entomology) attended two Webinars – Drill bit PDS demonstration to PG students, Research scholars and faculty members of ANGRAU on 21.7.2020 and Webinar on Paradigm shift in Plant disease management for the millennium organized by ICAR-NBAIR on 24.07.2020.
2. International webinar on “Advances in Rice Researches for food security and environmental sustainability” organized by Tamil nadu Rice Research Institute, Aduthurai, Tamil nadu on 13.08.2020.
3. Webinar on “Making Small holder farming climate Resilent “organized by ICAR-NBAIR, Bangalore (Town talk series 2) on 14.08.2020.
4. Webinar (Town talk series 3) organised by ICAR-NBAIR, Bangalore on “The Agrobiodiversity index in India: leading the path for other countries “on 17.08.2020.
5. Webinar organised by ICAR-NBAIR, Bangalore on “Invasive insect pests threat in horticultural crops and strategies for their management”organized by Dr. YSR Horticulture University, Venkataramannagudem on 18.08.2020.
6. Webinar on: Biocontrol of Parthenium(as a part of 15th parthenium awareness week, 2020) organised by ICAR-NBAIR, Bangalore on 21.08.2020.
7. ANGRAU-IDP-Alumni webinar series-I on 1.8.2020
8. Dr.M.Visalakshi, Principal Scientist (Entomology) attended National webinar on “Plant health management for sustainable agriculture “organized by NIPHM, Hyderabad on 4.09.2020.
9. Dr.M.Visalakshi, Principal Scientist (Entomology) attended International webinar on “ Advances in red palm weevil research and management “ organized by Don Bosco College of Agriculture, Goa on 8.9.2020
10. Dr.M.Visalakshi, Principal Scientist (Entomology) attended national webinar on “Coconut cultivation “organized by DRYSRHU, Venkataramannagudemon 2.09.2020.
11. Dr.M.Visalakshi, Principal Scientist (Entomology) attended National Virtual Meeting on “Biopesticides- Registration and Quality Assurance : Issues and Way forward” jointly organised by The Entomological society of India and Society for Biocontrol Advancement in association with ICAR- National Bureau of Agircultural Insec Resources, Bangalore on 06.10.2020.

12. Dr.M.Visalakshi, Principal Scientist (Entomology) attended webinar on Agricultural processing, supply chain and warehousing on 06.10.2020 organised by ANGRAU.
13. Dr.M.Visalakshi, Principal Scientist (Entomology) attended webinar on Current reforms in Agriculture on 16.10.2020 organised by Agrovision foundation.
14. Dr.M.Visalakshi, Principal Scientist (Entomology) attended webinar on Rural development Transformation through cillage on 29.10.2020 organised by Agrovision foundation , Nagpur
15. Dr.M.Visalakshi, Principal Scientist (Entomology) attended webinar on Agricultural Technology for marketing organized by KisanMitr CCS NIAM, Governement of india on 29.10.2020.
16. Dr.M.Visalakshi, Principal Scientist (Entomology) participated National symposium on plant health management organized by Navsari Agricultural University from 2-4 November, 2020 and presented oral paper on "Management of termites using Biocontrol agents in sugarcane in coastal Andhra Pradesh" on 3.11.2020.
17. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in International E-Conference on "Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity" 24 to 27th November, 2020 and presented poster paper on Field evaluation of biological control agents and biopesticides in the management of new invasive pest, fall army worm, *Spodoptera frugiperda*(J. E. Smith) (Lepidoptera: Noctuidae) in maize.
18. Dr.M.Visalakshi, Principal Scientist (Entomology) attended online training on "Analysis of Experimental data using SAS "conducted by NAARM,Hyderabad from 9-17 November, 2020.
19. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in online training on "Onfarm production of Biocontrol agents and microbial Biopesticides "organised by NIPHM, Hyderabad from 9-13 November, 2020.
20. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in online training on "Impact of indiscriminate use of chemical fertilizers and pesticides on food crops" organised by NIPHM, Hyderabad from 16-18 November, 2020.
21. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in webinar on "Regulatory approaches and registration requirements for biopesticides" organised by NIPHM, Hyderabad on 20.11. 2020.
22. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in webinar on "Biointensive management for sustainable agriculture" organised by NIPHM, Hyderabad on 21.11. 2020.
23. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in webinar on "Advances in stored grain pest management "organised by NIPHM, Hyderabad on 25.11. 2020.
24. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in webinar on " Implementation of Innovative technologies in agriculture and allied sectors for

sustainable economic development "organised by Sri. Padmavati MahilaVisvavidyalayam on 27.11. 2020.

25. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in Webinar on Transboundary pests Threats to Bio security and Bio safety issues organized by SV Agricultural college, Tirupati on 21.12.2020
26. Dr.M.Visalakshi, Principal Scientist (Entomology) participated in webinar on Biointensive pest management for sustainable agriculture organized by NIPHM, Hyderabad from 21.12.2020

AAU, Anand

Oral presentation

1. Raghunandan, B. L., Patel, N. B and Mehtapresented, D. M. the paper (oral presentation) entitled "Fungal entomopathogens: Promising biocontrol agents against mango hopper"in 'National Symposium on Plant Health Management' organized by Dept. of Plant Pathology and Entomology, College of Agriculture, Navsari Agriculture University, Bharuch campus during 2-4th November 2020.

CPCRI, Kayankuam

Presentations in workshops/Seminars/Symposia

1. Chandrika Mohan., Josephrajkumar, A and Anes K. M. (2020) Advances in red palm weevil IPM in coconut pp 14-27 In: Proceeding of International webinar "Advances in Red palm weevil Research and Management held on 08 September 2020 (Eds: Rajan Shelke and J.R. Faleiro), Don Bosco College of Agriculture, Goa, India. 78p.
2. Josephrajkumar, A. (2020) Smart Diagnosis of Exotic Pests and Intelligent Pest Management Solutions in Coconut and cardamom. *Proceedings National Conference on Recent Advances in Agricultural Forestry and Medical Entomology in India*, Entomology Research Institute, Loyola College, Chennai, 15, December 2020.

DRYSPUHF, Solan

Papers presented in conferences/symposia

1. Banshtu, T., Verma, S. C and Sharma, P. L. 2020. Evaluation of synthetic and neem based insecticides against aphid *Macrosiphum euphorbiae* Thomas in tomato under mid hill conditions of Himachal Pradesh. Presented in: International Web Conference "Perspective on Agricultural and Applied Sciences in COVID-19 Scenario (PAAS-2020)" held on October 4-6, 2020, Abstract Book, p300.
2. Sharma, P. L., Verma, S. C., Chandel, R. S and Nidhi. 2021. Biointensive management of invasive South American tomato leafminer, *Tuta absoluta*. Presented in Sixth National Conference on Biological Control: Innovative Approaches for Green India held held at Bengaluru, 3-5 March, 2021, Abstract Book, p.115.
3. Nidhi., Sharma, P. L and Yankit P. 2021. Effect of host plants and developmental stages of *Tetranychus urticae* on the demographics of *Neoseiulus longispinosus*. Presentedin Sixth National Conference on Biological Control: Innovative

Approaches for Green India held held at Bengaluru, 3-5 March, 2021, Abstract Book, p 91.

4. Sharma, P., Verma, S. C., Sharma, P. L and Yanki P. 2021. Spatial distribution of *Aphidiu smatricariae* (Haliday) (Hymenoptera: Aphididae) against *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) in capsicum under protected conditions. Presented in Sixth National Conference on Biological Control: Innovative Approaches for Green India held held at Bengaluru, 3-5 March, 2021, Abstract Book, p 45.
5. Verma, S. C., Walia, A., Sharma, P. L., Chandel, R. S., Palial, S and Sharma, N. 2021. Foraging behaviour and mutual interference of *Encarsia formosa* Gahan parasitizing greenhouse whitefly, *Trialeurodes vaporariorum* Westwood. Presentedin Sixth National Conference on Biological Control: Innovative Approaches for Green India held held at Bengaluru, 3-5 March, 2021, Abstract Book, p59.
6. Palial, S., Verma, S. C, Sharma, P. L and Sharma N. 2021. Predatory potential of aphidophagous syrphids, *Eupeodes corolla* (F.) and *Episyrphis balteatus* (De Geer) against cabbage aphid, *Brevicoryne brassicae* L. infesting cauliflower. Presentedin Sixth National Conference on Biological Control: Innovative Approaches for Green India held held at Bengaluru, 3-5 March, 2021, Abstract Book, p 69.

GBPUAT, Pantangar

Papers presented in conferences

1. Roopali Sharma., Sapna., Manju Sharma., Shubham Kumar and Bhupesh Chandra Kabdwal. 2021. Success Story of Microbial Consortia of *Trichoderma* and *Pseudomonas* for the management of Rice Sheath blight from Lab to the Farmers' Field. Inthe Sixth National Conference on Biological Control "Innovative Approaches for Green India", March, 2021, Bengaluru, India.
2. Bhupesh Chandra Kabdwal., Roopali Sharma and Kumar, J.2021.Bio-intensive Management of Major Diseases in Vegetable Cultivation on Uttarakhand. In the Sixth National Conference on Biological Control "Innovative Approaches for Green India", March, 2021, Bengaluru, India.

National Conference/Seminar/Workshop attended

1. Roopali Sharma (2020).Webinar on "Paradigm Shift in Plant Disease Management" organized by ICAR-NBAIR, held at GBPUA&T, Pantnagar, 24 July, 2020.
2. Roopali Sharma and Manju Sharma (2020).Review meeting-Webinar of AICRP on Biological Control organized by ICAR-NBAIR.14 September, 2020.
3. Roopali Sharma (2020). International Online/Virtual Conference on Role of Basic and Applied Sciences in Human Well Being". GBPUA&T Alumni Almamater Meet. 23-24 November, 2020.
4. Roopali Sharma and Bhupesh Chandra Kabdwal (2021). National Conference on Biological Control "Innovative Approaches for Green India", Bengaluru, India. 3-6 March, 2021.

PAU, Ludhiana

Paper presented in conferences, symposia, trainings, workshops

1. Sharma, T and Shera, P. S (2021). Parasitism effects of *Fulgoraecia melanoleuca* (Fletcher) on the fitness of sugarcane leafhopper, *Pyrilla perpusilla*(Walker). p 38. In: Rajgopal N N, Thamilarasi K, Mohanasundaram A, Paramaguru P K, Ghosal S, Sinha N K and Sharma K K (eds.). Souvenir and Book of Abstracts, National Web Symposium on "Recent Advances in Beneficial Insects and Natural Resins and Gums" February 25-26, 2021. Society for Advancement of Natural Resins and Gums, ICAR-IINRG, Ranchi
2. Singh, A., Kaur, R., Mangat, H. K., Thakur, A., Sharma, S., Mohanasundram, A and Shera, P. S. (2021). Natural enemy fauna associated with lac insect, *Kerria lacca*(Kerr) under Punjab conditions. P 22. In:
3. Rajgopal N N, Thamilarasi K, Mohanasundaram A, Paramaguru P K, Ghosal S, Sinha N K and Sharma K K (eds.). Souvenir and Book of Abstracts, National Web Symposium on "Recent Advances in Beneficial Insects and Natural Resins and Gums" February 25-26, 2021. Society for Advancement of Natural Resins and Gums, ICAR-IINRG, Ranchi

National Conference/Seminar/Workshop attended

1. Dr P.S. Shera attended Webinar on Best Practices for Production, Processing and Marketing of Tribal Based Commodities organized by Ch. Charan Singh National Institute of Agricultural Marketing, Jaipur and ICAR-IINRG Ranchi on May 3, 2020.
2. Dr. S Neelam Joshi, P.S. Shera, Rabinder Kaur and Sudhendu Sharma participated in 29th Biocontrol Workers' Group Meeting of All India Coordinated Research Project on Biological Control of Crop Pests (Online) May 21-22, 2020.
3. Dr Neelam Joshi, P.S. Shera, Rabinder Kaur and Sudhendu Sharma attended Webinar on "Locust Management: Current status and Future Strategies organized by Department of Entomology, PAU, Ludhiana on May 30, 2020`
4. Drs Neelam Joshi and P.S. Shera attended virtual meet on Desert Locust organized by ICAR-NBAIR, Bengaluru on June 5, 2020.
5. Drs Neelam Joshi, P.S. Shera, Rabinder Kaur and Sudhendu Sharma attended webinar on Desert Locust in Indian Context- Retrospect, Current Status and Threat Imminence organized by Department of Entomology, PAU, Ludhiana on June 6, 2020.
6. Drs P.S. Shera and Sudhendu Sharma attended meeting on Improving Sugar Recovery and Sugarcane Productivity in Punjab at RRS Kapurthala on July 3, 2020.
7. Dr Neelam Joshi attended online meeting of research and extension officer's Workshop for Rabi crops on August 24, 2020.
8. Dr P.S. Shera and Rabinder Kaur attended National Webinar on Management of Biotic and Abiotic Stresses in Protected Agriculture organized by CSK Himachal Pradesh Krishi Vishvavidhalaya, Palampur on September 22-24, 2020.
9. Dr Neelam Joshi attended National Webinar on 'Biopesticide-registration and quality assurance; issue and way forward' on 6.10.2020 organized by

Entomological Society for Biocontrol advancement (SBA) in association with ICAR-National Bureau of Agricultural Insect Resources.

10. Dr Rabinder Kaur attended National Webinar on Conservation biological control and Bio-pesticides in Agriculture organized by Ch. Chhotu ram (PG) College, Muzaffarnagar on October 13, 2020.
11. Dr Sudhendu Sharma participated in virtual training programme on ‘Plant Quarantine Procedures for Import and Export’ from November 9 to 13, 2020, organized by NIPHM, Hyderabad.
12. Drs P.S. Shera, Rabinder Kaur and Sudhendu Sharma participated in participated in 8th Coordination Committee Meeting of Network Project on Conservation of Lac Insect Genetic Resources (Online) on December 29-30, 2020.
13. Dr P.S. Shera, Rabinder Kaur and Sudhendu Sharma participated in National Web Symposium on Recent Advances in Beneficial Insects and Natural Resins and Gums organized by Society for Advancement of Natural Resins and Gums, ICAR-IINRG, Ranchi on February 25-26, 2021.
14. Dr P.S. Shera chaired technical session on theme - Potential of Insects as Food and Medicinal resources (poster presentations) during National Web Symposium on Recent Advances in Beneficial Insects and Natural Resins and Gums organized by Society for Advancement of Natural Resins and Gums, ICAR-IINRG, Ranchi on February 26, 2021.

Participation in *Kisan melas*

Table 328.

Kisan mela	Date	Name of Scientist(s)
Virtual PAU *Kisan Mela*	18.9.2020 &19.9.2020	Drs Neelam Joshi, P S Shera, Rabinder Kaur &Sudhendu Sharma
Virtual Regional *Kisan Mela*	15.3.2021	Drs P S Shera, Sudhendu Sharma

SKUAST, Jammu

Abstracts in conference / symposia

1. Jha, A.C., Jamwal, S., Reena., Singh, A. P., Singh, P., Vikas Gupta and Jamwal, A. Integrated management of Turcicum leaf blight of maize caused by *Exserohilum turcicum* under rainfed farming system. Agriculture Technology Development Society ATDS, Ghaziabad, U.P. *4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture “GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020 Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.*
2. Arvind Parkash Singh., Jai Kumar., Brinder Singh., Rai, A. P., Reena., Permendra Singh and Sunny Raina. Evaluation of maize-based intercropping system under rainfed conditions of North-Western Himalayas. *4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture “GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020*

Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.

3. Bhav Kumar Sinha., GurdevChand., Reena., Muneeba Banoo and Sapalika Dogra. Autophagy: an intracellular self-degradation system in plants. *4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture "GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020 Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.*
4. Jai Kumar, A. P., Singh., Brinder Singh., Rai, A.,P., Reena and Sunny Raina. Evaluation of the most efficient maize-based intercropping system under rainfed sub tropical*Shiwalik* foothill conditions. *4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture "GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020 Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.*
5. Kumawat, P. K., Reena and Talim Hussain. Insect Pests Management in Zero Budget Natural Farming: A Review. *4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture "GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020 Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.*
6. Reena, S., Baloor, A. P., Singh, P., Singh, Jha, A. C., Jai Kumar and Jamwal, S. Effect of intercropping and border cropping on *Spodoptera* population in Maize. *4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture "GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020 Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.*
7. Sonika Jamwal., Reena., Vikas Gupta, A. C., Jha, A. P., Singh and Anamika Jamwal Management of powdery mildew disease caused by *Podosphaera xanthii* in cucumber with biocontrol agents.*4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture "GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020 Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.*
8. Talim Hussain., Reena and Kumawat, P. K. Habitat Manipulation/Bio-ecological Engineering for Management of Insects Pests: A review. *4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture "GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020 Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.*
9. Vikas Gupta, A. P., Singh., Sanjeev Kumar., Reena, A. C., Jha and Sonika Jamwal Growth and productivity of different pearl millet (*Pennisetum glacum*) varieties under N-W plain zone of lower *Shivalik* hills. *4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture "GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020*

Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.

Conferences / Trainings Attended

1. Attended Virtual National Conference on Strategic Reorientation for Climate Smart Agriculture VAGMET-2021 (on-line) w.e.f. 17-19 March, 2021, organized by Department of Climate Change and Agricultural Metrology in association with Ludhiana Chapter of Association of Agrometerologists.
2. Attended Virtual 4th International Conference on Global approaches in Natural Resources management for Climate Smart Agriculture "GNRSA-2020 during Pandemic Era of Covid-19, Dec. 26-28, 2020 Venue: Conference Hall, Shobit Deemed University, Modipuram, Meerut, UP, India.

Paper presented

1. Oral Presentation of research paper entitled,"*Effect of abiotic factors on various agromet indices and population dynamics of insect pests of field pea in N-W Plains of sub-tropical region of Jammu and Kashmir*" authored by Reena, Vikas Gupta, Mahender Singh, A.P. Singh, B.K. Sinhaand Brinder Singh in Virtual National Conference on Strategic Reorientation for Climate Smart Agriculture VAGMET-2021 w.e.f. 17-19 March, 2021, organized by Department of Climate Change and Agricultural Metrology in association with Ludhiana Chapter of Association of Agrometerologists.

UBKV, West Bengal

Seminar/ Symposium/ Workshop Attended

1. Virtual Training on Whole genome sequencing in bacteria held on 29th – 30th August, 2020 organized by Foundation for Innovation Research in Science and Technology, Nagercoil.
2. Participated in the International webinar on "Moth diversity, Ecology and Conservation" held on 24th July, 2020 organized by St. Joseph College, Bangaluru.
3. Participated in the International webinar on "Insect Systematics: Importance, Challenges and Way Forward" held on 29th January, 2021 organized by ICAR-NBAIR, Bangaluru.
4. Attended in the 29th Annual Group Meeting of AICRP-Biological held via Virtual mode on 21 -22nd May, 2020.
5. Attended in the Webinar on Desert Locust Management: Current Status & Future Strategies held on 30th May, 2020 organized by IARI, New Delhi.
6. Participated in the webinar on bioecology and management of locust held on 05th June, 2020 organized by NBAIR, Bangalore.
7. Participated in the webinar on "Locusts: Myth and Reality, How to tackle if we come across?" held on 09th June, 2020 organized by MPKV, Rahuri.
8. Participated in the webinar series on "Be+ during Covid-19" held on 22-27th June, 2020 organized by NAHEP (ICAR).

9. Participated in the webinar on "Challenges and Recent Initiatives for management of Fall Army Worm" held on 16th July, 2020 organized by Bihar Agricultural University, Sabour, Bhagalpur.
10. Participated in the virtual conference on "Drones application technology in spraying for crop protection" held on 29th July, 2020 organized by Crop Life India and FICCI.
11. Participated in the webinar on "Digital agriculture –Piloting to Scaling out proven technologies" organized by Ray Consulting in association with ICRISAT on 1st August, 2020.
12. Participated in the National virtual meeting on "Biopesticides-Registration and Quality control: Issues- way forward" held on 6th October, 2020 organized by SBA, ICAR-NBAIR and ESI, New Delhi.

KAU, Thrissur

Meetings attended

Attended virtual AICRP workshop on 21 & 22-05-20.

Attended virtual midterm review meeting of AICRP-BC on 14-9-20.

35.11 Technology included

AAU, Jorhat

BIPM on rice

1. Release of egg parasitoids *Trichogramma* spp. @ 50,000/ha (six releases) on observing the moths of YSB
2. Application of *Beauveria bassiana* impregnated Rice Husk Saw Dust Rice Bran (RHSDRB) medium @ 3kg/ha in 600 litres of water (10^7 spores/ml) (Package of Practices for *Kharif* Crops of Assam, 2019, pp.130)

BIPM on brinjal

1. Azadirachtin 1500 ppm @ 2ml/liter of water *Lecanicillium lecanii* @ $1x10^8$ spores/ml (5g/liter of water)
2. Eight releases of *Trichogramma chilonis*(MITS) @ 1,00,000/ha (13500/bigha) at weekly interval starting from initiation of flowering.(Package of Practices for Horticultural Crops of Assam, 2019, pp.68)

ANGRAU, RARS

1. Technology – "Validation of *Trichogramma chilonis* for the management of sugarcane borers" of AICRP on Biological control centre, ANGRAU Individual technology Questionnaire was prepared and submitted to NBAIR for onward submission to ICAR for third party evaluation .
2. Technology –" Validation of abiotic stress tolerant strain *Trichogramma chilonis* for the management of sugarcane borers" of AICRP on Biological control centre, ANGRAU on Individual technology Questionnaire of institute, stake holders and beneficiaries list for Impact evaluation study given by agency was submitted on 11.11.2020.

AAU, Anand

1. Technology developed and recommended to the scientific community ‘Application of *Bacillus thuringiensis* NBAIR strain – *Bt*G4 (1% WP - $2x10^8$cfu/g) @ 50g/10 litre water or *Bacillus thuringiensis* AAU strain -AAU*Bt*1 (1% WP - $2x10^8$cfu/g) @ 50g/10 litrefor three timesat ten days interval with the initiation of the pest found effective for the management of fall armyworm *Spodoptera frugiperda* in maize’.

Dr YSPUHF, Solan

Technologies developed/ demonstrated

1. Bio-intensive management of *Tuta absoluta* in tomato.
2. Biological control of apple root borer, *Dorysthenus hugelii* by using *Metarhizium anysopliae.*
3. Technology assessed/ transferred
4. Management of apple root borer, *Dorysthenes hugelii* by using *Metarhizium anisopliae.*
5. Bio-intensive management of *Tutaabsoluta* in tomato.

KAU, Thrissur

Technology assessed/ transferred

1. The *Beauveria bassiana* local isolate has been recommended for inclusion in the Package of Practices of KAU.

PAU, Ludhiana

1. *Bacillus thuringiensis Kurstaki* (DOR Bt 1) @ 800 g/ acre for the management of gram caterpillar in gram.
2. Ecotin 5% (azadirachtin 50000 ppm) @ 80 ml/ acre for the management of leafhopper in okra.
3. Ecotin 5% (azadirachtin 50000 ppm) @ 80 ml/ acre for the management of stem borers and leaf folder in rice/*basmati* rice under conventional and organic conditions.
4. Integrated management of chafer beetle in grapes using anisole based traps and cultural practices.
5. Integrated management of early shoot borer, *Chilo infuscatellus* with pheromone traps and *Trichogramma chilonis*in sugarcane.
6. Integrated management of top borer, *Scirpopha gaexcerptalis* with pheromone traps and *Trichogramma japonicum* in sugarcane.
7. Technology transferred/demonstrated
8. Large scale demonstrations of biocontrol technologies using bioagents, *T. chilonis* and *T. japonicum* for the management of sugarcane borers conducted over an area of 2004 hectares at farmers’ fields in collaboration with sugar mills of Punjab.
9. Large scale demonstrations of biocontrol based pest management technologies using bioagents, *T. chilonis* and *T. japonicum* conducted over an area of 124 ha for the management of leaf folder, *Cnaphalocrocis medinalis* and yellow stem borer *Scirpophaga incertulas* at farmers’ fields in organic *basmati* rice.

10. Large scale demonstrations on the bio-suppression of stem borer, *Chilopartellus* using *T. chilonis* conducted over an area of 24 ha at farmers' fields in maize crop.

PJTSAU, Hyderabad

Technologies assessed and transferred

1. BIPM package in cotton for the management of Pink bollworm came into the University recommendations and was given to the extension scientists for further popularising among the farmers
2. Three sprays of entomofungal biopesticide *L. lecanii* and Neem oil 1500 ppm @ 1kg/acre foliar spray in cotton was effective in managing sucking pests and recorded yields on par with the chemical check.
3. Developed Mass Production Protocols for *Trichogramma*, *Chrysoperla*, *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

SKUAST, Srinagar

Technology developed

1. Mass production of *Corcyra cephalonica*
2. Mass production of *Trichogramma* spp.
3. Integrated management of Codling moth, *Cydiapomonella* infesting apple in Ladakh
4. Mass production technique of *Blaptostethus pallescens*

UAS, Raichur

FLD programmes **Table 329.**

Sl No.	Crop	Technology demonstrated	No. of demonstration
1	Sugarcane	Method of application of entomopathogenic fungi, *Metarhizium anisopliae* against whitegrubs	30
2	Rice	Use Tricho cards and Application of entomopathogenic fungi, *Metarhizium anisopliae* against BPH	25
3	Chilli	Application of entomopathogenic fungi *Verticilium lecani*	45
4.	Guava	Application of entomopathogenic fungi *Verticilium lecani* and *Beauveria bassiana*	30

5.	Arecanut	Method of application of entomopathogenic fungi, *Metarhizium anisopliae* against whitegrubs	15
6	Mango	Application of entomopathogenic fungi *Verticilium lecani* and *Beauveria bassiana*	10
7	Sorghum	Use of entomopathogenic fungi *Nomureae rileyi* Against *Spodoptera litura*	10

OFT **Table 330.**

Sl No.	Crop	Technology demonstrated	No. of demonstration
1	Cotton	Management of Pink bollworm by using Trichocards (*Trichograma bactrae)*	15
2	Rice	Management of stem borer usingTricho cards (*Trichograma japonicum*)	30

ACRONYMS

Table 331.

AICRP – BC	All India Coordinated Research Project of Biological Control
NBAIR	National Bureau of Agricultural Insect Resources, Bengaluru
AAU-J	Assam Agricultural University, Jorhat
AAU-A	Anand Agricultural University, Anand
ANGRAU	Acharya N.G. Ranga Agricultural University, Anakapalle
YSPUHF	Y.S. Parmar University of Horticulture and Forestry, Solan
GBPUAT	Govind Ballabh Pant University of Agriculture and Technology, Pantnagar
KAU	Kerala Agricultural University, Thrissur
MPKV	Mahatma Phule Krishi Vidyapeeth, Pune
PJTSAU	Pandit Jayashankar Telangana State Agricultural University, Hyderabad
PAU	Punjab Agricultural University, Ludhiana
SKUAST-S	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
TNAU	Tamil Nadu Agricultural University, Coimbatore
CAU	Central Agricultural University, Pasighat
MPUAT	Maharana Pratap University of Agriculture & Technology, Udaipur
OUAT	Orissa University of Agriculture & Technology, Bhubaneswar
UAS	University of Agricultural Sciences, Raichur
IGKV	Indira Gandhi Krishi Viswavidhyalaya, Raipur
KAU RARS	KAU-Regional Agricultural Research Station, Kumarakom
KAU RARS	KAU-Regional Agricultural Research Station, Vellayani
DRYSRHU	Dr. Y S R Horticultural University, Ambajipeta
UBKV	Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal
CISH	Central Institute of Subtropical Horticulture, Lucknow
CPCRI	Central Plantation Crops Research Institute, Kayamkulam
IIRR	Indian Institute of Rice Research, Hyderabad
IIMR	Indian Institute of Millet Research, Hyderabad
IIHR	Indian Institute of Horticultural Research, Bangalore
IIVR	Indian Institute of Vegetable Research,Varanasi
NCIPM	National Centre for Integrated Pest Management, New Delhi
NRRI	National Rice Research Institute, Cuttack
SBI	Sugarcane breeding Institute, Coimbatore
PDKV	Panjabrao Deshmukh Krishi Vidyapeeth, Akola
SASRDMC	School of Agriculture Science & Rural Development, Medziphema Campus, Nagaland University
SKUAST-J	Sher-e-Kashmir University of Agricultural Science & Technology, Jammu
NIPHM	National Institute of Plant health Management, Hyderabad
UAHS	University of Agricultural and Horticultural Sciences, Shimogga
CRS	Citrus Research Station, Dr. Y.S. R. Horticultural University, Tirupati
NRRI	ICAR- National Rice Research Institute, Cuttack