Azadi Ka Amrit Mahotsav

NBAIR

All India Coordinated Research Project on Biological Control of Crop Pests

Annual Progress Report 2021

Compiled and Edited by

G. Sivakumar, T. Venkatesan, K. Subaharan, G. Mahendiran, Richa Varshney, Omprakash Navik, K. Selvaraj, U. Amala, M. Sampath Kumar, Jagadeesh Patil, A. Kandan, P. Ram Kumar, M. Nagesh and S. N. Sushil

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ICAR-NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES

Bengaluru, India

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Technical Programme for 2021

CONTENT

EXPERIMENTAL RESULTS

I. BIODIVERSITY OF BIOCONTROL AGENTS FROM VARIOUS AGROECOLOGICAL ZONES

I. 1. Basic research work at National Bureau of Agricultural Insect Resources

I.1.1. Taxonomic and biodiversity studies on parasitic wasps

Cotesia ruficrus (Haliday) was reported to parasitize rice horn caterpillar, *Melanitis leda* (Linnaeus) (Lepidoptera: Nymphalidae) in Assam. In the comprehensive yet complicated food web associated with the niche of the recently invaded cassava mealybug (CMB) *Phenacoccus manihoti* Matile-Ferrero (Homoptera: Pseudococcidae), there was a multitrophic interaction structured vertically as well as horizontally. Altogether 45 species (recorded for the first time to be associated directly or indirectly with CMB): thirty four species of insects from six orders (Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, and Neuroptera) and eleven species of spiders (Arachnida) were grouped under four trophic levels into 11 guilds. The analysis of trophic guild structure and interaction indicated that many indigenous parasitoid species, which qualified to be placed under the fourth trophic level, actively parasitized the potential native predators of CMB and thereby negatively impacted the natural biological control of CMB.

First record of a braconid solitary koinobiont endoparasitoid, *Meteorus pulchricornis* (Wesmael) (Hymenoptera: Braconidae: Euphorinae) which was found parasitizing *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in maize. *Meteorus pulchricornis* is a new addition to the known and rapidly expanding parasitoid complex of FAW in India.

Overall, 80.46% FAW larval mortality by the natural enemy complex was observed in northern India. *Chelonus* nr. *blackburni* (Hymenoptera: Braconidae) was the predominant parasitoid in the study area causing 49.24% larval mortality followed by *Chelonus formosanus* Sonan.

I. 1. 2. Spider diversity in paddy ecosystem

Tetragnathid spider diversity in the paddy ecosystem from different agro-climatic zones of Tamil Nadu (14 locations) was documented. Collected specimens belonging to two genera, *Tetragnatha* Latreille and *Leucauge* White, and six species viz. *Tetragnatha javana* Thorell (10.75%), *T. keyserlingi* Simon (58.78%), *T. mandibulata* Walckenaer, *T. nitens* Audouin (13.26%), *T. vermiformis* Emerton (5.81%) and *Leucauge decorata* Blackwall (0.71%) .

I. 1. 3. Development of mobile apps on non-chemical methods for management of important crop pests

A mobile app on management of the invasive pest, *S. frugiperda* in maize was developed. A mobile app BIPM on FAW was developed. This mobile app gives detailed information about the biology of FAW, damage symptoms in the field conditions, pest identification, and management through biological control, pheromone traps and chemical control. Attempts were also made to present the content in North Eastern languages of India, so as to benefit the farmers of North-Eastern region, where maize is grown widely. This mobile app was developed in several languages viz., English, Hindi, Marathi, Tamil, Telugu, and the North-Eastern languages like Assamese, Bengali, Khasi, Manipuri, Nagamese and Sikkimese.

I. 1. 4. Parasitisation potential of *Trichogramma chilonis* and *Telenomus remus* against fall armyworm, *Spodoptera frugiperda*

In a single release, the percent parasitism of *T. remus* was highest (92%) followed by *T. chilonis* (81%) and *T. pretiosum* (45%). In the simultaneous release of *T. remus* and *T. chilonis* per cent parasitism was 88.9% and was on par with *T. remus* single release. Among all the duration-dependent treatments of sequential release, *T. chilonis* release post 24-48 hours of *T. remus* release provided the most satisfactory outcome.

I. 1. 5. Field evaluation of *Trichogramma chilonis* against *Spodoptera frugiperda*

Field evaluation of *T. chilonis* was carried out at Bagalur, Karnataka against *S. frugiperda* in the naturally infested maize crop. Four releases of *T. chilonis* at weekly intervals significantly ($P < 0.05$) increased the egg mass and egg parasitism of *S. frugiperda*. After four releases of *T. chilonis*, the egg mass parasitism was 66.25% and egg parasitism was 42.15% in maize field. The plant damage incidence (7.0%) and leaf damage score (1.15 on 0-9 Davis scale) was significantly ($P < 0.05$).

I. 1. 6. Evaluation of *Blaptostethus pallescens* against thrips

The biocontrol potential of anthocorid predator, *B. pallescens* was evaluated against *Scirtothrips dorsalis* and *Thrips palmi* on capsicum grown in polyhouse at Doddabalapura. Weekly release of *B. pallescens* @ 20-30 per square meter (total 4-5 releases) with alternation of biopesticide *Bacillus subtilis* reduced the thrips population by 26.2%.

I. 1. 7. Geographical and host distribution of whiteflies

Surveys were conducted in Goa, Gujarat, Karnataka, Lakshadweep, Meghalaya and Odisha West Bengal to document the new geographical and host distribution record for whiteflies viz., rugose spiraling whitefly, *Aleurodicus rugioperculatus*. Woolly whitefly, *Aleurothrixus floccosus* was recorded in Karnataka, Lakshadweep and Tamil Nadu. Bondar's nesting whitefly, *Paraleyrodes bondari* and *A. floccosus* was recorded from Andhra Pradesh, Odisha and West Bengal. Besides, 45 host plants for rugose spiraling whitefly; 21 host plants for nesting whitefly, *Paraleyrodes minei*; 9 host plants for Bondar's nesting whitefly, *P. bondari*; 13 host plants for solanum whitefly, *Aleurothrixus trachoides* and 5 host plants for palm infesting whitefly, *A. atratus* was recorded for the first time in India.

I. 1. 8. Field efficacy of EPN formulations for the management of fall armyworm in maize

Field trials were repeated to study the comparative effect of WP and novel granular formulations of *H. indica* NBAII Hi101, *S. carpocasae* NBAII Sc01 and *H. bacteriophora* NBAII Hb105 against fall armyworm, *Spodoptera frugiperda*. The results indicated that granular formulation of *H. indica* and *S. carpocapsae* were on par with respective WP formulations in reducing the populations of fall armyworm (58-65%), however granular formulation of *H. bacteriophora* imparted only 24-28% control.

I. 1. 9. Evaluation of entomopathogenic nematode, *Heterorhabditis indica* against *Holotrichia* sp.

During 2020-2021 two field demonstrations were carried out at Bagalakote district of Karnataka to evaluate the efficacy of two species of entomopathogenic nematodes (EPN), *Steinernema carpocapsae* (NBAIRS59) and *Heterorhabditis indica* (NBAIIH38), along with a commonly used insecticide (chlorpyrifos) against *Holotrichia* species. Field trial data showed that the reduction in *Holotrichia* grub population was significantly higher in field treated with *H. indica* (NBAIIH38) at rate of 2.5×10^9 IJ ha^{-1} than *S. carpocapsae* (NBAIRS59) and chlorpyrifos application. Chlorpyrifos application was more efficient in reducing the grub population than both nematode species at the lower application rate (1.25×10^9 IJ ha^{-1}). These experiments suggest *H. indica* (NBAIIH38) to be a promising biocontrol agent against *Holotrichia* species.

I.1.10. Molecular Characterization and DNA barcoding of agriculturally important parasitoids, predators and other insects

Five field collected specimens of *Trichogramma chilonis* from Tamil Nadu were identified using morphological and molecular tools. Different populations of invasive cassava mealybug *Phenacoccus manihoti* was identified using cytochrome oxidase–I gene (CO-1) for the first time in India and DNA barcode was generated for the same. The parasitoid *Anagyrus lopezi* received from IITA, Republic of Benin was identified using molecular tools and GenBank Acc. No. (OK85480) and barcode was generated. Specimens of the invasive thrips in chilli were received from different parts of Andhra Pradesh, and it was identified as *Thrips parvispinus* (OM095426, OM095429, OM085663 and OM085664) employing morphological and molecular tools.

I. 2. Reports from different AICRP- BC centers

I.2.1. AAU, Jorhat

Table 1.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agent observed			Relative abundance
		Parasitoids	Parasitism (%)	Predator	
Dergaon, Ahom gaon, Khanikargaon, Chowdungpothar, Mahuramukh Senchowa, Borkacharogaon Allengmora, Borholla, Raraiah, Titabor, Neulgaon, Teok	Papaya (Mealybug, *Paracoccus marginatus*)	*Acerophagous papayae*	10.0	*Spalgius epius*, *Cryptolaemus montrouzieri*	++ +
	Cabbage (Cabbage caterpillar, *Pieris brassicae*) DBM, *Plutella xylostella*	*Brachymeria* sp. *Cotesia plutellae*	12.4 15.3	*Coccinella septempunctata* *C. transversalis* *Serangium parcesetosum* *Harmonia dimidiata*	+++ +++ + ++
	Bhutjalakia *(Aphis gossypi, Aleurodicus dispersus)*			*H. dimidiata, Micraspis discolor, Cheilomenes sexmaculata, Brumoides suturalis, C. septempunctata*	+ +++ +++ ++ +++
	Brinjal (*Leucinodes orbonalis, Bemisia tabacci*)	*Trichogramma chilonis*	7.8	*C. transversalis* *Cocinella septempunctata*	+++ +++ +++ +
	Okra Shoot & fruit borer *Bemisia tabacci*	*T. chilonis*	14.7	*Coccinella septempunctata* *C. transversalis*	+++ +++
	Potato (*Myzus persicae*)			*Micraspis* spp.	+++
	Bitter gourd (Fruit fly, leaf eating caterpillar)			*C. transversalis*	+
	Tomato (Aphid, Tomato fruit borer)	*T. chilonis*	9.7	*C. chlorideae*	+ +
	Paddy (Stem borer Leaf roller)	*Cotesia* sp., *T. japonicum*, *T. chilonis*	10.4 9.2 8.6	*A. femina* *Ceriagrion cerinorubellum* *Micraspis crocea*	+ + + +++ +++ + +++
	Maize (Stem borer, Fall armyworm)	*Cotesia* sp.	4.2	-	+
	Pumpkin (Pumpkin caterpillar, red pumpkin beetle, Flea beetle)			*Coccinella septempunctata* *C. transversalis*	+ +

	Sugarcane (Sugarcane Plassey borer, Early shoot borer, wooly aphid)	*Cotesia* sp. *Strumiopsis inferans* *Encarsia flavoscutellum*	7.2 3.26 2.3		++ + ++

Table 2. Seasonal abundance of predatory spiders in rice ecosystem

Period of observation	Visual count	*Sweep net	Pitfall traps
2nd wk. of August, 2021	2.0	1.0	-
1st wk. of September, 2021	1.8	1.0	-
2nd wk. of September, 2021	1.8	1.2	0.2
1st wk. of October, 2021	2.0	1.1	0.4
2nd wk. of October, 2021	1.2	1.0	0.4
1st wk. of November, 2021	1.0	-	0.4
2ndwk.of November, 2021	1.3	-	0.7
1st wk. of December, 2021	0.8	-	-
2nd wk. of December, 2021	0.8	-	-

*Sweep net was not used from first week of November, 2021 due to reproductive growth phases of the crop

Table 3. Natural enemies (Class: Arachnida) of the rice ecosystem

Species	Family	Collected Specimen (Total No.)	Period of activity	Relative abundance (%)
Lycosa pseudoannulata	Lycosidae	58	Throughout the cropping season	28.85 (+++)
Oxyopes javanus	Oxyopidae	48	Throughout the cropping season	23.88 (+++)
O. shweta	Oxyopidae	12	Throughout the cropping season	5.97 (+)
O. lineaptis	Oxyopidae	11	Throughout the cropping season	5.47 (+)
Tetragnatha sp.	Tetragnathidae	38	Throughout the cropping season	18.90 (+++)
Argiope catenualata	Araneidae	19	August-Sept-October	9.45 (++)
Neoscona theisi	Araneidae	2	August-Sept-October	0.99 (+)
Araneus sp.	Araneidae	2	August-Sept-October	0.99 (+)
N. bengalensis	Araneidae	4	August-Sept-October	1.99 (+)
Uluborus sp.	Uluboridae	3	Oct -Nov	1.49 (+)
Telamonia sp.	Salticidae	4	Oct-Nov	1.99 (+)

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

I. 2. 2. AAU, Anand

Table 4.

Site of collections	Crop ecosystem and host insect	Biocontrol agents observed	Genbank accession No.
Godhra, Ghoghamba, Panchmahal Chorwad, Junagadh AAU, Anand Petlad, Anand Jetpur,Rajkot Bhuj, Kutch Jahangirpura, Chorwad, Junagadh Navli, Godhra,	*S. frugiperda* in maize	*Chelonus formosanus*	OM422609
	S. frugiperda in Maize	*Telenomus remus*	OM424280
	Rugose spiralling whitefly in coconut	*Encarsia* sp.	
	Aonla	*Cotesia ruficrus*	OM422642
	Rice	*Cotesia ruficrus*	OM422687
	Castor	*Charops* sp.	
	Castor, Cabbage	*Cotesia* sp.	
	Plutella xylostella in cabbage	*Campoletis* sp.	
	Aphidin cabbage	*Diaeretiella rapae*	
	Cowpea, cotton & groundnut	*Cheilomenes sexmaculata*	OM422837
	Mustard and Oats	*Chrysoperla zastrowi sillemi*	
	Tobacco	Reduviid bug	
	Rugose spiralling whitefly in coconut	*Mallada* sp.	
	Cabbage, Maize Oats	Syrphid fly	
	Cluster bean, Rose, Brinjal, Maize, Okra	Spiders	
	Scale insect in Crape Jasmin	*Cryptolaemus montrouzieri, Brumoides suturalis* & *Nephus quadrimaculatus*	
	Spodoptera litura in tobacco	NPV	
	S. frugiperda in maize	NPV	
	Maruca vitrata in cowpea	NPV	

I. 2. 3. MPUAT, Udaipur

Table 5.

Site of collections	Crop eco-system surveyed and the hostinsects	Biocontrol agent observed
Southern Rajasthan (Rama, Kailashpuri, Sare, Chirva(Badgaon), Hayla, Vishma(Sayara), Brahminoki Hunder (Madar), Madar, Lakhawali,Veerpura, Pilader, Bovas (Jaisamand), Dabok, Khokharwas, Intali, Mavali, Falichadakhedi, Fatehanagar and Vallabhnagar)	Chickpea, tomato and maize during kharif and rabi seasons	Coccinellids, Preying mantid Reduvid bug. Green lacewing Predatory pentatomid bug, Spiders, *Campolet chlorideae* and *Cotesia flavipes*

I. 2. 4. KAU, Thrissur

Table 6. Biodiversity of spiders in rice ecosystem

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Mannuthy, Pazhayannur, Thekkinkara, (Thrissur) Pattambi and Kattussery, (Palakkad)	Rice	222 spiders were collected from rice ecosystem by using pit fall trap and sweep net method

I. 2. 5. UBKV, Pundibari

Table 7.

Sites of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
Instructional Farm, UBKV, Pundibari	Rice	Six numbers of spiders were collected from rice field during last week of December 2021.
Alipurduar, West Bengal	Potato	*Trichoderma* spp.

I. 2. 6. TNAU, Coimbatore

Table 8.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agent observed
Different agro-climatic zones of Tamil Nadu	Coconut, Banana, Custard apple	*Encarsia guadeloupae*
	Papaya	*Acerophagus papayae*
	Brinjal	*Trichogramma chilonis*
	Cassava	*Tetrastichus* sp.
	Cassava	*Prochiloneurus aegyptiacus*
	Coconut, Papaya, Cotton, Cassava	*Apertochyrsa astur*
	Coconut, Guava,Crotons	*Cryptolaemus montrouzieri*
	Coconut	*Chilocorus nigrita*
	Coconut, Chillies, Cassava, Brinjal, Maize	*Cheilomenes sexmaculata*
	Coconut	Praying mantis and Spider, *Argiope* sp.
	Cassava	*Hyperaspis maindroni*
	Cotton, Cassava, Curryleaf, Cabbage, Ornamentals	*Chrysoperla zastrowi sillemi*
	Sugarcane	*Dipha aphidivora*
	Sugarcane	*Micromus igorotus*
	Paddy	*Cyrtorhinus lividipennis* and *Lycosa pseudoanulata*
	Guava	*Scymnus* sp.
	Helicoverba armigera in chickpea	*Nomuraea rileyi*

The Encyrtid parasitoid, *Copidosomyia ambiguous* (Subba Rao) (Chalcidoidea: Encyrtidae) was found parasitizing the eggs of *Mallada desjardinsi* (Navas).

I. 2. 7. SKUAST, Kashmir

Table 9.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agent observed
Shalimar campus, Srinagar	*Aphis pomi* in high density apple	*Harmonia eucharis*Adalia tetraspolita*
	Aphid in nectarine	*H. eucharis*
	Walnut aphid on Walnut	*H. eucharis*
	Pear *Psylla* in high density Pear	*Calvia punctata***, *Chilocorus* sp. ** *H. eucharis*, *Oenopia conglobata***

*Variants of *Harmonia eucharis*** Recorded first time

I. 2. 8. Dr YSPUHF, Solan

Table 10.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed	Occurrence/ Parasitism (%)
Nauni, District Solan	*Tuta absoluta, Trialeurodes vaporariorum, Helicoverpa armigera, Liriomyza trifolii, Tetranychus urticae* in tomato	*Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, Diglyphus horticola*	3-9 bugs/plant 10-15%
	Cauliflower/ cabbage *Brevicoryne brassicae, Pieris brassicae*	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Diaeretiella rapae, Cotesia glomerata*	2-7 beetles/ plant 3-4%
	Chromatomyia horticola in pea	*Diglyphus horticola, D. isaea, Quadrastichus plaquoi, N. formosa, Chrysocharis* sp., *Chrysocharis indicus, Pediobius indicus*	15-28%
	Trialeurodes vaporariorum, Aphis gossypii in cucumber	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Oenopia kirbyi, O. sauzetii, O. sexareata, C. zastronii sillemi, Encarsia formosa*	7-11 beetles/ plant 3-8 grubs/ plant 8-12%
Rajgarh, district Sirmaur	Tomato *Tuta absoluta, Trialeurodes vaporariorum, Helicoverpa armigera, Liriomyza trifolii, M. euphorbiae*	*Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, Diglyphus horticola, Coccinella septempunctata, Hippodamia variegata*	2-5 bugs/plant 10-20% 3-5 beetles/plant
	Brachycaudus helichrysi, thrips in Peaches	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Anthocoris* sp, *Orius* sp.	8-15 beetle/plant, 1-2 bugs/ leaf

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed	Occurrence/ Parasitism (%)
Deothi, district Solan	*Brevicoryne brassicae, Pieris brassicae, Plutella xylostella* in cauliflower	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Diaeretiella rapae, Cotesia glomerata, Diadegma* sp.	1-9 beetles/ plant 6-9%
	Tomato *Tuta absoluta, Trialeurodes vaporariorum, Helicoverpa armigera, Liriomyza trifolii,*	*Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, Diglyphus horticola, Hippodamia variegata*	1-4 bugs/plant; 5-10% 1-2 beetle/plant
Naineti, district Sirmaur	Tomato *Tuta absoluta, Trialeurodes vaporariorum, Liriomyza trifolii,*	*Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, Diglyphus horticola*	3-4 bugs/plant; 5-10%
Sundernagar, district Mandi	Tomato *Tuta absoluta, Trialeurodes vaporariorum, Liriomyza trifolii, Helicoverpa armigera*	*Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, C. zastrowi sillemi*	5-10 bugs/plant; 15-25% 1-2 larvae/ plant
Kotkhai, district Shimla	*Eriosoma lanigerum, Panonychus ulmi, Dorysthenus hugelii* in apple	*C. zastrowi sillemi, Coccinella septempunctata, Hippodamia variegata, Harmonia dimidiata*, *Aphelinus mali*	1-2 egg mass/ plant; 5-10 beetles/ plant; 3-8% parasitism
Rekongpeo, District Kinnaur	*Eriosoma lanigerum, Panonychusulmi, Dorysthenus, Quadraspidiotus perniciosus* in apple	*Adalia tetraspilota, Chilocorus infernalis, Priscibrumus uropygialis, Harmonia dimidiata*, *Harmonia eucharis, Stethorus* sp.	5-15 beetles/ plant
Poorbani, District Kinnaur	*Eriosoma lanigerum, Panonychusulmi, Dorysthenus hugelii, Quadraspidiotus perniciosus* in apple	*Coccinella septempunctata, Hippodamia variegata, Priscibrumus uropygialis, Harmonia dimidiata*, *Harmonia eucharis, Aphelinus mali*	15-20 beetles/ plant 15-20%
	Leaf curl aphid and scale in Almond	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Adalia tetraspilota, Harmonia eucharis, Oenopea sauzetii, Anthocoris* sp. and *Orius* sp.	10-15 beetles/ plant 1-2 bugs/ leaf
Roghi, District Kinnaur	*Eriosoma lanigerum, Panonychus ulmi, Dorysthenus* in apple	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Harmonia dimidiata, Harmonia eucharis, Aphelinus mali*	5-10 beetles/ plant 15-20%
	Leaf curl aphid and scale in Almond	*Coccinella septempunctata, Cheilomenes sexmaculata, Harmonia eucharis, Oenopea sauzetii,*	8-15 beetles/ plant
Udaipur, district Lau-hal&Spiti	*Brevicoryne brassicae, Pieris brassicae* in Cauliflower/ cabbage	*Coccinella septempunctata, Hippodamia variegata, Diaeretiella rapae, Cotesia glomerata*	2-3 beetles/ plant 4-6%

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed	Occurrence/ Parasitism (%)
	Chromatomyia horticola in Peas	*Diglyphus horticola*, *D. isaea*, *N. formosa*,	8-15%
	Eriosoma lanigerum in apple	*Aphelinus mali*	5-8%
Tandi, district Lauhal & Spiti	*Brevicoryne brassicae, Pieris brassicae* in cauliflower/ cabbage	*Coccinella septempunctata, Hippodamia variegata, Diaeretiella rapae,Cotesia glomerata,*	1-5 beetles/ plant 3-8%
	Chromatomyia horticola in pea	*Diglyphus horticola*, *D. isaea*, *N. formosa*	5-10%
	Eriosoma lanigerum in apple	-	5-10%
Bajaura, district Kullu	*Eriosoma lanigerum, Panonychus ulmi, Dorysthenus hugelii* in apple	*C. zastrowi sillemi, Coccinella septempunctata, Hippodamia variegata, Harmonia dimidiata*, *Aphelinus mali*	1-2 egg mass/ plant 5-10 beetles/ plant
Rohin, district Bilaspur	*Spodoptera frugiperda* in maize	-	-

I. 2. 9. PAU, Ludhiana

Table 11.

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
PAU, Ludhiana	Maize	Seventeen natural enemies including ten parasitoids (*Trichogramma chilonis*, *Chelonus formosanus*, *Chelonus blackburni*, *Campoletis flavicincta*, *Charops bicolor*, *Temelucha* sp., *Cotesia rufricus*, *Microplitis* sp., *Campoletis* sp. and unidentified Braconid) and seven predators (*Eocanthecona furcellata*, *Cheilomenes sexmaculata*, *Paederus* sp., *Neoscona theisi*, *Oxyopes* sp, unidentified Carabid beetle, unidentified Coccinellid beetle) were recorded to be associated with fall armyworm on maize/fodder maize. Among parasitoids, *Chelonus formosanus* was the predominant species (72.2% abundance).
	Sugarcane	*Fulgoraecia melanoleuca* (nymphal and adult parasitoid) was recorded parasitizing *Pyrilla perpusilla* on sugarcane crop with peak activity in September month (30.6% parasitism).

Site of collections	Crop eco-system surveyed and the host insects	Biocontrol agents observed
	Cotton	Among predators, coccinellids (*Coccinella septempunctata*, *Cheilomenes sexmaculata*, *Brumus suturalis, Serangium* sp.), green lacewing (*Chrysoperla zastrowi sillemi*), *Geocoris* sp. and spiders were prevalent on cotton crop. Out of these, spider species were predominant (68.4% abundance) followed by *Chrysoperla* (21.4% abundance). The population of *Chrysoperla* increased till July, but declined thereafter. However, spider population was at peak during August-September. The abundance of different coccinellid predators varied from 0.4 to 5.9% in cotton crop. The natural parasitization of whitefly by *Encarsia* spp. varied from 5-10%.
	Rice	A total of 6 spider species from three families, Tetragnathidae, Salticidae and Araneidaewere recorded from the rice fields. *Neoscona theisi* was the predominant species.
	Chickpea	Larval parasitoid, *Campoletis chlorideae* was found to be parasitizing *Helicoverpa armigera* (8.33% parasitism) in gram crop.
	Wheat, oilseed and cole crops	Coccinellids (*Coccinella septempunctata* and *Cheilomenes sexmaculata*) and syrphids (*Ischiodon scutellaris*, *Episyrphus* sp. and *Metasyrphus* sp.) were collected from wheat and oilseed crops. *Cotesia glomerata* was recorded from *Pieris brassicae* on oilseed and cole crops.

I. 2. 10. MPKV, Pune

Table 12.

Site of collection	Crop eco-system surveyed and the hostinsects	Biocontrol agent observed
Pune, Satara, Solapur, Ahmednagar, and Sangli districts of Western Maharashtra	Cotton, Maize, Bean, Sorghum, Okra and Brinjal	*Chrysoperla zastrowi sillemi*
	Mango and Hibiscus	*Mallada boninensis*
	Coconut	*Apertochrysam aster*
	Cotton, Sugarcane, Sorghum, Maize, Cowpea, Okra, Soybean, Mango and Custard apple	*Coccinella septempunctata, Menochilus sexmaculatus*
	Papaya	*Acerophagus papayae*
	Sugarcane	*Dipha aphidivora* (activity ranged from 0.78-1.2 per leaf); *Micromus igorotus* (activity ranged from 1.26-2 per leaf) *Encarcia flavoscutellum* (0.6-1.5 per leaf) and Spiders (0.20-0.50 per leaf)

I. 2. 11. CISH, Lucknow

Table 13.

Site of collec-tions	Crop eco-systemsur-veyed and the host insects	Biocontrol agent observed (numbers)
Lucknow, Uttar Pradesh	Major insect pests recorded were hopper, mealy bugs, thrips midge and shoot borer in mango ecosystem	Chrysopids activity was recorded from 11th to 25th SMW and peak population was recorded during 21st SMW with population of 3.21 individuals/tree. The predator coccinellids was noticed during 5th to 21st SMW. The peak population of the predator was recorded as high as 3.54 individuals /tree during 10th SMW. The major 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 coccinellids coincided with the peak prevalence in insect pests infesting mango at its reproductive stage namely mango hoppers, mealy bugs, thrips and scale insects.

I. 2. 12. UAS, Raichur

Table 14.

Site of collections	Crop eco-systemsurveyed and the host insects	Biocontrol agent observed (numbers)
Bidar	Defoliators in Soybean	05
Yadagir	Fall armyworm in maize	10
Raichur	Fall armyworm in maize and pink bollworm in Cotton	15
Ballari	Fall armyworm in maize	10
Koppal	Fall armyworm in maize	10

NIPHM

Studies on biodiversity of natural enemies in maize ecosystem

Survey for occurrence of natural enemies was carried out in different maize growing areas of farmer's fields in surrounding Hyderabad. A total of 13 natural enemies including parasitoids and predators *viz*. coccinellids, reduvid bugs, syrphid fly, bigeyed bugs, earwigs, spiders etc. were recorded from maize ecosystem.

II. SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS

II. 1.1 ANGRAU, Anakapalle

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

Periodicity: Once in a month.

Moderate to severe incidence of fall armyworm in maize in kharif, 21 (4-30%) and rabi, 21 (8-20%). Observed mixed populations of borers (*Chilo partellus*, *Sesamia inferens* and *Spodoptera frugiperda*) in maize. Rugose spiraling whitefly (RSW) incidence in coconut was low (<5%) in coconut during October 2021 and severe (>50%) in March 2022. Spread of RSW was noticed in mango, guava, sugarcane, maize, banana, papaya, sapota. Monitored moderate incidence of leaf folder in rice (5-8%), low to moderate incidence of sheath blight, blast in rice; early shoot borer (ESB) incidence was moderate to severe (6-19%) and internode borer (INB) incidence was moderate to high (18-46%) in sugarcane.

Borer damage (stem borer 6 to 9%; pink borer 4 to 5% and fall armyworm 4-30%) was observed in maize crop during kharif and rabi, 2021-22; field populations were collected and submitted for species variation study at NBAIR, Bengaluru.

Root grub adult populations collected from sugarcane growing areas of Visakhapatnam, Krishna, Chittore districts of Andhra Pradesh using light traps andidentified at NBAIR, Bengaluru. Out of 56 collections, majority of root grub adults identified as *Schizonycha fuscescens, Maladera rufocuprea* and other species were *Adoretus lasiopygus*, *Apogonia* sp.

Recorded invasive flower thrips/black thrips in chillies and capsicum in Srikakulam, Vizianagaram, Visakhapatnam and Guntur districts during November 2021 to January 2022. Collected thrips populations were identified at molecular level as *Thrips parvispinus* at NBAIR, Bengaluru.

Collected naturally parasitized fall army worm eggsin maize and observed emergence of parasitoids, *Telenomus remus* and *Trichogramma chilonis*.

Cadavers of fall army worm collected from maize during July 2021 and November 2021 showed the symptoms of virus infection and its identification is in progress.

Observed natural parasitization of *Encarsia guadeloupa*e on rugose spiraling whitefly on coconut, banana and sugarcane.

Table 15. Crop pest outbreak during 2021-22

Month	Date	Location	Crop	Pest	Problems & Level of incidence
July, 21	15.7.21	Nellimarla mandal, Vizianagaram dist	Rice Maize	Thrips in nursery FAW	Moderate to high (>14%) Low (<5%)
	16.7.21	Pusapatirega mandal, Vizianagaram dist	Rice	Hispa in nursery	Moderate to high (12-20%)

Month	Date	Location	Crop	Pest	Problems & Level of incidence
	31.7.21	Garividi, Cheepurupalli mandals, Vizianagaram dist	Rice	Hispa in nursery Thrips in transplant-ed crop	Moderate to high (15-18%) Moderate to high (>14%)
Aug , 21	4.8.21	Pusapatirega, Nellimar-la mandals, Vizianaga-ram dist	Maize	FAW	Low to Moderate (5-14%)
Sep, 21	12.9.21	Munagapaka, Anakapalli mandals, Visakhaptnam dist	Maize Rice Sugarcane	FAW Stem borer Early shoot borer Internode borer	Low to moderate (4-10%) Low (5%) Moderate (10-12%) Low (<10%)
	24.9.21	Gajapathinagaram, Garivid mandals, Viz-ianagaram dist	Maize Sugarcane Rice	FAW Early shoot borer Leaf folder	Moderate (14-18%) Moderate (8-12%) Low (5-6%)
Oct, 21	10.10.21	Munagapaka, Anakapalli mandals, Visakhaptnam dist	Maize Sugarcane	FAW Termites Root grub	Low to moderate (5-11%) Severe (>20%) Low to moderate (5-7%)
Nov, 21	5.11.21	Ranasthalam,Rajam mandals, Srikakulam dist	Maize Coconut	FAW	Moderate to high (8-22%)
	18.11.21	Garividi, Gurla man-dals, Vizianagaram dost	Maize Rice	FAW Leaf folder	Low to moderate (4-13%) Moderate to high (6-15%)
Dec, 21	8.12.21	Etcherla, Ranasthalam mandals, Srikakulam dist	Maize Coconut Chillies	FAW RSW Flower thrips	Moderate (6-14%) Low to moderate (10-22%) Severe (45-78%)
	9.12.21	Gajapathinagaram, Denkada mandals, Vizianagaram dist	Maize Rice	FAW Panicle mite	Low (3-5%) Severe (>25%)
	15.12.21	Bheemili mandal, Visakhapatnam dist ; Pusapatirega mandal, Vizianagaram dist	Maize Rice	FAW Panicle mite Leaf folder	Low to moderate (4-12%) Severe (15-20%) Low to Moderate (5-9%)
	18.12.21	V.Madugula, Cho-davaram mandals, Visakhapatnam dist	Coconut Sugarcane	RSW Internode borer	Moderate (15-35%) Severe (30- 45 %)
	21.12.21	Padmanabham Dum-briguda, Araku M, Visakhapatnam dist	Maize	FAW	Low (<5%)
	29.12.21	Bhogapuram, Pusapat-irega mandals, Viz-ianagaram dist	Maize Coconut Chillies	FAW RSW Flower thrips	Moderate (10-15%) Moderate to high (20-45%) Severe (>70%)
Jan, 22	28.01.22	Anandapuram, Bheemi-li mandals, Visakhapat-nam dist	Maize Coconut Chillies	FAW RSW Flower thrips	Low to moderate (4-10%) Severe (>50%) Severe (>55%)
	31.01.22	Bheemili, Pad-manabham mandals, Visakhaptnam dist	Maize Coconut	FAW RSW	Low to moderate (5-15%) Severe (40-50%)

Month	Date	Location	Crop	Pest	Problems & Level of incidence
Feb, 22	7.2.22	Munagapaka Anakapalle, Atchtapuram mandals, Visakhapatnam dist	Sugarcane	Early shoot borer Internode borer	Moderate (10-14%) Severe (35-50%)
	11.2.22	Gajapathinagaram mandal, Vizianagaram dist, Ranasthalam mandal, Srikakulam dist	Maize	FAW	Moderate (10-15%)
	19.2.22	Pusapatirega, Bhogapuram, mandals, Vizianagaram dist	Maize	FAW	Low to moderate (5-15%)
	28.2.22	Gajapathinagram mandal, vizianagaram dist, Ranasthalam mandal, Srikakulam dist	Maize	FAW	Moderate (6-12%)
	11.3.22	Munagapaka Atchutapuram mandals, Visakhapatnam dist	Sugarcane	Internode borer, Early shoot borer	Severe (50-60%) Moderate (9-12%)
	15.03.22	Sabbavaram, Padmanabham mandal, Visakhapatnam dist Denkada mandal, Vizianagaram dist	Maize Coconut	FAW RSW	Low (4-5%) Moderate to severe (35-48%)

Fig 1. Surveillance for pest incidence sugarcane and maize

Fig 2. NPV infected cadavers of maize fall armyworm

Fig 3. *Thrips parvispinus* in chillies and capsicum

II. 1.2 AAU, Anand

Survey was conducted in various locations of Anand district and other districts of Gujarat. During the survey, incidence of fall armyworm in maize fields (20-25%, during June, July and August 2021) and invasive thrips, *Thrips parvispinus* in chilli fields (20-25%, January 2022) of Anand district was recorded.

Monitoring and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts (Table 16).

During the survey, incidence (<2-3%) of papaya mealybug was noticed in three orchards. The parasitoid *Acerophagus papayae* was noticed parasitizing mealybug.

Table 16. 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.	15.9.2021	Atulbhai Ramjibhai Patel Village - Sandeshar Ta. Anand, Dist. Anand	-	-	-	-	0
2.	15.09.2021	Rasikbhai Mangalbhai Talpada Village - Bhavanipura Ta.Petlad, Dist. Anand	-	-	Azadirachtin 1500 ppm	-	0

3.	13.10.2021	Harshadbhai Gordhanbhai Patel, Village - Bhavanipura Ta.Petlad, Dist. Anand	-	-	Azadirachtin 1500 ppm	-	0
4.	21.10.2021	Navgan Bharwad Village - Bhavanipura Ta. Petlad, Dist. Anand	-	-	-	-	< 2-3% (Trace incidence)
5.	18.1.2022	Rajeshbhai D. Patel, Village - Dungri Dist. Valsad	Papaya	-	Fipronil Buprofezin	-	< 2-3% (Trace incidence)
6	18.1.2022	Dilipbhai N. Patel, Village - Vasan Dist. Valsad	-	-	-	-	0
7.	21.01.2022	Lat: 22.547019 Long: 73.050352 Village - Ode Ta. Anand, Dist. Anand	Papaya	-	-	*A. papayae*	< 2-3% (Trace incidence) *One plant is severely infested
8.	21.01.2022	Lat:22.624452 Long: 73.120579 Village - Ode Ta. Anand, Dist. Anand	Papaya	-	-	-	0
9.	24.01.2022	Lat:22.547084 Long: 73.050338 Village - Ode Ta. Anand, Dist. Anand	-	-	-	-	0

Expt. No. 4: Survey and surveillance of natural enemies of pinworm, *Tuta absoluta* in tomato

Adult moth catches (8-13/trap) of *Tuta absoluta* was recorded during the survey. However, no conspicuous infestation/damage symptoms caused by *Tuta absoluta* in tomato and other non-host crop plants was observed during the survey period.

Table 17. Survey details of tomato pinworm, *Tuta absoluta*

On-campus					
Date	**Name of the farmer**	**Place**	**No. of Adult/ trap**	**Host crop, non-host crops and weed plants**	**Natural enemies**
25.11.2021	--	Agronomy farm, AAU campus	9	Tomato (NIL)	NIL
25.11.2021	--	MVRS Farm, AAU, Anand campus	10	Tomato (NIL)	
Off-campus					

16.12.2021	Dharmendrabhai C. Patel	Village-Doli Ta.Sojitra, Dist. Anand	13	Tomato (NIL)	NIL
	Manishbhai P. Patel	,,	11		
	Hiteshkumar J. Patel	,,	10		
	Kanubhai B. Parmar	,,	12		
17.12.2021	Kanubhai A. Patel	Village- Runaj, Ta.Sojitra, Dist. Anand	8	Tomato (NIL)	NIL
18.12.2021	BhagvantbhaiN. Patel	Village-Bechari. Ta. Umreth Dist. Anand	11	Tomato (NIL)	NIL

II. 1.3 AAU, Jorhat

Surveillance of rugosespiraling whitefly (RSW) in coconut

The experiment was conducted at Horticultural Research Station, Kahikuchi, Guwahati and Experimental Farm, Department of Horticulture, AAU, Jorhat. The incidence of invasive RSW, *Aleurodicus rugioperculatus* on coconut was recorded from June, 2021 to February, 2022 at monthly intervals (Table 18). Five plants (Variety: Kamrupa) were selected randomly from the field in each garden for observation of per cent infestation by RSW and percentage of infested leaves per palm were calculated. The live colonies, pest status and natural enemy (if any) were also calculated from the observed samples.

The table indicated that the live colonies / leaflet of coconut varied from 1.20 to 4.22 in Location I (Horticultural Research Station, Kahikuchi, Guwahati), whereas in Location II (Experimental Farm, Department of Horticulture, AAU, Jorhat) the live colonies varied from 1.60 to 3.23 per leaflets from June,2021 to February, 2022, respectively. However, low number of colonies was observed from June, 2021 to October, 2021 in both the locations. But from November, 2021 to February, 2022 colonies per leaflet were found to be gradually increased from 2.25 to 4.22 in case of Location I and from 2.62 to 3.23 in case of Location II.

Natural enemies were recorded during survey period of RSW in both the Locations from June2021 to February 2022. The most common natural enemy associated with RSW was *Encarsia guadeloupae*. The per cent of parasitization was near about in between 14.00 to 23.00%. However, the predator, like spider (unidentified), coccinellids and lacewing were also recorded.

Table 18. Occurrence of rugose spiraling whitefly (RSW) in coconut and its natural enemies at Assam

Months	Infestation (%)	Live colonies/leaf	Severity of infestation
Location I: Horticultural Research Station, Kahikuchi, Guwahati			
June, 2021	11.76	1.2	Low
July, 2021	17.64	1.8	Low
August, 2021	23.52	2.15	Medium
September, 2021	21.05	2.20	Low
October, 2021	20.00	2.25	Low
November, 2021	25.00	3.15	Medium
December, 2021	26.31	2.80	Medium
January, 2022	31.57	3.62	Medium

February, 2022	36.84	4.22	High
Location II: Experimental Farm, Department of Horticulture, AAU, Jorhat			
June, 2021	15.78	1.60	Low
July, 2021	16.67	1.82	Low
August, 2021	25.0	2.35	Low
September, 2021	22.02	2.20	Low
October, 2021	21.05	2.20	Low
November, 2021	23.52	2.62	Medium
December, 2021	27.78	2.80	Medium
January, 2022	29.04	2.84	Medium
February, 2022	31.25	3.23	Medium

II.1.4 KAU, Thrissur

Bacterial leaf blight (BLB) was reported in rice in the Kole areas of Thrissur during February. Field visit was conducted to the affected areas and it was observed that BLB incidence was pronounced in fields sown with the susceptible variety Jyothi. Farmers did not adoptany prophylactic measures of lime application as well as application of potassium fertilizers due to non-availability. Curative measures including use of antibiotics were recommended.

Survey for invasive alien pests

Survey was carried out in different parts of Thrissur district to monitor the incidence of invasive alien pests in cassava and other crops.

Incidence of invasive alien pests, *Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus solenopsis, Pseudococcus jackbeardsleyi* and *Icerya purchasi* was observed in cassava. In addition, incidence of wax scale on cassava and hard scale on mango was also reported. Incidence of *P. jackbeardsleyi* was noticed in other plants like green manure crop, glyricidia. Some species of mealybugs were observed in weed plants. During survey, we could observe the mealybug, *Rastrococcus iceryoides* on the weed, *Triumfetta rhomboidea*. Two species of mealybugs were noticed in coconut and one of them was identified as *Pseudococcus longispinus* (Table 19 & Fig 4).

Table 19. Surveillance for invasive alien pests at Thirssur

Pests	Host plants
Mealybugs *Paracoccus marginatus, Phenacoccus manihoti, Ferrisia virgata, Pseudococcus jackbeardsleyi, Phenacoccus solenopsis*	Cassava
Scales Cottony cushion scale (*Icerya purchasi*) Wax scale (*Ceroplastes* ? *cirripediformis*)	
Hard scale (*Ceroplastes ? ceriferus*)	Mango
Pseudococcus jackbeardsleyi	Glyricidia
Rastrococcus iceryoides	*Triumfetta rhomboidea*

Pseudococcus jackbeardsleyi *Rastrococcus iceryoides* *Pseudococcus longispinus*

Wax scale on cassava Hard scale on mango

a b c d e

a – *Icerya purchasi* adult b to e - *Icerya* sp. nymphs

Fig 4. Different insect pests observed during survey

Survey for incidence of *Phenacoccus manihoti* in cassava and its natural enemies Extensive roving as well as fixed plot surveys were carried out for cassava mealybug, *Phenacoccus manihoti*. Incidence of *P. manihoti* was recorded from 105 locations (70.95%) out of a total of 148 locations/cassava plots covered during the roving surveys. A total of 162 samples were collected and sent to NBAIR for identification. Taxonomic identification of 89 samples completed so far revealed that the mealybugs coexisted as a complex on cassava and involved *Paracoccus marginatus* (40.66%), *Ferrisia virgata* (30.77%), *Phenacoccus manihoti* (20.88%) and *Pseudococcus jackbeardsleyi* (7.69%) (Fig 5). During the study, incidence of *Icerya purchasi* was also observed on cassava plants. While the sample analysis is yet to be complete, it is noteworthy that a change in the species composition could be observed in favour of *P. marginatus* compared to 2020-21 when *P. manihoti* dominated to the extent of 47.13 % of samples collected.

Natural enemies of mealybug complex were also collected during the surveys and were sent to NBAIR for identification (Fig 6). Association of *Cryptolaemus* sp. was observed in one of the locations (Ollukkara). Like previous year, association of ape fly, *Spalgis epius* was observed in many fields. Three entomopathogenic fungi, *viz*., *Purpureocillium* sp., *Simplicillium* sp. and *Lecanicillium psalliote* were isolated from the mummified cadavers of mealybug. Among these, *Purpureocillium* sp. was obtained from *P. manihoti* and other two isolates from *P. marginatus*.

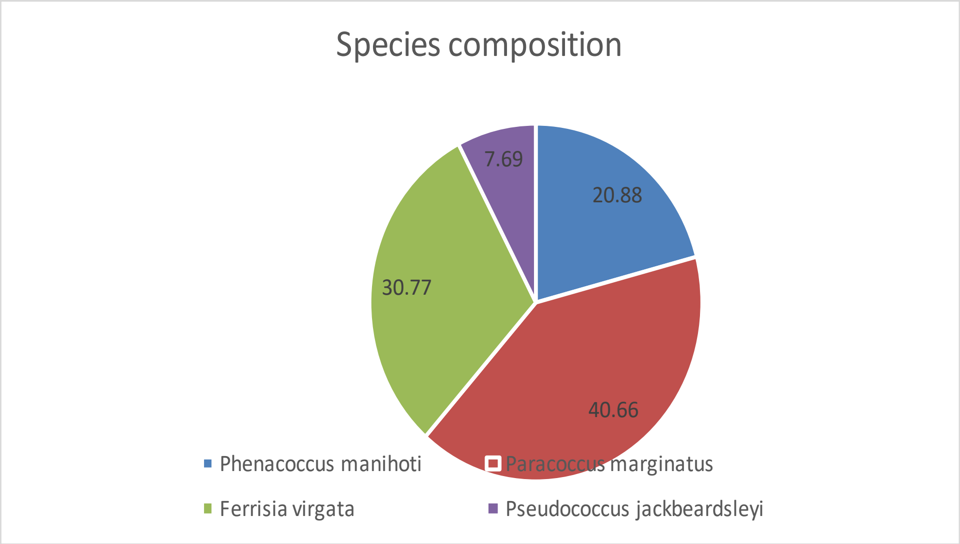

Fig 5. Graphic representation of the mealybug composition in Cassava (2021-22)

Fig 6. Hymenopteran parasitoids of mealybug complex in cassava

Fixed plot surveys were carried out in five different locations (Pazhayannur, Ollukkara, Anthikkad, Chalakkudi and Irinjalakkuda) of Thrissur district from October 2021 to March 2022, since the incidence of mealybug was very low from June to September. Observations were recorded from twenty-five randomly selected plants in each field. Number of mealybugs was recorded from 3 leaves (top, middle and lower canopy) of each plant. The intensity of mealybug infestation was assessed as per standard scale (Geetha and Venkatachalam, 2020). The results of fixed plot survey are presented in Table 20. The mealybug infestation was observed to increase from January onwards and peaked during March (Fig 7).

Table 20. Infestation level and intensity of mealybug on cassava

Month	Number of mealybugs per leaf				Intensity
	Top	Middle	Bottom	Mean	
October 2021	0.19	0.77	1.26	0.74	Very low to low
November 2021	0.12	0.55	1.43	0.69	Very low to medium
December 2021	0.35	0.39	1.69	0.8	Very low to medium
January 2022	1.43	1.3	2.73	1.82	Very low to very high
February 2022	3.06	2.1	2.65	2.6	Medium to very high
March 2022	3.42	4.11	6.67	4.73	Medium to very high

II.1.5 MPKV, Pune

The fields, horticultural and ornamental crops were observed during survey in Pune, Satara, Sangli, Solapur and Ahmednagar districts in Western Maharashtra. At the same time, fruit and vegetable market areas around Pune were visited for record of previously reported invasive pests *viz.,* spiralling white fly, *Aleurodicus dugessi,* mealy bug species, *Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis* and *Pseudococcus jackbeardsleyi.* The infested fruits and vegetable samples were collected from the market and observed for alien invasion of pest species and natural enemies.

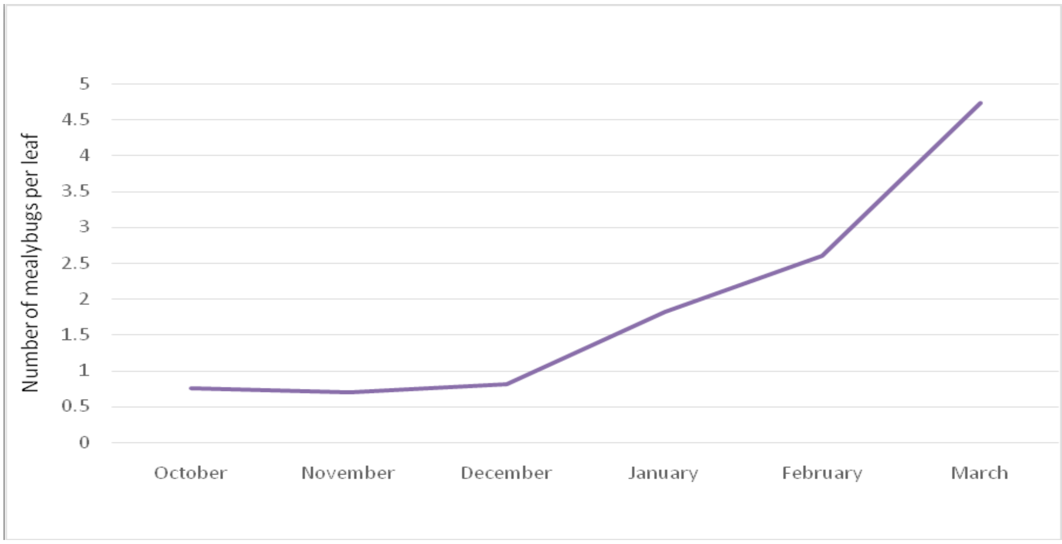

Fig 7. Intensity of mealybug infestation in Thrissur district

Nymphs and adults of mealybug *P.jackbeardsleyi* were collectedon custard apple fruits and tea mosquito bug also reported on custard apple plants.

Alien pest, fall armyworm, *Spodoptera frugiperda* was reported in all maize growing areas of Western Maharashtra (Table 21). The fall armyworm infestation was ranged between 4.00 to 100.00 per cent in maize crop in Pune, Solapur, Satara, Sangli and Ahmednagar district. Fall armyworm incidence also found on sorghum in few fields but it was 1.00 to 2.00 per cent only. The new alien pest, rugose spiraling whitefly (*Aleurodicus rugioperculatus*) first time observed on coconut palms in Western Maharashtra during the year 2021-22. Parasitoid, *Encarsia guadaloupae* and a predator, *Apertochrysa* were seen in the colonies of rugose spiraling whitefly and parasitoid, *Encarsia guadaloupae* and predator, chrysopids were also seen in the colonies of rugose spiraling whitefly on guava and coconut plants.

Table 21. Survey of new insect pests and alien pests on important crops in Western Maharashtra

Name of the pest	No. of fields visited in survey	Pests on crops (%)		Attack of pest on crop %			Range %	
		Pest free	Attacked	Low	Medium	High	(Min)	(Max)
Papaya Mealybug (No./fruit)	20	100.00	-	0.00	0.00	0.00	0.00	0.00
Custard apple mealybug (No./fruit)	10	70.00	30.00	20.00	10.00	10.00	0.00	82.00
Custard apple fruit fly (No. of maggots/fruit)	22	72.73	27.27	0.00	33.33	0.00	0.00	11.00
Custard apple tea mosquito bug (No. shoots/plant)	43	93.03	6.97	50.00	0.00	0.00	0.00	16.00
Sugarcane whitegrub (No. of grubs/mt^2)	70	39.40	60.60	48.48	6.06	12.12	0.00	11.00
Sugarcane woolly aphid No. of aphids/cm^2)	70	70.97	29.03	20.00	0.00	0.00	0.00	17.00
Maize fall armyworm (Plant damage %)	41	-	100.00	35.29	64.71	0.00	4.00	51.00
Coconut spiralling whitefly (No./cm^2)	36	16.67	83.33	18.75	37.50	0.00	0.00	32.00

II.1.6 MPUAT, Udaipur

The extensive survey was conducted to record the present biodiversity of insects from different locations of Southern Rajasthan *viz.,* Udaipur, Chittorgarh and Rajasamand districts during *Kharif*, 2021. The diversity of insect pests and their natural enemies were recorded (Table 22) on different sown crops such as maize, soybean, pulses (blackgram, greengram and cowpea), and vegetables (tomato, brinjal, bhendi etc.)

Fig 8. Fall armyworm infestation in maize

Fig 9. Aphid infestation in different crops


Fig 10. Fuit borer infestation in tomato

Table 22. List of crop wise associated insect pests at Uadaipur

Crop	Common name	Insect	Family	Order
Maize	Maize stem borer	*Chilo partellus*	Crambidae	Lepidoptera
	Fall army worm	*Spodoptera frugiperda*	Noctuidae	Lepidoptera
	Chafer beetle	-	Scarabaeidae	Coleoptera
	Aphid	*Rhopalosiphum maidis*	Aphididae	Hemiptera
	Grasshopper	*Hieroglyphus* spp.	Acrididae	Orthoptera
Vegetables (Tomato, Brinjal, Bhendi)	Fruit borer	*Helicoverpa armigera*	Noctuidae	Lepidoptera
	Brinjal shoot and fruit borer	*Leucinodes orbonalis*	Crambidae	Lepidoptera
	Jassids	*Empoasca kerri*	Cicadellidae	Hemiptera
	Whitefly	*Bemisia tabaci*	Aleyrodidae	Hemiptera
	Aphid	*Aphis craccivora*	Aphididae	Hemiptera
Soybean	Girldle beetle	*Oberea brevis*	Cerambycidae	Coleoptera
	Tobacco caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera
Pulses (Black-gram, green-gram, cowpea)	Jassids	*Empoasca kerri*	Cicadellidae	Hemiptera
	Whitefly	*Bemisia tabaci*	Aleyrodidae	Hemiptera
	Aphid	*Aphis craccivora*	Aphididae	Hemiptera

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

Surveys were conducted to record the incidence of fall armyworm, *S. frugiperda* from June, 2021 to March, 2022. The survey indicated that the incidence of fall armyworm was noticedto be low to moderate in different districts of Southern Rajasthan with an average incidence range of 5-10 percent (Table 23).

Table 23. Monitoring of FAW, *Spodoptera frugiperda* by pheromone traps at RCA Farm, Udaipur

Date of installation of pheromone trap	Number of traps/acre	No. of adults trapped (week)	Trap-1	Trap-2	Trap-3	Trap-4	Total trapped adults
01/06/2021	04	I	03	05	04	03	15
		II	04	06	09	08	27
		III	01	03	05	05	14
		IV	01	02	04	02	09
		V	02	04	10	05	21
		VI	00	03	05	02	10
01/11/2021	04	I	00	02	02	05	09
		II	03	01	07	02	13
		III	01	03	12	08	24
		IV	04	05	04	10	23
		V	01	03	06	04	14
		VI	04	04	13	02	23
		VII	00	08	11	03	22
		VIII	04	10	05	02	21
		IX	01	07	00	07	15
		X	02	04	04	02	12
		XI	00	01	01	00	02

II.1.7. PJTSAU, Hyderabad

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

Tomato pinworm:

Fixed plots survey was conducted in Shamshabad and Moinabad mandals of Rangareddy district. Tomato pinworm population was noticed in all the surveyed villages. The population was observed from 39 th to 49nd SMW during *Kharif* (1.2-5 adults / trap).Roving survey was conducted in Ranga reddy district. The population of pinworm was less than five adults/trap in surveyed villages. The population of pin worm was more in polyhouses and in inderterminate varieties 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, *Nesidiocoris*. Abundance studies showed that in five locations, mean population of spiders, Coccinellids, *Cotesia, Nesidiocoris, Charops* and *Trichogramma* in 0.35, 0.35, 0.007, 1.88, 0.001 and 2.5 per quadrat.

rabi surveys are in progress. Abundance studies showed that in five locations, mean population of spiders, Coccinellids, *Cotesia, Nesidiocoris, Charops* and *Trichogramma* in five NICRA village locations was 0.45, 0.32, 0.005, 1.87, 0.001 and 3.80 per quadrat

Table 24. Tomato pinworm infestation in Rangareddy district in AP.

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	Marriguda mandal, Nalgonda	Less - Moderate
16	Kondur		
17	Metichandapur		
18	Namapur		
19.	Tirgandlapalli		
20	Yergandlapalli		
21	Tammad palli		
22	Somrajguda		

Table 25. Population of natural enemies (no./quadrat) in villages

S. No	Naturalenemy	Laxmithanda		Kasimbowli		Sayyedguda		Kondur		Nagaram		Mean	
		Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	kharif	*rabi*
1	Spiders	0.45	0.63	0.20	0.22	0.31	0.89	0.45	0.41	0.25	0.35	0.35	0.45
2	Coccinellids	0.22	0.32	0.30	0.40	0.32	0.47	0.63	0.47	0.32	0.35	0.35	0.32
3	*Cotesia* sp.	0.001	0.001	0.001	0.001	0.001	0.003	0.002	0.02	0.001	0.001	0.007	0.005
4	*Nesidiocoris bug*	1.21	1.36	1.25	1.89	1.35	1.89	2.00	1.88	1.99	1.58	1.88	1.87
5.	*Charops*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001
6.	*Trichogramma chilonis*	2.7	3.6	1.3	2.5	2.6	3.4	2.8	3.9	4.9	5.3	2.5	3.8

The trial involved surveys of Mahbubnagar, Rangareddy and Nalgonda districts of Telangana in both Kharif and rabi seasons of 2021-22. Visit, survey and surveillance and interaction with state/line department officials and local farmers was done.

Target Area:

Covering the district where centre is located and 2-3 adjoining districts. In case of pest outbreaks, affected area may be specifically visited (Table 26). The Pink Bollworm was observed in many cotton growing areas of the state.

Fall armyworm (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 Thogunta mandal of Siddipet district, *viz.*, Govardhanagiri, Gudikandula, Ghanapur and Varadarajupalli were examined for incidence and damage by the pest.

Surveys in 2021-22 *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. 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 Moinabad mandals, 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* 2021-22, 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 Shamshabad mandal was severely damaged (more than 75%) by *T. absoluta.* Fusarial wilt was noticed in chick pea, chillies, Colocasia crops.

Table 26. Surveillance of incidence of insect pests

Crop	Pests observed	Areas surveyed	Level of Incidence
Paddy	Yellow stem borer Gall midge Green Leafhopper Brown plant hopper	Ranga Reddy dt Shamshabad mandal Bahadurguda village Laxmi thanda Sayyedguda Pedda Golconda ChinnaGolconka Shahpur Kothurmandal	Moderate to severe incidence
		Mahbubnagar dt Chegoremandal	
		Nalgonda dt Marriguda mandal Nampally Mandal Chintapally mandal	Moderate to severe
Cotton	Sucking pests leaf hoppers, whiteflies, thrips, aphids Pink Bollworm	Shamshabadmandal Bahadurguda village Laxmi thanda Syedguda Villages of Chegore mandal Kasimbouli, Moinabad mandal, Aziznagar	Moderate to severe
Redgram and other pulses	*Maruca* sp	Mahbubnagar and surrounding areas	Moderate
Vegeta-bles	Brinjal shoot and fruit borer	Ibrahimpatnam Moinabad Maheshwaram mandal Chevella mandal Shabad mandal Yacharam mandal Sheriguda Bhadraipally	Moderate
	Brinjal leaf hopper		Severe
	Brinjal whitefly		Moderate to severe
	Bhendi shoot and fruit borer		Moderate
	Bhendi leaf hopper		Severe
	Bhendi whitefly		Moderate to severe
	Tomato pinworm		Moderate
	Tomato fruit borer		Moderate
	Tomato Mirid bug		Less
	Tomato whiteflies		Less
Leafy vegetables	Sucking pests	Ibrahimpatnam, Moinabad, Shamshabad, Maheshwaram, Abdullapurmet	*Helicoverpa armigera*
Chilli	Blossom midge		Severe
	Fusarial wilt		Severe


Fig 11. Examining dry seeded rice plots in adopted villages

Fig 12. Field visit to document invasive Thrips incidence in chilli at Jangamandla Palem

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).

Maize: The damage of fall armyworm, *Spodoptera frugiperda* was recorded to be 10-25 per cent on maize and fodder maize crops in various maize growing districts of Punjab. However, it was 40-50 per cent in late sown crop. No FAW incidence was recorded on any other crop.

Cotton: The incidence of pink bollworm, *Pectinophora gossypiella* was recorded in Bathinda and Mansa districts only during August-September (0-45 %). However, the incidence up to 90 per cent was also observed in few fields. Negligible damage due to pink bollworm was recorded in other cotton growing districts (Fazilka, Muktsar, Faridkot, Barnala) of Punjab.

II. 1. 9. SKUAST, Jammu

Table 27. Crop Pest Outbreak Report

S. No.	Month	Date	Locations	Crop	Problems noticed & Level of incidence
1.	April	20/04/2021	Vill. - Yogpur District: Samba	Cucurbits	Red Pumpkin Beetle-Moderate Gummosis and bacterial blight (30% incidence)
2.	May	6/05/2021	Vill. - Deoli, Bish-nah District: Samba	Moong bean, Urdbean	Stem fly 30 – 40% infestation

S. No.	Month	Date	Locations	Crop	Problems noticed & Level of incidence
3.	June	28/06/2021	Vill. - Dhiansar District: Samba	Guava	Mealy bug:Moderate to Severe
4.	July	07/07/2021 14/07/2021 17/07/2021	Vill. – Shahpur, Sarore District: Samba Vill. – Sarore District: Samba Vill. – KharaMad-ana District: Samba	Cucumber Chilli Maize	Mites and Aphids: Moderate Chilli wilt 25% disease incidence Maize stem borer and *Spodoptera frugiperda* - Moderate
5.	August	13/08/2021 23/08/2021	Vill. – Channi Manhasa Vijaypur, District: Samba Vill. – Kalakote District: Samba	Brinjal Rice	Fruit and Shoot borer -Moderate Rice Hispa - Moderate
6.	September 14/09/2021 20/09/2021	05/09/2020	Vill. – Channi Manhasa Vijaypur, District: Samba	Cucurbits, Beans	Leaf hopper, whitefly and Blister beetle: Moderate Yellow mosaic - Severe
		Vill. - Palli District: Samba	Maize	Scarabaeid beetles – Moderate to severe	
		Vill. – Channi Manhasa Vijaypur, District: Samba	Marigold	Wilt complex 25-30% disease incidence	
7.	October	13/10/2021	Vill. - Sarore District: Samba	Cucumber	Yellow mosaic 35-40% incidence
8.	November	17/11/2021 30/11/2021	Vill. - Raya Suchani District: Samba Vill. – Sarore District: Samba	Kinnow, Lemon, Litchi, Mango, citrus Variety: Hybrid Potato	Mealy bug – Moderate to Severe Potato Aphids - Moderate
9.	December	08/12/2021 15/12/2021	Vill. – Deoli, Bishnah District: Samba Vill. – Ismailpur, District: Samba	Guava Mango	Mealybug – Moderate Fruitfly – Moderate Gall formation - Moderate
10.	January	Nil			

S. No.	Month	Date	Locations	Crop	Problems noticed & Level of incidence
11.	February	03/02/2021 15/02/2021	Vill. – Channi Manhassan, District: Samba Vill. – Ranjhari, Raya District: Samba	Cucumber Mango	Alternaria Leaf Blight - 20-25% incidence Anthracnose and leaf blight 30-35% disease incidence
12.	March	09/03/2021 12/03/2021 29/03/2021	Vill. - Channi-Manhassan, District: Samba Vill. – Khara District: Samba Vill. - Channi-Manhassan, District: Samba	Cucumber Onion Watermelon	Leaf spot of cucumber 10-15% incidence Onion Maggot - Moderate Cucumber beetles: Severe


Fig 13. Cucumber mosaic disease **Fig 14.** Scarab beetles in maize


Fig 15. Stem fly damage in black gram **Fig 16.** Aphid infestation in Potato

TNAU, Coimbatore

II. 1.10. Survey, surveillance and monitoring of rugose spiraling whitefly and its natural enemies

Surveys were conducted to assess the infestation of rugose spiraling whitefly (RSW) *Aleurodicus rugioperculatus* and Bondars Nesting Whitefly (BNW) *Paraleyrodes bondari* on coconut in various districts in Tamil Nadu *viz.,* Coimbatore, Tirupur, Erode, Salem, Kallakurichi, Karur, Thiruvallur, Thiruvannamalai and Ramanathapuram. The population of RSW ranged between 4.00 and 33.00/leaflet in various districts in Tamil Nadu. The parasitisation by *Encarsia guadeloupae* ranged between 20.00 and 60.00 per cent on coconut gardens and a predator *Apertochrysa astur* was seen in all the coconut gardens.The population of BNW ranged between 1.00 and 43.00/leaflet in various districts in Tamil Nadu. Besides *E. guadeloupae* and *A. astur*, many predators *viz., Cybocephalus* spp., *Chilocorus nigritus*, preying mantids, dragonflies and spiders (*Argiopes* sp) were also recorded as natural enemies of *A. rugioperculatus* in Tamil Nadu. In fixed plot survey, the population of RSW was maximum during second fortnight of August, 2021 while it was minimum during first fortnight of April, 2021. BNW population ranged between 4.0 and 39.0/leaflet. Parasitisation by *Encarsia* sp was 45 per cent during first fortnight of September, 2021. A maximum of 3 numbers of grubs/leaflet of *Apertochrysa astur* was observed.

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

Surveys were conducted to assess the occurrence of tomato pinworm, *T. absoluta* in tomato growing areas of Coimbatore district. The leaf damage was maximum (7.50%) in Thenkarai during second fortnight of February, 2021 while the fruit damage was 10.00 per cent. The leaf damage ranged between 3.30 and 5.00 per cent in other villages.

Monitoring the incidence of papaya mealybug and its natural enemies

The infestation of *Paracoccus marginatus* was noted in crops like papaya, tapioca, mulberry and guava. The incidence of papaya mealybug on papaya was recorded in Coimbatore and Tiruppur districts. In cassava, *P.marginatus* was observed in Erode, Coimbatore, Tiruppur, and Dindigul Districts of Tamil Nadu. Infestation of papaya mealybug ranged between 0.8 and 3.00 per cent in papaya fields. Papaya field in Thhetipalayam, Coimbatore dt., was free from papaya mealybug. Natural enemies of papaya mealybug *viz., Acerophagus papayae*, *Spalgis epius* and *Cryptolaemus montrouzieri* were seen in papaya fields.

UAS, Raichur

II. 1.11. Incidence of *Thrips parvispinus* Karny on chilli and gherkin

During current year 2021-22 heavy incidence of *Thrips parvispinus* was noticed in chilli growing areas of North-eastern Karnataka and its incidence observed from August month and peak activity was noticed during December month (Table 28) (Fig 17). Apart from chilli its incidence was noticed on coriander and gherkins and huge population was noticed on chilli flowers/ gherkin flowers and leaves (Fig. 18).

Fig 17. Incidence of *Thrips parvispinus* on chilli


Fig 18. Incidence of *Thrips parvispinus* on gherkin in protected cultivation

Table 28. Incidence of *Thrips parvispinus* on chilli in major chilli growing areas during 2021-22

Period of observation	Number of thrips per growing tip			
	Raichur	Devdurga	Ballari	Average
August 2021	8.6	5.2	4.5	6.1
September 2021	9.8	6.5	15	10.4
October 2021	12.2	15.6	19.8	15.9
November 2021	15.5	20.5	21.5	19.2
December 2021	25.6	28.5	30.2	28.1
January 2022	27.5	30.5	26.5	28.2
February 2022	21.5	26.2	20.8	22.8

Natural epizootics of entomopathogenic fungi, *Metarhizium rileyi* on fall armyworm

During 2021-22 the roving survey was conducted in major maize growing areas of Northeastern Karnataka and the natural epizootics of entomopathogenic fungi, *Metarhizium rileyi* was correlated with weather parameters. The results indicated that the relative humidity and rainfall had positive and significant correlation with natural epizootics (Table 29).

Table 29. Correlation of weather parameters with natural incidence of *M. rileyi* in North eastern region of Karnataka during 2021-22

Districts	Mycosis (%)	Temp (Max)	Temp (Min)	Rainfall	RH
Raichur	0.61**	-0.09	0.10	-0.01	0.23*
Ballari	1.00**	-0.18	0.12	0.27	0.20*
Koppal	0.67**	-0.13	-0.32	0.37*	0.39*

* Correlation is significant at the 0.01 level ** Correlation is significant at the 0.05 level

II. 1.12. YSPUHF, Solan

Different locations in districts Bilaspur, Una, Mandi, Solan, Sirmour, Shimla and Kinnaur were surveyed for alien invasive pests like, *Aleyrodicus dugessi, Phenacoccus manihoti, Paracoccus marginatus*, *Phenacoccus madeirensis, Tuta absoluta* and *Spodoptera frugiperda.* During the survey two invasive pests namely *T. absoluta* and *S. frugiperda* were recorded infesting tomato and maize, respectively (Tables 30). The details are given below:

Table 30. *Tuta absoluta* incidence on tomato at different locations

S.No.	Location	District	Plants infested (%)	Mines/leaf/infested plant	Fruit damage (%)
1	Nauni	Solan	28-52	0-3	1-2
2	Deothi	Solan	13-42	1-2	0-2
3	Rajgarh	Sirmaur	21-57	1-4	1-2
4	Naineti	Sirmaur	30-45	0-3	1-3
5	Sarahan	Sirmaur	36-61	1-3	1-3
6	Sundernagar	Mandi	43-67	2-3	3-5
9	Bajaura	Kullu	Nil	Nil	Nil
10	Udaipur	Lauhal&Spiti	Nil	Nil	Nil
11	Tandi	Lauhal&Spiti	Nil	Nil	Nil
12	Rekongpeo	Kinnaur	Nil	Nil	Nil
13	Poorbani	Kinnaur	Nil	Nil	Nil
14	Roghi	Kinnaur	Nil	Nil	Nil

Table 31. *Spodoptera frugiperda* incidence on maize at different locations

S.No.	Location	District	Plants infested (%)
1	Rohin	Bilaspur	30-55
2	Kandraur	Bilaspur	20-40
3	Sunder Nagar	Mandi	45-60
4	Jahu	Mandi	50-70
5	Una	Una	40-65
6	Sarahan	Sirmaur	25-40
7	Nauni	Solan	30-55
8	Nalagarh	Solan	60-70

II. 1.13. ICAR - CPCRI, Kasargod

The experiment was initiated in the Kalparaksha (Selection of Malayan Green Dwarf) block at the Regional Station. Observations on the incidence of invasive whiteflies on coconut were recorded at monthly intervals. Five whitefly-infested palms were selected and four leaflets were examined for the occurrence of exotic whiteflies and the natural enemies. Data is also interrelated with the weather factors prevailed.

The modulation of whitefly population during the period is presented in Fig 19. Rugose spiraling whitefly (*Aleurodicus rugioperculatus*) population was found to be lower than the Bondar's nesting whitefly population (*Paraleyrodes bondari*) during most of the months in 2021-2022. The population of both the whiteflies are getting stabilized during the year ranging from 2.3 to 0.4 live colonies. The population of *P. bondari* was found to be relatively higher registering as high as 2.3 colonies per leafletin the month of March 2021and got reduced subsequently reaching as low as 1.0 colonies on May 2021. Weather factors especially relative humidity and rainfall supplemented with parasitism by *Encarsia guadeloupae* on *A. rugioperculatus* played a crucial role in the whitefly dynamics. Competitive regulation of rugose spiraling whitefly (RSW) by the Bondar's nesting whitefly (BNW) was realized. The non-native nesting whitefly (*Paraleyrodes minei*) that co-existed with BNW and RSW during 2018 was not observedduring the period under report and was completely displaced by the other exotic whitefly species. Sparse and sporadic incidence of palm whitefly, *Aleurotrachelus atratus* (Fig 20) was observed in Kidu (Karnataka), Kannur (Kerala) and Coimbatore (Tamil Nadu) during the period.

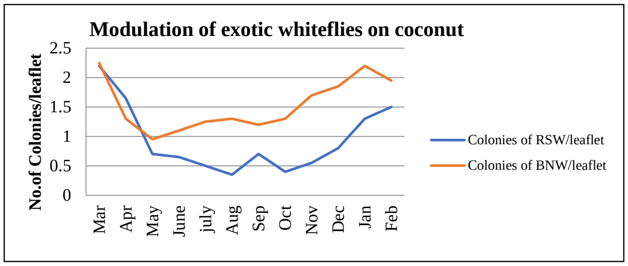

Fig 19. Modulation of exotic whitefly population on coconut palms

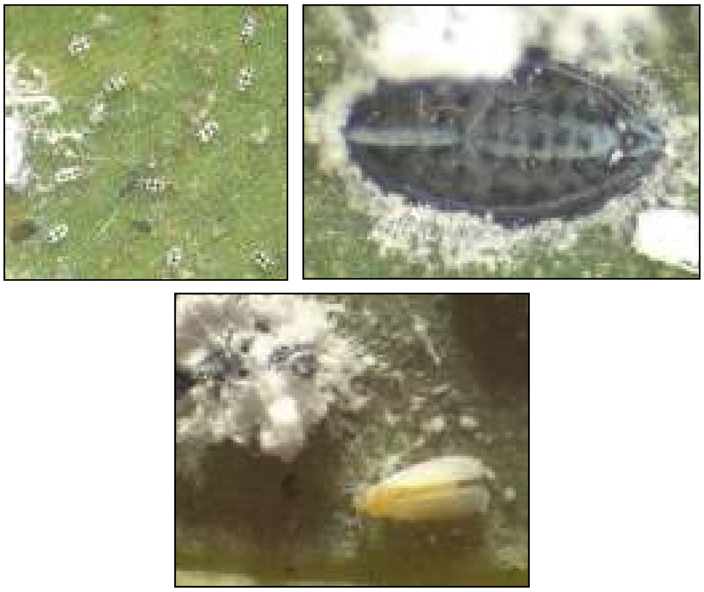

Fig 20. Different life stages of the palm whitefly, *Aleurotrachelus atratus* infesting coconut

Parasitism of rugose spiraling whitefly by the aphelinid parasitoid, *Encarsia guadeloupae* is presented in Fig 21. Percentage parasitism by *E. guadeloupae* on RSW colonies was found maximum during March-April 2021 and January-February 2022. Highest parasitism was observed in March 2021 (35%) and the lowest during October 2022 (14%). Rugose spiraling whitefly population was subdued with higher parasitism by *E. guadeloupae*, whenever the pest population rose up in March 2021 and February 2022. The population of RSW thus showed a downward and stabilized trend in 2021-22

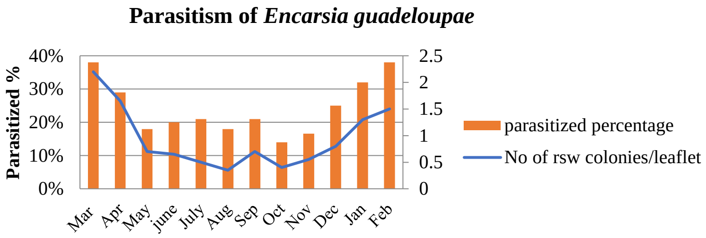

Fig 21. Parasitism of RSW by *Encarsia guadeloupae* Weather factors *versus* whitefly population

Maximum temperature, relative humidity, rainfall and the difference between maximum and minimum temperature was correlated with RSW population and presented in Fig 22. The population of RSW was found to be positively correlated with maximum temperature (r=0.86) and difference in temperature (r=0.78), whereas, negative correlation was observed with relatively humidity (r=-0.81) and rainfall (r=-0.67). Thus, both weather factors and parasitic potential of the aphelinid parasitoid, *E. guadeloupae* played a critical role in the population dynamics of RSW.

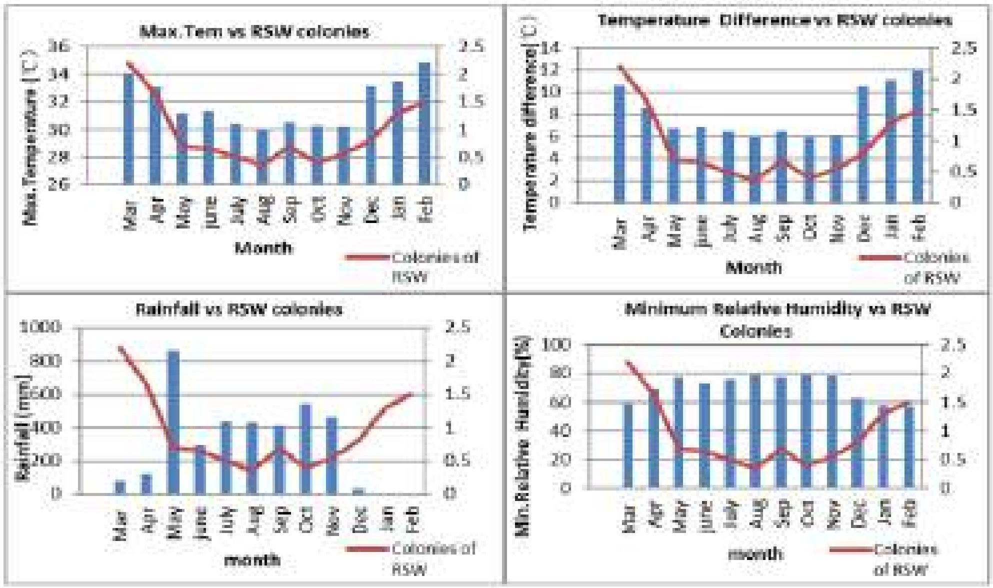

Fig 22. Weather factors versus RSW population

Maximum temperature, relative humidity, rainfall and the difference between maximum and minimum temperature was correlated with BNW population and presented in Fig 23. The population of BNW was found to be positively correlated with maximum temperature (r=-0.72) and difference in temperature (r=0.61), whereas, negative correlation was observed with relatively humidity (r=-0.83) and rainfall (r=-0.72). This indicates a kind of competitive regulation of whitefly population in the co-existence phase in coconut system.

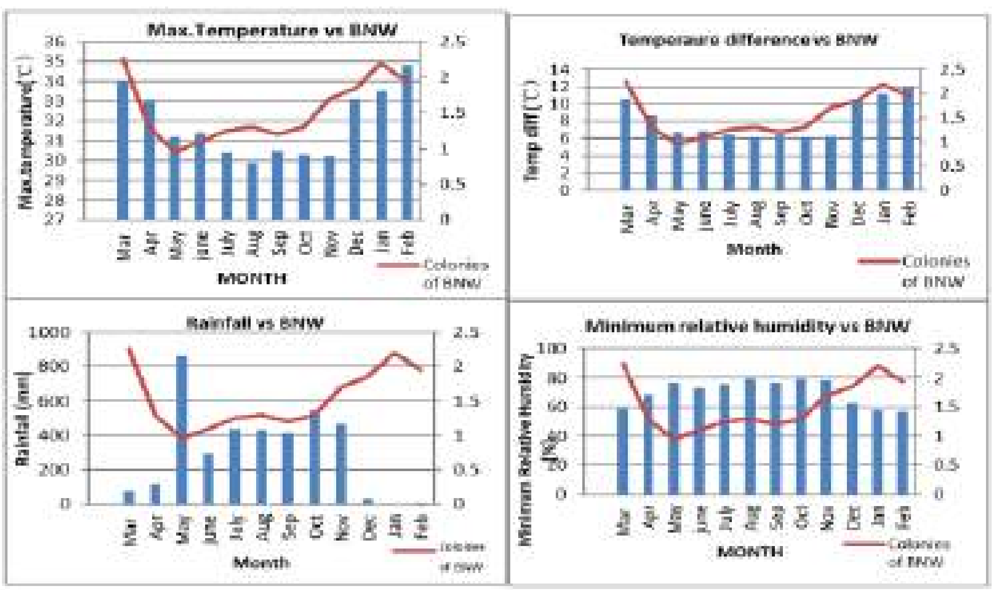

Fig 23. Weather factors versus BNW population Co-existence of invasive whiteflies

Co-existence of Bondar's nesting whitefly (*Paraleyrodes bondari*), with other whiteflies have been commonly observed in coconut system. Besides the co-occurrence with rugose spiraling whitefly, *P. bondari* was found to share the feeding and breeding niche with coleus whitefly (*Aleuroclava canangae*) and the ficus whitefly, *Singhiella simplex* (Fig 24).

Fig 24. Co-existence of exotic whiteflies in different crop system

II. 1.14. KAU, Kumarakom

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

Incidence of rugose spiraling whitefly in coconut in three localities *viz*., Kumarakom, Moncompu and Vyttila was observed over a period of one year from April 2021 to March 2022 (Table 32). Since the population of RSW was found to be very less, observations on surveillance were recorded with respect to Bondar's nesting whitefly alone from April 2021 onwards, just as in previous year.

Among the three locations, highest infestation was observed in Vytilla (98.53%) during September. Percentage of infestation was found to be fluctuating and it was low when compared to 2020-2021 in all the three locations. Severity of infestation was low in Kumarakom during the entire study period, where the other two locations also severity of infestation was low except during September 2021. This may be due to the heavy rainfall obtained during 2021-2022. Number of live colonies per leaflet was found to be fluctuating upto November 2021, from there onwards found to be increasing in both Kumarakom and Moncompu. This may be due to the increase in temperature and relative humidity and also the absence of parasitoids. Highest live colony count (16.50) was obtained during the month of September 2021 in Vytilla which is similar to highest infestation.

Table 32. Severity of infestation of Bondar's nesting whitefly at three different locations during 21-22 (Kumarakom, Moncompu, Vyttila)

Location	Month	Infestation (%)	Intensity of damage (%)	Live colonies /leaflet	Severity of infestation
Kumara-kom	April 2021	72.28	88.76	6.05	Low
	May 2021	78.67	91.00	5.85	Low
	June 2021	81.86	88.83	6.55	Low
	July 2021	85.25	86.63	5.70	Low
	August 2021	80.25	84.91	6.15	Low
	September 2021	77.57	80.85	5.65	Low
	October 2021	89.12	89.38	5.10	Low
	November 2021	94.82	86.66	4.35	Low
	December 2021	90.36	84.97	6.00	Low
	January 2022	86.49	85.22	6.55	Low
	February 2022	86.79	82.70	6.80	Low
	March 2022	85.51	82.21	6.95	Low

Location	Month	Infestation (%)	Intensity of damage (%)	Live colonies /leaflet	Severity of infestation
Vyttila	April 2021	70.57	92.15	5.35	Low
	May 2021	82.56	93.08	6.05	Low
	June 2021	89.55	86.78	6.65	Low
	July 2021	84.33	84.60	7.25	Low
	August 2021	82.69	86.15	6.80	Low
	September 2021	98.33	94.58	16.50	Medium
	October 2021	96.67	95.13	5.75	Low
	November 2021	88.59	94.30	4.70	Low
	December 2021	92.36	95.90	5.60	Low
	January 2022	83.57	90.15	7.80	Low
	February 2022	85.04	92.53	3.60	Low
	March 2022	86.54	93.68	9	Low
Moncompu	April 2021	71.72	82.23	5.70	Low
	May 2021	72.30	84.28	6.05	Low
	June 2021	71.56	84.01	6.65	Low
	July 2021	80.44	87.09	5.75	Low
	August 2021	91.92	85.46	4.10	Low
	September 2021	80.85	81.25	11.75	Medium
	October 2021	93.33	85.75	6.25	Low
	November 2021	92.09	92.59	4.90	Low
	December 2021	91.68	94.70	4.75	Low
	January 2022	85.80	79.61	6.65	Low
	February 2022	75.57	89.45	7.00	Low
	March 2022	87.16	93.33	9.05	Low

II. 1.15. UBKV, Pundibari

Table 33. Crop Pest Outbreak Report (2021-22)

Following the same trend as of the last year, we continued the procedure of survey of crop pest outbreak in this year, too. We tried to focus on our survey in each and every month reaching different blocks throughout the year (April, 2021–January, 2022) to assess the infestation of different pests in the field. The detailed Crop Pest outbreak report is as follows –

Sl. No.	Date	Location	Crops	Pest/Disease Incidence with severity	Advices for Farmers
1.	01.04.2021	1. Village(s) with GPS Co-ordinates: Falakata 26°31’48” N 89°12’ E Block: Falakata District: Alipurduar 2. Village(s) with GPS Co-ordinates: Damdim26°5’11’’N 88°40’17’’ E GP: Damdim Block: Malbazar District: Jalpaiguri	Coconut	Rugose Spiralling Whitefly Level of infestation: Moderate	-
2.	14.07.2021	Village with GPS Co-ordinates: Nagrakata 26.88° N, 88.90° E GP: Luksan Gram Panchayat. Block: Nagrakata	Tea(Mixed clone)	Tea looper Level of infestation: Moderate	Use of light trap to attract and collect the moth. Use in early evening is effective. Spraying of Flubendiamide 20WG (HV-1:5000 and LV-1:2500) or Emamectin benzoate5%SG(HV-1:2500 and LV-1:1250)
3.	23.08.2021	Village with GPS Co-ordinates: Bara Mangwa Busty 27.07° N, 88.47° E GP: Takling-I Gram Panchayat. Block: RangliRangliot, Dist: Darjeeling	Darjeeling mandarin (*Citrus reticulata*)	Citrus leaf miner, 45-47% infestation	Spray Imidacloprid 17.8% SL @ 0.3ml/lit of water
6.	30.12.2021	Village(s) with GPS Co-ordinates:Chhat Singimari(26°51’82”N 89°34’63” E) GP: Patlakhawa Block: Cooch Behar II District: Cooch Behar	Lablab Bean	Hairy Caterpillar Level of infestation: Moderate.	Application of insecticide Anaconda @ 2 ml/lit (Chlorpyrifos 50 % + Cypermethrin 5 %)

III. BIOLOGICAL CONTROL OF PLANT DISEASE USING ANTAGONISTIC ORGANISMS

Biological Control of Cereal Diseases

III. 1. Biological Control of Rice Diseases

TNAU

III. 1. 1. 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 was used in the field trial

Result: A field trial to evaluate the effect of *Bacillus subtilis* (TNAU strain) on major diseases of rice. Results revealed that T5 (T1-Soil application *Bacillus subtilis* (2.5kg/ha) + T2-Seed treatment *Bacillus subtilis* (10g/kg) + T3-Seedling dip *Bacillus subtilis* (2.5kg/ha) + T4-Foliar spray *Bacillus subtilis* (20g/lit) was found to be the best in reducing the incidence of blast, brown spot, bacterial leaf blight, false smut to a considerable level (Table 35). Yield was 3585Kg/ha in T5 and it was higher than the yield in T6-Azoxystrobin (1ml/lit) (3295Kg/ha).

Table 35. Management of major diseases of rice with *Bacillus subtilis* (TNAU strain)

Treatments	Blast	Brown spot	BLB	False smut	Yield
T1-Soil application *Bacillus subtilis* (2.5kg/ha)	20.6 (26.99)	22.9 (28.59)	10.97 (19.33)	11.8 (20.08)	2763
T2-Seed treatment *Bacillus subtilis* (10g/kg)	20.9 (27.20)	21.43 (27.58)	10.03 (18.46)	11.1 (19.45)	2605
T3-Seedling dip *Bacillus subtilis* (2.5kg/ha)	21.27 (27.46)	21.33 (27.50)	9.13 (17.58)	9.93 (18.34)	2861
T4-Foliar spray *Bacillus subtilis* (20g/lit)	15.27 (34.49)	17.23 (24.52)	6.5 (14.76)	7.3 (15.66)	3460

T5-T1+T2+T3+T4	11.37 (19.69)	13.33 (22.78)	6.23 (14.46)	6.57 (14.82)	3585
T6-Azoxystrobin (1ml/lit)	16.97 (24.32)	19.5 (26.20)	10.67 (19.06)	8.57 (17.01)	3295
T7-Control	23.37 (28.91)	27.4 (25.61)	11.67 (19.96)	13.1 (21.27)	2622
CD (0.05)	1.307	6.772	1.155	1.455	169
SEd.	0.5996	3.108	0.5301	0.6677	77.57

*Values in parenthesis are Arc sine transformed values

NRRI, Cuttack

III. 1. 2. Field evaluation of ICAR-NBAIR strains against Rice Blast (*Magnaporthe oryzae*), Brown spot (*Bipolariso ryzae*) and sheath blight (*Rhizoctonia solani*).

Replication: 4 Design: RBD 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/Tricyclazole

T7. Control (Untreated)

The field experiment was conducted at ICAR-NRRI to test the efficacy of identified bio-agents against sheath blight, brown spot and blast diseases of rice. Among the tested strains, NBAIR-PFDWD (*Pseudomonas flourescens*) was the most effective isolate against sheath blight, brown spot and blast with lesser Percent Disease Index (PDI) of 17.58%, 20.72% and 11.43%, respectively. The percent disease reduction over the control was highest for chemical fungicide against sheath blight (84.97%), brown spot (75.01%) and blast (81.57%) followed by NBAIR-PFDWD and NBAIR-TATP. Results revealed that NBAIR-PFDWD treatment enhanced the growth of rice plants in terms of plant height, fresh shoot weight, fresh root weight, dry shoot weight, and dry root weight as compared with control plants. The highest grain yield/plot (14.50 kg/plot) was recorded in chemical treatment followed by plants treated with NBAIR-PFDWD which had the 13.90 kg/plot. Similarly, NBAIR-TATP and NBAIR-BtoyPS enhanced growth and yield components but at a lower level of efficacy than NBAIR-PFDWD.

Table 36. The biocontrol efficacy of identified bio-agents against rice sheath blight, brown spot and blast

Treatments	Sheath blight		Brown spot		Blast	
	Percent Disease Index (%)	Disease reduction over control (%)	Percent Disease Index (%)	Disease reduction over control (%)	Percent Disease Index (%)	Disease reduction over control (%)
NBAIR-PFDWD	17.58 (24.78)[b]	63.37[b]	20.72 (27.07)[b]	52.64[b]	11.43 (19.75)[b]	59.89[b]

NBAIR-PEOWN	34.91 (36.21)^{f}	27.27^{f}	32.86 (34.97)^{f}	24.89^{f}	21.53 (27.64)^{f}	24.45^{f}
NBAIR-BATP	32.16 (34.54)^{e}	33.00^{e}	28.05 (31.97)^{e}	35.88^{e}	19.00 (25.83)^{e}	33.33^{e}
NBAIR-BtoyPS	27.75 (31.78)^{d}	42.18^{d}	24.96 (29.96)^{d}	42.94^{d}	13.20 (21.30)^{c}	53.68^{c}
NBAIR-TATP	23.06 (28.69)^{c}	51.95^{c}	22.83 (28.53)^{c}	47.81^{c}	15.60 (23.25)^{d}	45.26^{d}
Carbendazim/Tricy-clazole	7.21 (15.57)^{a}	84.97^{a}	10.93 (19.30)^{a}	75.01^{a}	5.25 (13.24)^{a}	81.57^{a}
Control	48.00 (43.85)^{g}		43.75 (41.40)^{g}		28.50 (32.26)^{g}	

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

Table 37. Effect of bio-agents on plant growth attributes and yield of rice plants under field conditions

Treatment	Plant height (cm)	Fresh shoot weight (g)	Fresh root weight (g)	Dry shoot weight (g)	Dry root weight (g)	Yield (kg/plot)
NBAIR-PFDWD	108^{a}	32.15^{a}	3.15^{b}	9.71^{a}	1.97^{a}	13.9^{b}
NBAIR-PEOWN	105^{b}	29.50^{e}	2.49^{f}	9.25^{e}	1.68^{e}	10.9^{f}
NBAIR-BATP	103^{c}	29.03^{f}	2.55^{e}	9.21^{f}	1.74^{d}	11.6^{e}
NBAIR-BtoyPS	105^{b}	31.50^{c}	3.02^{d}	9.45^{c}	1.80^{c}	12.5^{d}
NBAIR-TATP	100^{d}	31.77^{b}	3.20^{a}	9.49^{b}	1.95^{a}	13.2^{c}
Carbendazim/Tricyclazole	105^{b}	30.00^{d}	3.10^{c}	9.35^{d}	1.90^{b}	14.5^{a}
Control	94^{e}	27.32^{g}	2.40^{g}	8.89^{g}	1.15^{f}	8.1^{g}

Values are the mean of four replications. Means followed by a common letter are not significantly different at 5% level by DMRT.

IGKV, RAIPUR

III. 1. 3. Rice blast (*Pyricularia oryzae*)

Table 38. Showing percentage of rice blast disease

Treatments	Pre-treatment	Post-treatment
T1 (Control)	2.82 (9.55)	14.14 (22.08)
T2 (Farmer's practice)	2.20 (8.50)	11.50 (19.82)
T3 BIPM (FYM 50% + Vermicompost 50%)	1.63 (7.20)	7.64 (16.04)
T4 BIPM (FYM 100%)	2.01 (8.04)	8.54 (16.98)
T5 BIPM (Vermicompost 100%)	1.41 (6.75)	6.70 (14.99)
SEm ±	0.637	0.202
C.D. (P = 0.05)	NS	0.629

Maximum disease incidence (symptoms) due to rice blast in the form of percentage of disease incidence was maximum in control (14.14) while it was minimum (6.70) in BIPM treated (Vermicompost 100%).

Rice brown spot (*Helminthosporium oryzae*)

Table 39. Showing percentage of rice brown spot disease

Treatments	Pre-treatment	Post-treatment
T1 (Control)	1.83 (7.73)	8.82 (17.27)
T2 (Farmer's practice)	1.40 (6.73)	6.98 (15.31)
T3 BIPM (FYM 50% + Vermicompost 50%)	0.81 (4.41)	3.87 (11.34)
T4 BIPM (FYM 100%)	1.01 (5.69)	4.83 (12.68)
T5 BIPM (Vermicompost 100%)	0.62 (3.90)	2.90 (9.79)
SEm ±	0.913	0.183
C.D. (P = 0.05)	NS	0.569

Maximum disease incidence (symptoms) due to rice brown spot in the form of percentage of disease incidence was observed in control (8.82) while it was minimum (2.90) in BIPM treated (Vermicompost 100%).

False smut of rice

Table 40. Showing percentage of false smut of rice disease

Treatments	Pre-treatment	Post-treatment
T1 (Control)	0.00 (0.00)	2.67 (9.41)
T2 (Farmer's practice)	0.00 (0.00)	2.14 (8.40)
T3 BIPM (FYM 50% + Vermicompost 50%)	0.00 (0.00)	1.21 (6.30)
T4 BIPM (FYM 100%)	0.00 (0.00)	1.55 (7.15)
T5 BIPM (Vermicompost 100%)	0.00 (0.00)	0.90 (5.46)
SEm ±	0.000	0.115
C.D. (P = 0.05)	NS	0.358

Result: Maximum disease incidence (symptoms) due to false smut of rice in the form of percentage of disease incidence was recorded in control (2.67) while it was minimum (0.90) in BIPM treated (Vermicompost 100%).

G.B.P.U.A. & T., Pantnagar

III. 1. 4. Large scale field demonstration

Rice-200 ha

Rice (var. Pant Basmati 1, Narendra 357, Govind, Pant Dhan 4)

Table 41. Location: Farmers fields of District Nainital and Udham Singh Nagar of Uttarakhand.

Treatments T1= Biocontrol (microbial) Package	Use of Bioagent Seed bio-priming through Pant Bioagent formulation, PBAT-3 (*T. harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) @ 10g/kg of seeds. Seedling dip with PBAT 3@ 10 g/ liter for about 30 minutes. Spray of PBAT 3 @ 10 g/ liter on standing crop at 10-12 days intervals.
T2 = Farmers Practice	(Carbendazim, Copperoxychloride, Streptocycline, Nuvan, Imidachlorpid pesticides used by farmers')
Observations	Disease incidence Grain yield of crop (q/ha) Cost-benefit ratio

Large scale field demonstrations of bio-control were conducted at the end of 135 farmers of 25 villages of District Nainital and U S Nagar, covering an area of 200 ha. The farmer's acreage ranged was from 0.2-7.0 ha. Twelve quintals PBAT-3 (*Trichoderma harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) was distributed to the farmers to conduct to popularize use of biocontrol agents in place of chemical pesticides amongst farmers. Polysheet (2x10m to each farmer) was distributed for nursery soil solarization. Neem oil was distributed for the control of stem borer in rice. Pheromone traps were placed @ 20/ha to control rice stem borer. A total of twenty five visits at different locations were made to provide inputs, technical knowledge and collection of data.

Table 42. Package of practices advised to the farmers for rice crop were as under:

Crop	Rice
Diseases	Sheath blight, Bacterial blight, False smut and Brown spot
Components with dose, concentration, frequency and method of application	Soil solarization of nursery beds before sowing seeds. Seed treatment with Bioagent @10 g/kg seed. Seedling root dip treatment @10 g/lit water for 30 min. prior to transplanting. Four foliar sprays with PBAT-3 @10 g/lit water at 15 days interval.

Sheath blight (*Rhizoctonia solani*), Bacterial leaf blight (*Xanthomonas oryzae*), False smut (*Ustilaginoidea virens*) and Brown spot (*Drechslera oryzae*) diseases were observed.

Table 43. Occurrence of rice diseases at farmer's field

Disease	Causal Organism	PBAT-3	Conventional Practices
		Disease severity (%)	Disease severity (%)
Sheath blight	*Rhizoctonia solani*	8	30
Bacterial blight	*Xanthomonas oryzae* pv. *oryzae*	6	20
False smut	*Ustilaginoidea virens*	12-15	20-22
Brown spot	*Drechslera oryzae*	2-3	5-7

An average yield of 68.0 q/ha was recorded by the farmers adopting bio-control technologies along with need based organic practices as compared to yield of 52.0 q/ha by the farmers adopting conventional practices for the management of insect pests and diseases.

Table 44. Cost-benefit ratio with biocontrol practices and with conventional practices

Management Practices	Cost of production per ha (Rs.)	Yield (q/ha)	Selling price (Rs./q)	Total selling price (Rs.)	Net Profit (Rs.)	Cost benefit ratio
Biocontrol Practices	35,500.00	68.0	1780.00	1,21,040.00	85540.00	1: 2.40
Conventional practices	40,800.00	52.0	1780.00	92560.00	51760.00	1: 1.26

Fig 25. View of large scale field demonstration of Biocontrol technologies in Rice

III. 2. Wheat

SKUAST, Jammu

III. 2. 1. Field evaluation of ICAR-NBAIR antagonistic organisms against Wheat Yellow rust (*Puccinia striiformis* f. sp. *tritici*)

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

T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)

T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)

T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)

T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)

T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)

T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)

T_7 - Recommended fungicide application (Propiconazole @ 1 ml/L)

T_8 - Control (Untreated)

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 organismsat the 10^8cfu/ml has been given at 14 days interval starting from 75 Days after Sowing when the disease start appearing

Fig 26.

Table 45. Yield and Yield attributes of wheat as affected by the application of various antagonistic organisms

Treatments	Plant Height (gm)	Ear length (cm)	Number of seeds / ear	Biomass (gm)	Yield (q/ha)
T_1	79.90	10.44	31.89	10.28	33.33
T_2	76.12	9.44	29.33	9.11	25.67
T_3	79.10	9.78	30.44	10.00	27.33
T_4	75.40	9.11	27.11	8.66	22.00
T_5	73.12	9.00	25.33	7.66	20.00
T_6	75.57	9.33	26.89	8.11	20.67
T_7	74.52	9.14	26.44	8.00	19.67
T_8	73.03	9.00	25.11	7.44	18.67
C.D. at 5%	**2.152**	**N.S.**	**1.489**	**0.874**	**1.217**

Table 46. Per cent 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	10.10	9.60	9.40	8.90	8.50	7.60	6.90	5.60
T_2	13.30	12.90	12.60	12.10	11.90	11.20	10.50	9.40

T_3	12.20	11.40	11.10	10.20	9.80	8.70	8.10	6.50
T_4	12.60	12.10	11.90	11.20	10.90	10.10	9.60	8.50
T_5	14.10	13.80	13.50	13.10	12.80	12.30	12.10	11.70
T_6	12.70	12.30	12.00	11.50	11.20	10.50	9.90	9.30
T_7	9.80	9.20	9.00	8.20	7.60	6.90	6.30	5.40
T_8	14.50	15.10	15.50	15.90	16.30	16.80	17.10	17.90
C.D. at 5%	**1.570**	**1.272**	**1.346**	**1.045**	**1.472**	**1.753**	**1.280**	**1.541**

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* (Talc formulation) T_1 - recorded lowest percent disease index (5.60%) followed by its liquid formulation T_3 - (6.50%). Percent disease index in Propiconazole spray T_7 - (5.40%) was comparable to that of T_1 and grain yield was significantly highest in T_1 (33.33 q/ha). The grain yield was lowest in T_8 – control (18.67 q/ha). Other growth and yield attributes (plant height, no. of seeds / ear and biomass) also corresponded, respectively with the grain yield.

III. 3. Maize

SKUAST, Jammu

III. 3. 1. Field evaluation of ICAR-NBAIR antagonistic organisms against Maize Turcicum leaf blight (*Exserohilum turcicum*)

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

T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)
T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)
T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)
T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)
T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)
T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)
T_7 - Recommended fungicide application (Carbendazim @ 2 g/L)
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 organismsat the 10^8 cfu/ml has been given at 14 days interval starting from 25 Days after sowing when the disease start appearing.

Yield and Yield attributes of maize as affected by the application of various antagonistic organisms

Table 47.

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	197.48	17.50	13.63	13.00	31.94	124.44	30.58
T_2	205.04	19.84	14.95	13.67	31.33	132.79	32.05
T_3	204.48	18.50	15.10	14.00	32.55	128.04	30.87
T_4	213.76	20.82	15.99	14.67	34.33	135.90	32.05
T_5	207.93	18.87	15.10	14.00	33.00	131.56	30.92
T_6	199.10	17.50	15.43	14.00	31.22	128.27	27.74
T_7	167.04	15.00	14.10	11.67	26.97	118.04	23.31
T_8	152.48	10.82	10.27	10.67	19.78	104.69	19.18
C.D. at 5%	19.232	1.834	1.575	1.670	4.931	17.345	2.210

Percent maize Turcicum leaf blight index in response to the application of various antagonistic organisms

Table 48.

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	36.20	35.80	34.00	33.70	31.50	31.00	29.90	28.50
T_2	31.50	30.90	28.10	26.50	25.20	24.60	24.00	21.10
T_3	35.10	34.40	32.10	31.50	30.00	28.50	27.10	26.30
T_4	30.10	29.60	26.00	25.60	24.10	23.50	21.00	20.50
T_5	33.90	33.00	30.90	29.40	28.70	25.10	24.90	23.00
T_6	35.50	35.00	34.30	33.50	32.00	31.50	30.00	29.10
T_7	29.00	28.50	25.50	24.90	23.00	22.50	19.50	19.10
T_8	40.10	41.00	41.50	42.50	43.00	43.40	44.50	45.30
C.D. at 5%	2.138	2.245	2.890	3.120	2.476	2.251	2.105	2.060

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 (20.50%) and its talc formulation T_2 - (21.10%), followed by T_5 (23.00%). Percent disease index in carbendazim spray T_7 - (19.10%) was comparable to that of T_4 -NBAIR-TATP strain *T. asperellum* (Liquid formulation). Grain yield was significantly highest in T_4 (32.05 q/ha) and T_2 (32.05 q/ha). The grain yield was lowest in T_8 – control (19.18 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

SKUAST, Jammu

III. 4. Chickpea

III. 4. 1. Field evaluation of ICAR-NBAIR antagonistic organisms against Chickpea *Fusarium* wilt (*Fusarium oxysporum* f. sp. *ciceris*)

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

T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)

T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)

T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)

T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)

T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)

T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)

T_7 - Recommended fungicide application (Carbendazim @ 2 g/L)

T_8 - Control (Untreated)

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 organismsat the 10^8cfu/ml has been given at 14 days interval starting from 75 Days after sowing when the disease start appearing.

Table 49. 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	31.70	1.78	32.11	10.45	8.67
T_2	28.99	1.56	29.78	9.23	7.00
T_3	30.44	1.67	31.44	9.50	8.00
T_4	26.88	1.78	28.33	8.41	6.67
T_5	25.61	1.67	28.11	7.56	5.33
T_6	24.82	1.56	27.78	7.22	4.67
T_7	25.99	1.33	27.33	8.07	4.86
T_8	24.18	1.33	21.56	6.94	3.67
C.D. at 5%	**1.840**	**0.21**	**1.76**	**1.432**	**1.15**

Table 50. Per cent Chickpea *Fusarium* wilt incidence in response to the application of various antagonistic organisms

Treatments	Per cent 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	13.30	14.20	14.90	15.20	17.10	18.20	19.50	21.20
T_2	14.90	15.80	17.20	19.10	20.50	21.30	22.50	23.80
T_3	14.70	15.60	18.00	19.10	19.90	21.10	22.20	23.10
T_4	15.10	16.20	17.10	19.90	21.10	22.90	24.20	26.80
T_5	16.70	17.10	18.90	20.10	21.90	23.80	27.50	29.90
T_6	16.80	17.20	19.50	20.90	22.30	24.50	27.90	30.60
T_7	13.20	14.10	14.80	15.10	16.90	18.00	19.40	20.90
T_8	17.20	23.50	27.10	31.20	36.30	44.10	45.20	49.10
C.D. at 5%	**N.S.**	**1.241**	**0.980**	**1.120**	**1.089**	**1.523**	**1.450**	**1.740**

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 (21.20%) and its talc formulation T_2 - (23.10%), followed by T_5 (23.80%). Percent wilt incidence in carbendazim spray T_7 - (20.90%) 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 (3.67 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.

III. 5. COWPEA

KAU, Vellayani

III. 5. 1. Management of *Fusarium* wilt in vegetable cowpea using microbial agents

Results revealed that seed treatment with *P. flourescens* (KAU strain) followed by fortnightly soil drenching and foliar spraying with *P. flourescens* (T1) and combined application of *Pseudomonas* (fortnightly) + *Trichoderma* (KAU Strain) as basal (T3) as well as need based CoC (T4) are equally good in managing fusarium wilt in cowpea. None of the plants show wilting symptom in these plots. Treatment with *Trichoderma* alone and treatment with *Trichoderma* + *Pseudomonas* + need based CoC was inferior, wherein the average number of plants wilted was 2-5.

Table 51. Efficacy of microbial agents in managing *Fusarium* wilt of cowpea at Vellayani

Treatments	Disease incidence (Weeks after planting)					
	2	**4**	**6**	**8**	**10**	**12**
T1- Seed treatment with *P. fluorescens* (KAU strain) @ 10g /kg+ Soil drenching @ fortnightly intervals + foliar drenching @ fortnightly intervals	NIL					
T2 – Basal application of *Trichoderma* sp. KAU strain (multiplied in cowdung + neemcake 9:1 ratio) @ 250 g /plant + monthy soil application	0	0	0	2	1	1
T3 - (TI + T2)	NIL					
T4 - (IDM) T3 + need based application of COC @ 2g/L foliar spray / 4g/ L soil drenching	NIL					
T5 – Chemical fungicide Carbendazim @ 2g/L need based	0	0	0	0	1	1
T6- Untreated check	0	0	0	2	2	1

Disease incidence was low to moderate in infected plots. The variety Polo was to be tolerant.

The yield recorded was highest *P. flourescens* treated plots and lowest in untreated plots. The yield recorded from other treatments did not vary among themselves.

III. 6. Pea

SKUAST, Jammu

III. 6. 1. Field evaluation of ICAR-NBAIR antagonistic organisms against Pea Rust (*Uromyces fabae*)

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

T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)

T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)

T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)

T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)

T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)

T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)

T_7 - Recommended fungicide application (Mancozeb @ 2.5g/L)
T_8 - Control (Untreated)

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 52. 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	75.11	30.22	5.33	10.48	7.00
T_2	72.78	28.55	5.00	9.12	6.67
T_3	74.33	28.78	5.00	9.05	6.63
T_4	71.33	26.11	4.67	8.45	5.47
T_5	68.22	25.22	4.67	8.15	4.33
T_6	71.66	25.77	5.00	8.67	5.00
T_7	72.89	27.55	5.33	9.61	6.67
T_8	66.33	21.22	4.67	8.28	4.67
C.D. at 5%	**1.972**	**1.581**	**0.543**	**0.795**	**0.628**

Table 53. 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	12.60	9.70	9.50	9.10	8.90	7.10	6.90	6.10
T_2	13.00	11.80	11.20	10.90	10.40	9.90	9.70	9.10
T_3	12.80	9.90	9.60	9.30	9.20	7.80	7.10	6.70
T_4	13.60	12.10	11.80	11.20	10.70	10.10	9.90	9.50
T_5	14.10	13.80	13.40	13.10	12.90	12.70	12.30	11.90
T_6	12.90	11.50	10.70	10.10	9.50	9.10	9.00	8.80
T_7	10.10	9.50	9.30	8.90	8.50	6.90	6.40	5.70
T_8	14.30	15.70	15.90	16.40	16.80	17.20	17.40	18.10
C.D. at 5%	**1.025**	**1.180**	**1.465**	**1.324**	**1.654**	**1.782**	**1.570**	**1.281**

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* (Talc formulation) T_1 - recorded lowest percent disease index (6.10%) followed by its talc formulation T_1 - (6.70%). Percent disease index in Mancozeb spray T_7 - (5.70%) was comparable to that of T_1 - *P. fluorescens* (NBAIR-PFDWD strain – talc formulation), and seed yield was significantly highest in T_1 (7.00 q/ha), followed by T_2 (6.67 q/ha) and T_7. The grain yield was lowest in T_8 – control (4.67 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 28.

Dr YSPUHF, Solan

III. 6. 2. Management of Fusarium wilt / root rot of pea through biological control agents

A field experiment on the management of Fusarium wilt (*F. oxysporum* f.sp. *pisi*) was laid out during October, 2021 at the Experimental Farm of Department of Entomology, Dr YSPUHF, Nauni. The pea variety, Punjab-89, seeds were sown in plots of 3x1m^2. Seven treatments comprising of seed as well as soil treatments of two biocontrol agents *Trichoderma asperellum* and *Pseudomonas fluorescens* including chemical and absolute controls were evaluated. 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 data thus recorded are presented in Table 54. Results reveal that all the biological control treatments reduced the wilt incidence in pea significantly as compared to control. The lowest incidence of 10.00 percent was, however, 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 found statistically at par with the chemical treatment T6 (Seed treatment with carbendazim @ 2g/kg seed and drenching with carbendazim @ 2g/L) and comparatively better than other biocontrol treatments such as 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) and 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). The treatment T4 also performed better w.r.t. green pod yield which was observed highest (3.09 kg) amongst all other treatments. The yield was statistically higher with this treatment even than chemical treatment (T6). It can be concluded from the experiment 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^2 provided significantly better control of *Fusarium* wilt of pea as compared to already recommended chemical treatment.

Table 54. Effect of seed treatment and soil application of *Trichoderma asperellum* and *Pseudomonas fluorescens* on *Fusarium* wilt and yield of pea cv. Pb-89

Treatment	Wilt (%)*	Yield per plot (kg)
T1: Seed treatment with *Pseudomonas fluorescens* formulation @ 10g/kg seed	17.67 (4.32)	2.23
T2: Seed treatment with *Trichoderma asperellum* formulation @ 10g/kg seed	15.67(4.08)	2.38

Treatment	Wilt (%)*	Yield per plot (kg)
T3: 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	14.00 (3.87)	2.65
T4: Seed treatment with *Trichoderma asperellum* formulation @ 10g/kg seed+ soil application of *Trichoderma asperellum* formulation after mixing with FYM (10g/Kg FYM) @40g/m^2	10.00 (3.31)	3.09
T5: 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	13.00 (3.74)	2.79
T6: Seed treatment with carbendazim @ 2g/kg seed and drenching @2g/L with carbendazim (University recommendation)	12.33 (3.65)	2.74
T7: Control (no treatment)	28.00 (5.38)	1.97
CD (P = 0.05)	0.35	0.14

*Figures in parenthesis are square root transformed values

PAU, LUDHIANA

III. 6. 3. 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, PAU, Ludhiana on 20.10.2021 in a randomized block design following standard agronomic practices. There were six treatments with three replications. The treatments were (1) *Pseudomonas fluorescens* (NBAIR-PF DWD) (2) *Trichoderma harzanium* (NBAIR) (3) *Trichoderma asperellum* (NBAIR TATP) (4) *Pseudomonas fluorescens* (local) (5) Chemical control (spray the crop twice with 200 g Sulfex and 400 g Indofil M45 per acre at an interval of 10 days) (6) Untreated control. The mode of microbial antagonists treatment was seed treatment: @ 10 g/kg, soil treatment of mix formulation @1 kg with 100kg FYM per acre which was broadcasted uniformly and two foliar sprays @ 10 g/litre at 10 days interval. The percent disease incidence was recorded per square meter

Table 55. Evaluation of microbial antagonists for the management of diseases in pea (2020-2021 and 2021-2022) pooled

Treatment	Disease incidence (%)	Percent reduction incidence over control	Disease severity (%)	Percent reduction severity over control	Yield (Q/ha)
T1: *Pseudomonas fluorescence* (NBAIR-PF DWD	39.76 ^{b} (39.06)	26.80	35.53 ^{b} (36.32)	31.63	138.33 ^{b}
T2: *Trichoderma harzanium* (NBAIR)	45.22 ^{c} (42.23)	16.75	41.36 ^{c} (39.90)	20.41	132.33 ^{b}
T3: *Trichoderma asperellum* (NBAIR TATP)	45.21^{c} (42.21)	16.77	39.43 ^{c} (38.73)	24.12	133 ^{b}

T4: *Pseudomonas fluorescence* (local)	43.82 [c] (41.38)	19.32	39.01 [c] (38.57)	24.93	130.83 [b]
T5: Chemical control (Sulfex (200g/acre) and Indofil M 45 (400g/acre)	25.43[a] (30.06)	53.18	26.61 [a] (30.93)	48.79	168.83 [a]
T6: Untreated Control	54.32 [d] (47.50)	-	51.97 [a] (46.11)	-	118.83 [e]
CD (P = 0.05)	3.07		5.09		15.72

Ascochyta blight was the only disease observed in the experimental field so, the percent disease incidence and severity of Ascochyta blight was recorded. The pooled percent disease incidence was minimum (39.76 %) in *Pseudomonas fluorescens* (NBAIR-PF DWD) and was significantly better than untreated control (54.32%). However, chemical control recorded (25.43 %) disease incidence. Disease severity was recorded from four plants per plot per replication. Minimum per cent disease severity (35.53%) was observed in *Pseudomonas fluorescens* (NBAIR-PF DWD). However chemical and untreated control recorded 39.01 and 48.79 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 158.6 and 108.3 q/ha, respectively.

Pseudomonas fluorescens (NBAIR-PF DWD) recorded lowest disease incidence (39.76%), disease severity (35.53%). Pod yield (138.33 q/ha) was at par with all other microbial antagonists treatments and significantly better than untreated control. However, chemical control recorded disease incidence (25.43%), disease severity (26.61%) and pod yield (168.8q/ha)

Pseudomonas fluorescens (NBAIR-PF DWD) recorded minimum per cent incidence reduction over control (26.80) and percent severity reduction over control (31.63). However chemical control recorded 53.18 % and 48.79 % reduction in incidence and severity over control, respectively.

G.B.P.U.A. &T., Pantnagar

III. 6. 4. Pea crop

Pea (Pant sabji matar-3) -25 ha

Location: Farmers fields of District Nainital of Uttarakhand.

Treatments

T1= Biocontrol (microbial) Package : Use of Bioagent

Seed bio-priming through Pant Bioagent formulation, PBAT-3 (*T. harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) @ 10g/kg of seeds.

Spray of PBAT 3 @ 10 g/ liter on standing crop at 10-12 days intervals.

T2 = Farmers Practice: (Carbendazim used by farmers)

Observations:

Disease incidence

Pod yield of crop (q/ha)

Cost-benefit ratio.

Large scale field demonstrations of bio-control technologies on pea were conducted at 65 different farmers of district Nainital covering an area of 25 ha. Four quintals PBAT-3 (*Trichoderma harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) was distributed to the farmers for seed treatment through biocontrol agents to counter soil borne diseases. An average green pod yield of 85.0 q/ha was recorded with bio-control technologies as compared to 58.0 q/ha with conventional farmers practices.

Table 56. Package of practices advised to the farmers for pea crop were as under:

Crop	Pea
Diseases	Root rot
Components with dose, concentration, frequency and method of application	Soil treatment with value added compost (enriched with biocontrol agent @1 kg /q compost) Seed treatment with Bioagent @10 g/kg seed. Four foliar sprays with PBAT-3 @10 g/lit water at 15 days interval.

Root rot complex (*Pythium* spp., *Fusarium* spp., *Rhizoctonia* spp.) in pea was observed.

Table 57. Occurrence of pea diseases at farmer's field

Disease	Causal Organism	PBAT-3	Conventional Practices
		Disease severity (%)	Disease severity (%)
Root rot complex	*Pythium* spp., *Fusarium* spp., *Rhizoctonia* spp.	5	18

An average yield of 90.0 q/ha was recorded by the farmers adopting bio-control technologies along with need based organic practices as compared to an yield of 71.0 q/ha by the farmers adopting conventional practices for the management of insect pests and diseases.

Table 58. Cost-benefit ratio with biocontrol practices and with conventional practices

Management Practices	Cost of production per ha (Rs.)	Yield (q/ha)	Selling price (Rs./q)	Total selling price (Rs.)	Net Profit (Rs.)	BC ratio
Biocontrol Practices	66000.00	90.0	2000.00	180000.00	110000.00	1: 1.66
Conventional practices	58000.00	71.0	2000.00	142000.00	84000.00	1: 1.44

Biological Control of Oilseed Crops

III. 7. Mustard

SKUAST, Jammu

III. 7. 1. Field evaluation of ICAR-NBAIR antagonistic organisms against Mustard White rust (*Albugo candida*)

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

T_1 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Talc formulation)

T_2 - NBAIR-TATP strain *Trichoderma asperellum* (Talc formulation)

T_3 - NBAIR-PFDWD strain *Pseudomonas fluorescens* (Liquid formulation)

T_4 - NBAIR-TATP strain *Trichoderma asperellum* (Liquid formulation)

T_5 - BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation)

T_6 - BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) (Talc formulation)

T_7 - Recommended fungicide application (Ridomil MZ @ 2.5g/L)

T_8 - Control (Untreated)

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 organismsat the 10^8cfu/ml has been given at 14 days interval starting from 75 Days after Sowing when the disease start appearing.

Table 59. 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	165.42	157.11	19.45	11.33	60.44	10.99
T_2	147.18	111.22	16.22	9.77	51.33	9.99
T_3	160.72	149.55	18.89	10.67	58.11	10.33
T_4	149.68	122.22	15.55	9.33	47.56	9.33
T_5	146.42	118.11	15.33	9.44	46.00	9.33
T_6	163.15	143.22	18.55	10.22	57.33	10.33
T_7	112.18	126.55	17.45	10.00	55.77	10.17
T_8	100.33	98.33	14.67	8.67	40.11	9.17
C.D. at 5%	**5.487**	**5.313**	**1.820**	**0.758**	**1.829**	**1.170**

Table 60. 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	32.90	29.70	27.50	26.10	23.40	21.50	21.10	19.50
T_2	42.10	39.30	38.60	36.70	35.40	33.20	32.10	30.40
T_3	35.30	31.50	29.10	27.80	25.30	23.50	23.10	22.60
T_4	45.20	43.90	42.10	40.80	39.30	38.70	37.20	36.10
T_5	46.80	45.70	43.20	41.90	39.80	39.10	37.90	37.20
T_6	38.80	34.70	34.40	33.20	29.80	28.10	27.90	27.30
T_7	33.10	29.90	27.50	26.20	23.50	21.60	21.20	19.70
T_8	53.40	55.60	59.20	58.50	59.80	61.30	63.50	65.20
C.D. at 5%	3.562	3.450	4.123	4.089	4.581	4.732	4.687	5.012

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 - PF-DWD strain *P. fluorescens* (Talc formulation) T_1 - recorded lowest percent disease index (19.50%) followed by its liquid formulation T_3 - (22.60%). Percent disease index in Ridomil spray T_7 - (19.70%) was comparable to that of T_1 - *P. fluorescens* (NBAIR - PFDWD strain – talc formulation), and seed yield was significantly highest in T_1 (10.99 q/ha) and T_3 (10.33 q/ha). The grain yield was lowest in T_8 – control (9.17 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 29.

III. 8. Sesame ANGRAU, Anakapalle

III. 8. 1. Ecofriendly management of stem rot, *Macrophomina phaseolina* in sesame using biocontrol agents

Techniques adopted:

Treatments: 10

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

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

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

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

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

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

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

T8: NBAIR - *Pseudomonas fluorescens* 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

During 2021-22, December sown rabi crop, initial plant population recorded significantly high in T4- *P. fluorescens* ST + *T.asperellum* SD and was on par with other biopesticide treatments and low in untreated control. Sesame germination wassignificantly high in T4 - *P. fluorescens* ST + *T. Asperellum* SD (93.28%), T2 –- *Pseudomonas fluorescens* ST + SD (91.11%) and was on par with other biocontrol agents and chemical whereas germination was low in control (70.56%). Stem rot disease was noticed at 60 days crop age as high in control (24.07%) and low in T4 - *P. fluorescens* ST + *T.asperellum* SD (5.49 %) followed by T3 -NBAIR *T. Asperellum* ST + *P. fluorescens* SD (6.17%) and T2- *Pseudomonas fluorescence* ST + SD (7.34%) compared to chemical treatment (11.225) (Table 61). Root length, shoot length and grain yield will be recorded after harvest in April , 2022.

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

Table 61. Ecofriendly management of stem rot, *Macrophomina phaseolina* in sesame using biocontrol agents

Treatment	Initial population /plot(27 m^2)	Germi-nation (%)	Stem rot (%) @ 60 DAS	Root length (cm)	Shoot length (cm)	Grain Yield (Q/ha)
T1: NBAIR *Trichoderma asperellum* ST + SD	533.33	88.220	8.07	26.3	108.2	330
T2: NBAIR*Pseudomonas fluorescens* ST + SD	546.67	91.110	7.34	25.2	101.2	315
T3: NBAIR *T. Asperellum* ST + *P.fluorescens* SD	540.00	87.833	6.17	22.0	97.0	353
T4: NBAIR *P. fluorescens ST* + *T. asperellum* SD	548.33	93.280	5.49	23.7	99.3	376
T5: NBAIR *T. harzianum ST + SD*	540.00	88.333	9.39	24.3	97.2	249
T6: NBAIR *T. harzianum ST*	533.33	87.277	9.83	26.0	94.3	258
T7: NBAIR *T. asperellum ST*	521.67	87.500	11.20	25.3	98.9	233
T8:NBAIR *P. fluorescens ST*	540.00	87.667	10.79	25.7	94.5	137
T9: Carbendazim ST +SD	533.33	85.277	11.22	25.3	92.1	258
T10- Control	473.33	70.557	24.07	17.7	88.5	129
CD	40.3	8.49	3.05	N/A	10.2	60.49
CV%	14.4	12.68	17.17	12.5	6.1	18.728

ST – Seed Treatment: SD: Soil Drenching

Biological Control of Commercial Crops Diseases

III. 9. Sugarcane

ICAR - SBI, Coimbatore

III. 9. 1. Efficacy of mechanized sett treatment with liquid formulation of biocontrol agents, fungicide and their combination for red rot management

Field experiments were laid out to evaluate mechanized means of sett treatment with *Trichoderma harzianum* and *Paenibacillus alvei* individually and in combination, fungicide alone and its combination with *P. alvei along* with suitable healthy and inoculated controls for the management of red rot using susceptible cultivar CoC 671. For fungicidal treatment, thiophanate methyl at 1000ppm was used in the STD either alone or in combination with bacterial antagonist 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 (0% PDI) as thiophanate methyl alone followed by combination of *P. alvei* and *T. harzianum* (10% PDI) as against 66.6% PDI in inoculated control. Further mechanized sett treatment with both the biocontrol agents and fungicide individually or in combination were found to be not deleterious and were effective in reducing the disease incidence, improving plant growth and yield attributes. The yield improvement by the combination of *P. alvei* and thiophanate methyl was found to be 1.74-fold over inoculated control and it was 15.5% increase over healthy control.

Table 62. Effect of different mechenized self treatment with biocontrol agents, fungicide against red rot diseases

Treatments	Germination Count (%)	Per cent Disease Incidence(%)	Number of Millable Canes	Yield/row (Kg)
T1- Mechanized sett treatment with *Trichoderma harzianum*	25^{b}	25^{b}	12^{bc}	19.0^{c}
T2-Mechanized sett treatment with *Paenibacillus alvei*	40^{a}	23.07^{b}	13^{bc}	21.5^{c}
T3- Mechanized sett treatment with *T. harzianum* + *P. alvei*	37.5^{a}	10^{a}	16^{b}	28.4^{b}
T4- Mechanized Sett treatment with *P. alvei* + Thiophanate Methyl	45.5^{a}	0^{a}	24^{a}	39.5^{a}
T5- Mechanized Sett treatment with Thiophanate methyl	37.5^{a}	0^{a}	19^{ab}	30.5^{b}
T6- Inoculated control	21.5^{b}	66.6^{c}	9^{c}	14.4^{d}
T7- Healthy control	42.5^{a}	8.6^{a}	23^{a}	34.2^{a}

Biological Control of Vegetable Diseases

III. 10. Tomato

AAU, Anand

III.10.1. Field efficacy of different combinations of *Trichoderma harzianum* and *Pseudomonas fluorescens* against the early blight of tomato

Treatments:

T1 - Th (SA+RD+FS)

T2 - Pf (SA+RD+FS)

T3 - Th+Pf (SA+RD+FS)

T4 - Th (SA+RD)+Azoxystrobin 23% SC (FS)

T5 - Pf (SA+RD)+ Azoxystrobin 23% SC (FS)

T6 - Th+ Pf (SA+RD)+ Azoxystrobin 23% SC (FS)

T7 - Azoxystrobin 23% SC (RD)+ Azoxystrobin 23% SC (FS)

T8 - Untreated control

Note:

Th = *Trichoderma harzianum* (AAUBC- Th1)

Pf = *Pseudomonas fluorescens* (NBAIR PFDWD)

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

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 T_6- Th+Pf (SA+RD)+Azoxystrobin 23% SC (FS) found effective in reducing the early blight disease intensity. This treatment recorded the disease intensity of 5.08%, which was followed by the treatment T_5 - Pf (SA+RD)+Azoxystrobin 23% SC (FS) (7.40 %). 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 (13.05%). The untreated control treatment recorded the disease intensity of 30.80%. The efficacy of treatments in reducing the disease intensity was depicted in yield of the crop. The chemical control recorded the highest yield (30.33 t/ha) which was followed by the treatment T_{6} - Th+Pf (SA+RD)+ Azoxystrobin 23% SC (FS) (28.67 t/ha) and T_5 - Pf (SA+RD)+ Azoxystrobin 23% SC (FS) (27.67 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 (9.00 t/ha).

The pooled data over the years pertaining to efficacy of different combinations of *Trichoderma* and *Pseudomonas* found consistent in reducing the early blight disease intensity. Among the different treatments, T_6 - Th+Pf (SA+RD)+ Azoxystrobin 23% SC (FS) was found effective and showed the significantly lower disease intensity (7.02%) as compared to other biopesticide treatments. The untreated control treatment recorded the highest disease intensity of 35.26%. Similarly, with regard to the yield of the crop, the treatment T_6 - Th+Pf (SA+RD)+ Azoxystrobin 23% SC (FS) recorded the highest yield (29.16 t/ha) which was statistically at par with the yield recorded in the treatment T_5 - Pf (SA+RD)+ Azoxystrobin 23% SC (FS) (28.16%). The lowest yield was recorded in untreated control treatment (9.33 t/ha)

Table 63. Efficacy of different combinations of *Trichoderma* and *Pseudomonas* against early blight disease intensity (%) in tomato during 2021-22

Treatments	Early blight disease intensity (%)			Yield (t/ha)	B:C Ratio
	First spray	Second spray	Pooled over sprays		
T_1	28.18*[d] (22.30)	24.83[ef] (17.63)	26.51[e] (19.92)	17.67[e]	2.90
T_2	25.30[cd] (18.26)	22.53[def] (14.68)	23.92[e] (16.44)	19.67[de]	3.22
T_3	23.04[c] (15.32)	19.32[cde] (10.95)	21.18[d] (13.05)	22.00[cde]	3.61
T_4	18.58[ab] (10.15)	15.61[bcd] (7.24)	16.87[c] (8.42)	24.33[bcd]	3.99
T_5	17.97[ab] (9.52)	13.61[bc] (5.54)	15.79[c] (7.40)	27.67[abc]	4.54
T_6	15.25[ab] (6.92)	10.78[ab] (3.52)	13.02[b] (5.08)	28.67[ab]	4.68
T_7	12.07[a] (4.37)	8.50[a] (2.18)	10.29[a] (3.19)	30.33[ab]	4.93

T_8	33.73^{e} (30.83)	33.73^{g} (30.83)	33.73^{f} (30.80)	9.00^{f}	1.64
S. Em ±	1.41	1.35	0.92	1.17	--
C.D. at 5 %	4.26	4.08	2.66	3.54	--
CV (%)	11.19	12.56	11.82	9.03	--

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

Table 64. Efficacy of different combinations of *Trichoderma* and *Pseudomonas* against early blight disease intensity (%) and yield in tomato (Pooled over years)

Treatments	Disease intensity (%)			Yield (t/ha)			B:C Ratio
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	
T1	29.31^{*e} (23.96)	26.51^{e} (20.06)	27.90^{f} (21.90)	18.33^{e}	17.67^{e}	18.00^{d}	2.95
T2	26.91^{e} (20.48)	23.92^{e} (16.44)	25.41^{e} (18.41)	20.33^{de}	19.67^{de}	20.00^{d}	3.28
T3	23.97^{d} (16.50)	21.18^{d} (13.05)	22.57^{d} (14.73)	22.67^{cde}	22.00^{cde}	22.33^{c}	3.66
T4	20.60^{bc} (12.38)	16.87^{c} (8.42)	18.73^{c} (10.31)	25.33^{bcd}	24.33^{bcd}	24.83^{b}	4.07
T5	20.04^{bc} (11.74)	15.79^{c} (7.40)	17.91^{c} (9.46)	28.67^{abc}	27.67^{abc}	28.16^{a}	4.62
T6	17.72^{b} (9.26)	13.02^{b} (5.08)	15.36^{b} (7.02)	29.67^{ab}	28.67^{ab}	29.16^{a}	4.76
T7	15.23^{a} (6.90)	10.29^{a} (3.19)	12.76^{a} (4.88)	31.33^{ab}	30.33^{ab}	30.83^{a}	5.01
T8	39.13^{f} (39.83)	33.73^{f} (30.83)	36.43^{g} (35.26)	9.67^{f}	9.00^{f}	9.33^{e}	1.70
S. Em ±	0.83	0.92	0.61	1.20	1.17	0.75	--
C.D. at 5 %	2.40	2.66	1.74	3.64	3.54	2.15	--
CV %	8.38	11.82	9.65	8.93	9.03	8.98	--

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

G.B.P.U.A.&T., Pantnagar

Tomato (Local, Hybrid)-25 ha

Location: Farmers fields of District Nainital of Uttarakhand.

Treatments

T1= Biocontrol

(microbial) Package: Use of Bioagent

Seed bio-priming through Pant Bioagent formulation, PBAT-3 (*T. harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) @ 10g/kg of seeds.

Seedling dip with PBAT 3@ 10 g/ liter for about 30 minutes.

Spray of PBAT 3 @ 10 g/ liter on standing crop at 10-12 days intervals.

T2 = Farmers Practice (Carbendazim, Copperoxychloride, Streptocycline, Nuvan, Imidachlorpid pesticides used by farmers)

Observations:

Disease incidence

Yield of crop (kg/ha)

Cost-benefit ratio.

Field demonstrations were laid at 68 farmers field at Golapar area of District Nainital covering an area of 25 ha. Fifteen quintals PBAT-3 (*Trichoderma harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) was distributed to the farmers for soil, seed, root dip treatment and foliar spray through biocontrol agents to counter soil borne diseases. An average yield of 70.0 q/ha was recorded with bio-control technologies as compared to 55.0 q/ha with conventional farmers practices.

Table 65. Package of practices advised to the farmers for tomato crop were as under

Crop	Tomato
Diseases	Damping off, root rot, fruit rot, early and late blight
Components with dose, concentration, frequency and method of application	Soil solarization of nursery beds before sowing seeds. Soil treatment with value added compost (enriched with biocontrol agent @1 kg /q compost) Seed treatment with Bioagent @10 g/kg seed. Seedling root dip treatment @10 g/lit water for 30 min. prior to transplanting. Five foliar sprays with PBAT-3 @10 g/lit water at 15 days interval.

Damping off of tomato in nursery, root rot, fruit rot, early and late blight diseases were observed in tomato.

Table 66. Occurrence of tomato diseases at farmer's field

Disease	Causal Organism	PBAT-3	Conventional Practices
		Disease severity (%)	Disease severity (%)
Damping off	*Pythium* spp., *Phytophthora* spp., *Rhizoctonia* spp.	3	12
Wilt	*Fusarium* spp.	7	25
Root rot	*Rhizoctonia* spp., *Phytophthora* spp.	3	11
Fruit rot	*Rhizoctonia* spp.	10	28
Early blight	*Alternaria solani*	12	27
Late blight	*Phytophthora infestans*	15	40

Table 67. Cost-benefit ratio with biocontrol practices and with conventional practices

Management Practices	Cost of production/ha (Rs.)	Yield (q/ha)	Selling price (Rs./q)	Total selling price (Rs.)	Net Profit (Rs.)	BC ratio
Biocontrol Practices	60000.00	70.0	2400.00	168000.00	108000.00	1: 1.80
Conventional practices	53000.00	55.0	2400.00	132000.00	79000.00	1: 1.49

KAU, Kumarakom

III. 10. 2. Screening of promising isolates antagonistic fungi and bacteria against bacterial wilt of tomato

Variety : Akshay

Plot size : 4x5m=20 m^2

Replications : 4

Design : RBD

Method of application of bioagents : Talc based formulations of the bioagents 2×10^8 c.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

Growth promotion characters *viz*., plant height (cm), biomass (g)

Yield

Table 68. Efficacy of isolates of antagonistic fungi and bacteria against bacterial wilt of tomato

Treatment	Plant height (cm)	disease incidence (%)	Yield (kg/plot)
T1: NBAIR-PFDWD isolate of *Pseudomonas fluorescens*	104.88	18.34 (25.32)	12.67
T2: NBAIR-BATP isolate of *Bacillus albus*	102.68	13.04 (21.14)	12.86
T3: NBAIR-TATP isolate of *Trichoderma asperellum*	91.13	24.48 (29.58)	9.90
T4: *P. fluorescens* PN026 (KAU strain)	105.55	17.92 (24.90)	14.21
T5: Soil drenching of Copper hydroxide (2g/l)	94.63	13.14 (21.17)	14.68
T6: Untreated control	88.85	28.12 (31.98)	9.45
CD (P = 0.05)	12.54	3.81	2.87
CV	8.49	9.84	15.46

Values in parentheses are arcsine transformed.

The results indicate that seed treatment, seedling dip and soil drenching with NBAIR-BATP isolate of *Bacillus albus* was highly effective in reducing wilt incidence which was on par with the effect of KAU strain PN026 of *P. fluorescens.* This was followed by the effect of NBAIR-PFDWD isolate of *P. fluorescens.* These three strains could also result in significant increase in plant height and fruit yield of tomato.

III. 11. Potato

AAU, Anand

III. 11. 1. Field efficacy of different combinations of *Trichoderma harzianum* and *Pseudomonas fluorescens* against the early blight of potato

Treatments:

T1 - Th (SA+ST+FS)

T2 - Pf (SA+ST+FS)

T3 - Th+Pf (SA+ST+FS)

T4 - Th (SA+ST)+Kresoxim-methyl 44.3% SC (FS)

T5 - Pf (SA+ST)+ Kresoxim-methyl 44.3% SC (FS)

T6 - Th+ Pf (SA+ST)+ Kresoxim-methyl 44.3% SC (FS)

T7 - Kresoxim-methyl 44.3% SC (ST)+Kresoxim-methyl 44.3% SC (FS)

T8 - Untreated control

Note:
Th = *Trichoderma harzianum* (AAUBC- Th1)
Pf = *Pseudomonas fluorescens* (NBAIR Pf DWD)
SA = Soil application, ST = Seed treatment, FS = Foliar spray

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 T_6- 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 6.47 %. 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 (13.50 %). The untreated control treatment recorded the disease intensity of 35.57 %. The efficacy of treatments in reducing the disease intensity was depicted in yield of the crop. The chemical control recorded the highest yield (20.33 t/ha) which was followed by the treatment T_6 - Th+ Pf (SA+ST)+Kresoxim-methyl 44.3% SC (FS) (19.33 t/ha), T_5 - Pf (SA+ST)+Kresoxim-methyl 44.3% SC (FS) (18.67 t/ha) and T_4–Th (SA+ST)+Kresoxim-methyl 44.3% SC (FS) (18.33 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 (8.67 t/ha).

The pooled data over the years pertaining to efficacy of different combinations of *Trichoderma* and *Pseudomonas* found consistent in reducing the early blight disease intensity. Among the different treatments, T_6- Th+ Pf (SA+ST)+Kresoxim-methyl 44.3% SC (FS)was found effective and showed the significantly lower disease intensity (7.46 %) as compared to other biopesticide treatments. The untreated control treatment recorded the highest disease intensity of 38.07%. Similarly, with regard to the yield of the crop, the treatment T_6- Th+ Pf (SA+ST)+Kresoxim-methyl 44.3% SC (FS) recorded the highest yield (19.83 t/ha) which was statistically at par with the yield recorded in the treatment T_5 - Pf (SA+RD)+ Azoxystrobin 23% SC (FS) (19.16%)& T_4 - Th (SA+RD)+ Azoxystrobin 23% SC (FS) (18.67%). The lowest yield was recorded in untreated control treatment (9.00 t/ha)

Table 69. Efficacy of different combinations of *Trichoderma* and *Pseudomonas* against early blight disease intensity (%) of potato during 2021-22

Treatments	Early blight disease intensity (%)			Yield (t/ha)	B:C Ratio
	First spray	Second spray	Pooled over sprays		
T_1	28.56*[d] (22.39)	26.22[ef] (19.52)	27.39[f] (21.16)	13.00[c]	1.25
T_2	28.24[d] (22.39)	24.04[def] (16.60)	24.14[de] (16.73)	14.00[c]	1.34
T_3	21.91[c] (13.92)	21.22[cde] (13.10)	21.56[cde] (13.50)	15.67[bc]	1.50
T_4	19.80[c] (11.47)	18.62[bcd] (10.19)	19.20[cd] (10.82)	18.33[abc]	1.76
T_5	18.84[bc] (10.43)	17.37[bc] (8.91)	18.10[c] (9.65)	18.67[a]	1.79
T_6	15.38[ab] (7.03)	14.09[b] (5.93)	14.73[b] (6.47)	19.33[a]	1.85
T_7	14.19[a] (6.01)	9.84[a] (2.63)	12.01[a] (4.33)	20.33[a]	1.95
T_8	34.74[e] (32.47)	38.48[e] (38.72)	36.61[g] (35.57)	8.67[d]	0.84
S. Em ±	1.26	1.26	0.94	0.92	--
C.D. at 5 %	3.80	3.81	2.71	2.78	--
C. V. (%)	9.79	10.26	10.02	9.91	--

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

Table 70. Efficacy of different combinations of *Trichoderma* and *Pseudomonas* against early blight disease intensity (%) in potato (Pooled over years)

Treatments	Disease intensity (%)			Yield (t/ha)			B:C Ratio
	2021-22	2021-22	Pooled	2021-22	2021-22	Pooled	
T1	30.12*[e] (25.18)	27.39[f] (21.16)	28.75[f] (23.14)	13.67[d]	13.00[c]	13.33[d]	1.28
T2	27.09[d] (20.74)	24.14[de] (16.73)	25.61[e] (18.68)	15.00[d]	14.00[c]	14.50[cd]	1.39
T3	24.48[c] (17.17)	21.56[cde] (13.50)	23.02[d] (15.29)	16.67[cd]	15.67[bc]	16.16[c]	1.55
T4	20.99[b] (12.83)	19.20[cd] (10.82)	20.10[c] (11.81)	19.00[bc]	18.33[abc]	18.67[b]	1.79
T5	20.48[b] (12.24)	18.10[c] (9.65)	19.29[c] (10.91)	19.67[a]	18.67[a]	19.16[ab]	1.84
T6	16.97[a] (8.52)	14.73[b] (6.47)	15.85[b] (7.46)	20.33[a]	19.33[a]	19.83[ab]	1.90
T7	15.70[a] (7.32)	12.01[a] (4.33)	13.86[a] (5.74)	21.00[a]	20.33[a]	20.67[a]	1.98
T8	39.58[f] (40.60)	36.61[g] (35.57)	38.10[g] (38.07)	9.33[e]	8.67[d]	9.00[e]	0.87
S. Em ±	0.84	0.94	0.60	0.98	0.92	0.60	--
C.D. at 5 %	2.44	2.71	1.69	2.96	2.78	1.72	--
CV %	8.32	10.02	8.96	10.04	9.91	9.98	--

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

Biological Control of Fruit Diseases

III. 12. Grapes

MPKV, Pune

III. 12. 1. Management of Powdery mildew (*Uncinula necator*) of Grape by using Biocontrol agents

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

The experiment was laid out on the farmer's field of Shri Rahul B. Awate At/Post: Rajuri.Tal: JunnarDist: Pune, with Thompson seedless variety having plot size with spacing 3.0 m x 1.5 m in Randomized Block Design having eight treatments with three replications with four plants/plot. Four sprays were given for powdery mildew management on 26.12.2021, 6.1.2022, 17. 1.2022 and 27. 1. 2022.

Observations:

Percent disease index on leaves and berries 10 days interval

Per cent disease over control

Yield

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:

The data presented in Table 71 revealed that, the Percent Disease Index (PDI) of powdery mildew on leaves was in the range of 3.33 to 4.57 before application of biocontrol agents and fungicides and the data were non-significant. The treatment *Trichoderma harzianum* @ 5 g/l +*A. quisqualis* @ 5 ml/l recorded the lowest Percent Disease Index (5.33%, 5.67 %) which was at par with the treatment *Bacillus subtilis* @ 5 g/l + *Ampelomyces quisqualis* @ 5 ml/l (5.67% , 6.00 % PDI) and the treatment *Ampelomyces quisqualis* @ 5 ml/l (6.33% , 6.33.00% PDI) and Sulphur 80%WP @ 2.0 g/l (6.67, 7.33% PDI) at 5 and 10 days after first spray. The untreated control treatment recorded maximum PDI (11.00 %, 14.67%) at 5 and 10 days after first spray.

The treatment *Trichoderma harzianum* @ 5 g/l +*A. quisqualis* @ 5 ml/lrecorded the lowest Percent Disease Index (5.67%, 6.00%) which was at par with the treatment *Bacillus subtilis* @ 5 g/l + *Ampelomyces quisqualis* @ 5 ml/l (6.33% , 6.67 % PDI) and *Ampelomyces quisqualis* @ 5 ml/l (6.67% , 6.00% PDI) at 5 and 10 days after second foliar application for powdery mildew of grape.The untreated control treatment, recorded maximum PDI (22.00 %, 24.00%) at 5 and 10 days after second spray.

Similar trend was found at 5 and 10 days after third foliar application for powdery mildew of grape. The treatment *Trichoderma harzianum* @ 5 g/l + *A. quisqualis* @ *5* ml/lrecorded the lowest Percent Disease Index (6.00%, 6.67%) which was at par with the treatment *Bacillus subtilis* @ 5 g/l +*Ampelomyces quisqualis* @ 5 ml/l (6.33%, 7.00% PDI) and the treatment T_3- *Ampelomyces quisqualis* @ 5 ml/l (7.00%, 7.33% PDI) at 5 and 10 days after third foliar application for downy mildew of grape.The untreated control treatment recorded maximum PDI (31.33%, 33.67%) at 5 and 10 days after third spray.

The treatment T_5- *Trichoderma harzianum @ 5 g/l + A. quisqualis* @ 5 ml/l recorded the highest fruit yield of 18.667 t/ha which was at par with the treatment *Bacillus subtilis* @ 5 g/l + *Ampelomyces quisqualis*@ 5.0 ml/l (18.517 t/ha) and *Ampelomyces quisqualis* @ 5 ml/l (18.417 t/ha) and treatment Sulphur @ 2.0 g /l (17. 467 t/ha). The untreated control treatment recorded minimum yield (11.150 t/ha) than rest of treatments (Table 71).

Powdery mildew (*Uncinula necator*) disease of grape was minimum in sprays with *Trichoderma harzianum* @

5 g/l. + *Ampelomyces quisqualis* @ 5 ml/l. recorded minimum 6.67 PDI with maximum fruit yield 18.667 mt/ha. *Bacillus subtilis @ 5 g /L + Ampelomyces quisqualis* @ 5 ml /L sprays recorded 7.00 PDI with fruit yield 18.517 mt/ha. The chemical check Sulphur 80% WP @ 2g/litre of water recorded 8.67 PDI with fruit yield of 17.467 MT/ha.

Table 71. Effect of Biocontrol agents against Powdery Mildew in Grapes (2021-22)

S.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*	4.33 (12.00)	8.00 (16.41)	8.67 (17.08)	10.00 (18.42)	8.33 (16.77)	8.67 (17.12)	9.33 (17.78)	16.240
T_2	*Bacillus subtilis* @5 g/L	4.00 (11.47)	8.67 (17,12)	8.67 (17.08)	11.00 (19.36)	9.33 (17.75)	10.33 (18.72)	10.67 (19.04)	15.200
T_3	*Ampelomycesquis-qualis* @5 ml/L	3.33 (10.34)	6.33 (14.51)	6.33 (14.09)	6.67 (14.92)	6.00 (14.15)	7.00 (15.32)	7.33 (15.68)	18.417
T_4	*Trichoderma harzia-num* @5 g/L + *Bacil-lus subtilis* @5 g/L	4.33 (12.00)	8.00 16.41)	8.00 (16.36)	8.67 (17.11)	8.00 (16.41)	9.00 (17.39)	8.67 (17.10)	13.517
T_5	*Trichoderma harzia-num* @ 5 g/L + *A. quisqualis* @ 5 ml/L	3.67 (11.02)	5.33 (13.34)	5.67 (13.76)	5.67 (13.76)	6.00 (14.07)	6.00 (14.07)	6.67 (14.78)	18.667
T_6	*Bacillus subtilis* @ 5 g/L + *Ampelomy-cesquisqualis* @ 5 ml/L	3.67 (11.01)	5.67 (13.76)	6.00 (14.15)	6.33 (14.57)	6.67 (14.96)	6.33 (14.57)	7.00 (15.32)	18.517
T_7	Sulphur 80% WP @ 2 g/L	4.00 (12.00)	6.67 (14.95)	7.33 (15.68)	8.00 (16.41)	8.00 (16.41)	8.33 (16.75)	8.67 (17.08)	17.467
T8	Control	3.67 (11.01)	11.00 (19.32)	14.67 (22.49)	22.00 (27.96)	24.00 (29.32)	31.33 (34.03)	33.67 (35.46)	11.150
	SE	0.69	0.70	0.84	0.74	0.73	0.93	0.96	0.54
	CD (P = 0.05)	NS	2.11	2.54	2.25	2.23	2.81	2.92	1.63
	CV	10.56	7.68	8.89	7.22	7.28	8.68	8.74	5.78

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

Biological Control of Plantation Crops Diseases

III. 13. Cocoa

DRYSRHU, Ambajipeta (HRS)

III. 13. 1. Management of *Phytophthora* pod rot in Cocoa

Methodology

Layout: RBD

Treatments: 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.

The experiment was carried out at Avidi village of East Godavari district during south west monsoon with the onset of rains and the treatments were given at 45 days interval. The experiment results revealed that after first round of treatment imposition there was a significant reduction in the mean disease incidence (45.20 %) in the treatment spraying of *Trichoderma reesei* (Acc No.NAIMCC-F-04174) @ 2 ×10^6 cfu/ml) followed by copper oxychloride (3g/litre of water)spraying and there is an increase in mean disease incidence in control (30.41) and Soil application of 50g *T. reesei* along with 5 kg neemcake (5.85). Similar trend was also observed even after second round of treatment imposition at 45 days (Table 72).

Table 72. Evaluation of bio control agents against *Phytophthora* Pod rot in cocoa

Treat-ment No	Name of the Treatment	Mean Disease incidence (MDI)						
		Pretreat-ment data	45 Days after treatment	MDI reduc-tion	MDI in-crease	90 days after treatment	MDI reduc-tion	MDI in-crease
T_1	Spraying of *T. reesei* @ 2 ×10^6 cfu/ml)	7.08 (13.44)*	3.88 (7.75)	45.20	-	2.82 (4.31)	27.34	-
T_2	Soil application of 50g *T. reesei* along with 5 kg neemcake	11.37 (19.17)	12.04 (15.18)	-	5.85	14.92 (23.63)	-	23.94
T_3	Spraying of copper oxychloride (3 g/litre of water)	15.38 (25.36)	9.34 (15.74)	39.26	-	7.71 (13.05)	17.49	-
T_4	Control (without any treatment)	12.44 (20.50)	16.23 (23.44)	-	30.41	18.79 (26.37)	-	15.79
SEM (±)		2.04	2.51	10.07		3.27		
CD (P = 0.05)		8.82	10.85					

Biological Control of Spices Crops Diseases

III. 14. Ginger

AAU, Jorhat

III. 14. 1. Evaluation of microbial antagonist for the management of ginger rot disease

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

Location: Diphu, Karbi Anglong (farmer's field).

Season: *Kharif*, 2021

Date of Planting: 2^{nd} week of June, 2021

Variety: Locally recommended variety

Area cover: 1ha

Replication: 3 RBD

Treatments:

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

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

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

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

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

T_6: Soil drenching of Copper hydroxide 2g/L @6 litres/m2

T_7: Untreated check

Mode of application: Seed treatment with biopesticide followed by 2 round of foliar applicationation @ 45, 60 daysafter planting

Observations:

Record of rhizome germination and numbers of tiller

Record of infected plant during vegetative stage

Estimation of diseasese verity

Yield data.

Disease severity was recorded using a 0-5 scale where, 0 = Noinfectiononrhizome; 1=0.1-5.0%rottingof rhizome; 2=5.1-15.0%rottingofrhizome; 3= 15.1-30.0% rotting of rhizome; 4 = 30.1-60.0% rotting or rhizome; 5 = More than 60% rotting ofrhizome. The weight of rhizome per plot was recorded and converted into per hectare yield.]

Table 73. Effectiveness of biopesticides against rhizome rot (*Pythium aphanidermatam*) of ginger

Treatment	Rhizome Germination (%)	No.of tillers /plant	Plant infected (%)	Disease severity (0-5scale)	Yield (t/ha)
T_1	68.00 ^{b}	16.67 ^{b}	32.00 ^{e}	2	14.83
T_2	72.35 ^{c}	19.67 ^{d}	28.00 ^{d}	2	16.67
T_3	81.42 ^{e}	18.67 ^{e}	17.67 ^{b}	1	16.93
T_4	72.63 ^{c}	17.00 ^{b}	26.67 ^{c}	1	16.00
T_5	84.25^f	20.33 ^{e}	14.67 ^{a}	1	18.00
T_6	75.00 ^{d}	18.33 ^{d}	26.00 ^{c}	2	17.33
T_7	61.67 ^{a}	11.33 ^{a}	41.00 ^{f}	4	12.33
CD (P = 0.05)	1.57	1.10	1.34		1.40
CV (%)	1.20	3.54	2.84		4.93

Mean of two observations

Results: Highest per cent germination (84.25) and highest number of tillers per plant (20.33) were recorded in T_5 followed byT_3 with 81.42% and 18.67 nos., respectively. However, it was observed that all the biopesticides were equally effective in rhizome germination and producing tillers per plant compared to untreated control, where the germination per cent was only 61.67 with 11.33 nos. tillers/plant.

Similarly, in case of disease infected plant 14.67% was observed in T_5 followed by T_3 with 17.67 % disease infection. The maximum disease severity (4) was recorded in T_7 which was untreated check. As regards to yield data, highest yield of ginger (18.00 t/ha) was recorded in T_5 followed byT_3 with 16.93 t/ha, where as in untreated control plot, it was only 12.33 t/ha (Table 73).

IV. Biological Control of Crop Pests

CEREALS

IV. 1. Biological Control of Rice Pests

IV. 1. 1. Validation of BIPM practices against pest complex of organic Black rice (AAU Jorhat)

The experiment over 1 ha area was undertaken with the treatment details mentioned here under

T_1: Organic package

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

Application of organic manure MUKTA 2t/ha

Application of *Beauveria bassiana* (10^{13} spores/ha) against sucking pests.

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)

T_2: Farmer's practice (chemical control). Two rounds of Chlorantraniliprole 18.5 SC @ 0.4 ml/ lit were sprayed against insect pests of rice.

Table 74. Observation on incidence of stem borer (Dead heart and White ear head (WEH)), leaf folder damage (LFD) and grain yield of Black Rice

Treatments	Dead heart (%) 65 DAT	WEH (%) 90 DAT	LFD (%) 65 DAT	Grain Yield (kg/ha)
BIPM Package	1.79	2.11	2.25	3139.1
Conventional	2.03	2.41	2.41	2897.2
"t" value	0.73	0.5	0.25	1.71
Remarks	S	S	S	S

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 damaged leaves in case of leaf folder incidence in BIPM fields were 1.79 and 2.25% at 65 Days after transplanting, respectively. The corresponding figures in farmers practice were 2.03 and 2.41 %. Similarly WEH incidence in BIPM field was 2.11 % as compared to 2.41 % in farmers practice. Maximum yield of 3139.1 kg/ha in BIPM plot was significantly superior compared to 2897.20 kg/ ha in farmers practice plots (Table 74)

Fig 30. An overiew of BIPM of black rice

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

The experiment was undertaken with the treatment details mentioned hereunder at Regional Agricultural Research Station, Pattambi

T1: *Heterorhabditis indica* (NBAIIH38 strain) @ $1.2x10^9$ IJs ha^{-1}

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

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

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

T5: Untreated control

Fig 31. Field view of experiment on management of rice stem borer and leaf-folder using entomopathogens at Pattambi.

Table 75. Effect of entomopathogens on incidence of stem borer in rice

Treatment	Mean number of dead hearts or white ear heads /m^2				Grain yield (kg/m^2)
	7 DAS1	14 DAS1	7 DAS2	14 DAS2	
T1: *H. indica* @ $1.2x10^9$ IJs ha^{-1}	11.00 (3.12)	36.25 (5.89)	47.25 (6.77)	42.50 (6.40)	0.169
T2: *Bacillus thuringiensis* 2ml/l	12.50 (3.43)	38.75 (6.09)	42.75 (6.50)	37.50 (6.10	0.186
T3: *Beauveria bassiana* @10^8 spores/ml	13.00 (3.58)	40.25 (6.24)	43.25 (6.54)	37.75 (6.11)	0.166
T4:Flubendiamide 25g.a.i.ha^{-1}	7.50 (2.56)	35.00 (5.88)	35.75 (5.90)	31.25 (5.49)	0.203
T5: Untreated control	13.00 (3.40)	41.25 (6.39)	49.00 (6.96)	42.75 (6.48)	0.162
CD@ 5% (P = 0.05%)	NS	NS	NS	NS	NS

* Values in parenthesis are square root transformed values

There was no significant difference between the treatments in terms of mean number of dead hearts or white ear heads. However, the infestation of stem borer was low in flubendiamide treated plot at 7 days after first spraying (7.5 number/m^2), followed by *H. indica* (11.00 number/m^2) and *B. thuringiensis* (12.50 number/m^2).

The same trend was observed 14 days after first spray as well (Table 75 & Fig 32).

Seven and fourteen days after second spay, infestation was again the lowest in flubendiamide applied plots (35.75 and 31.25 number/m^2, respectively. Among entomopathogens, *B. thuringiensis* recorded the second best values of 42.75 and 37.50 number/m^2 for the corresponding period. Overall, plots treated with the insecticide flubendiamide consistently recorded the lowest levels of stem borer infestation.

Table 76. Effect of entomopathogens on incidence of leaf folder in rice

Treatment	Mean number of leaf folds/m^2				Grain yield (kg/m^2)
	7DAS1	14DAS1	7 DAS2	14DAS2	
T1: *H. indica* @ 1.2x10^9 IJs ha^{-1}	3.25 (1.89)	10.50 (3.21)^{ab}	20.50 (4.42)^a	17.00 (4.02)^a	0.169
T2: *Bacillus thuringiensis* 2ml/l	2.00 (1.47)	8.50 (2.90)^{abc}	17.25 (4.12)^a	12.75 (3.48)^a	0.186
T3: *Beauveria bassiana* @10^8 spores/ml	1.75 (1.41)	6.25 (2.36)^{bc}	16.25 (4.02)^a	13.75 (3.63)^a	0.166
T4:Flubendiamide 25g.a.i.ha^{-1}	1.00 (1.13)	5.00 (1.85)^c	3.00 (1.62)^b	2.00 (1.39)^b	0.203
T5: Untreated control	4.00 (2.12)	15.00 (3.85)^a	20.75 (4.56)^a	18.00 (4.13)^a	0.162
CD@ 5% (P = 0.05)	NS	1.202	1.122	1.376	NS

* Values in parenthesis are square root transformed values

The moth activity of leaf folder remained at low levels till later stages of the crop (Table 76 and Fig 33). Seven days after first spray, no significant variation was observed among the treatments in terms of mean number of leaf folds. Fourteen days after first treatment, the lowest number of 5 leaf folds/ m^2 were recorded from flubendiamide treated plots, followed by *Beauveria bassiana* (6.25 no./m^2). Both the above treatments were on par with each other and were significantly superior to untreated control. Control plots recorded the highest number of leaf folds per m^2, which was on par with *H. indica* (10.50 no./m^2). Seven days after second spray, flubendiamide, with 3.00 leaf folds/m^2 was the most effective treatment and was significantly superior to the remaining treatments. Flubendiamide treated plots remained significantly superior to other treatments fourteen days after second treatment as well, with mean number of 2.00 no./m^2. All the remaining treatments remained at par, with mean number of folds ranging from 12.75 to 18.00/m^2.

Significant difference was also not observed among different treatments in terms of grain yield, though highest mean yield of 0.203 kg/m^2 was recorded in plots treated with flubendiamide.

Overview of the results suggested that the bioagents evaluated, particularly the entomopathogenic fungus *Beauveria bassiana* and the bacterium *Bacillus thuringiensis* could be viable alternatives to insecticides for the management of leaf folder in rice.

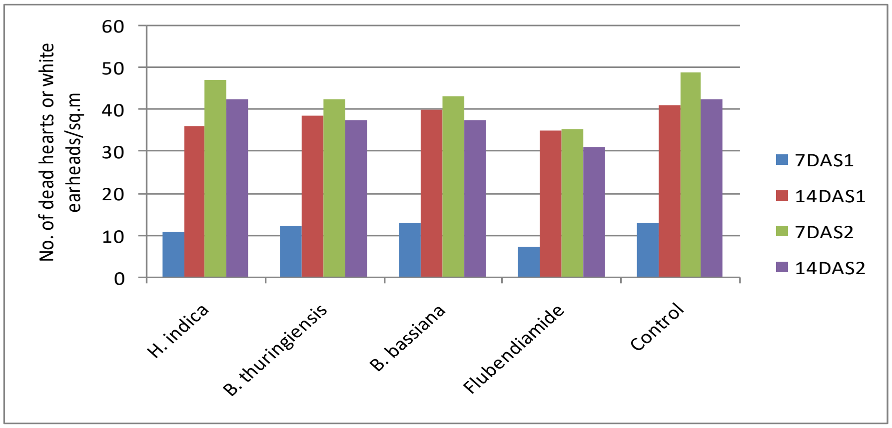

Fig 32. Effect of entomopathogens on incidence of stem borer in rice

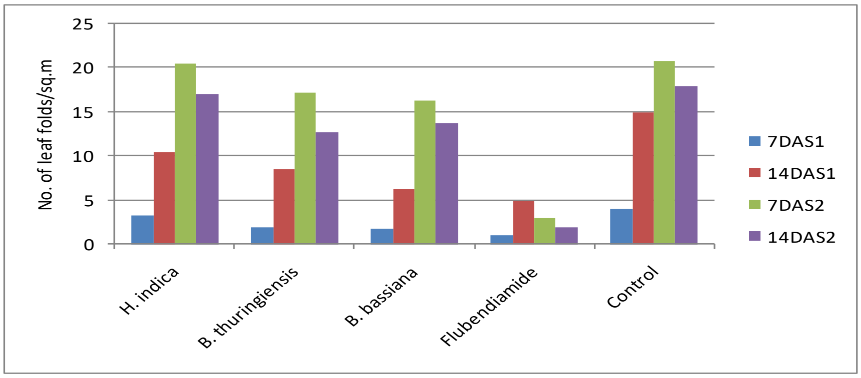

Fig 33. Effect of entomopathogens on incidence of leaf folder in rice

Large scale bio-intensive pest management on rice (KAU, PAU, AAU J, IIRR)

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.

Mechanical control by passing the 20-30 m long coir/jute rope before flowering, forwards and then backwards, both ways while touching the crop canopy for leaf folder. (PAU)

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

AAU-J: The experiment was undertaken at Jorhat district over 50 ha area

The per cent dead heart and damaged leaf caused by *Scirpophaga* sp and *Cnaphalocrocis* sp. were 3.85 and 2.45 in BIPM package as against 4.26 and 2.72 in farmer's practice after 60 DAT, respectively. In case of WEH, the per cent incidence was 3.15 in BIPM plots which was slightly higher than farmer's practice plots (3.12) at 100 DAT without any significant difference in between the treatments. Maximum yield of 4963.5 Kg/ha was registered in BIPM plots which was significantly higher compared to farmer's practice plot with 4637.5 Kg/ha. Minimum yield of 3357.10 Kg/ha was recorded in Untreated control plot (Table 77).

The population of natural enemies like predatory spiders and coccinellids per m^2 was significantly high in BIPM plot compared to farmers practice and untreated control plots. Higher numbers of spiders and coccinellids population of 2.08/ m^2 and 1.92/ m^2 was recorded BIPM package as against 0.72 and 0.62 / m^2 in chemical control plot, respectively at 60 DAT (Table 78). The net returns over control in BIPM package were Rs. 61291.90 as compared to Rs. 49967.50 in farmers practice plot with cost: benefit ratio of 1:1.751 and 1:1.249, respectively (Table 79).

Table 77. Observation on incidence of Dead heart, WEH, LFDL and grain yield of rice

Treatments	Dead heart (%)		WEH (%)	LFDL (%)		Grain yield (kg/ha)
	45DAT	60DAT	100DAT	45DAT	60DAT	
BIPM Package	4.19	3.85	3.15	3.33	2.45	4963.50
Farmers practice	3.97	4.26	3.12	3.10	2.72	4637.50
Untreated control	5.02	5.62	5.2	3.79	3.51	3357.10
CD (P = 0.05)	NS	0.32	0.49	NS	NS	220.17
CV(%)	29.45	16.13	28.06	46.33	23.84	5.43

Table 78. Observation on predatory spider and coccinelids population/m^2

Treatments	Post count (spider/ m^2)		Post count coccinellids /m^2	
	45 DAT	60 DAT	45 DAT	60 DAT
IPM package	1.32	2.08	0.84	1.92
Farmers' practice	1.08	0.72	0.56	0.62
Untreated control	1.14	1.22	0.72	1.6
CD (P = 0.05)	NS	0.487	NS	0.83
CV(%)	11.36	24.95	38.83	41.66

Table 79. Cost benefit analysis

Treatment	Yield (Kg /ha)	Additional yield over chemical control (Kg /ha)	Value of yield/ ha (Rs/ha)	Cost of cultivation (Rs /ha)	Net return (Rs/ ha)	C:B ratio
BIPM plot	4963.50	1606.40	96291.90	35000.00	61291.90	1.751
Farmers' practice	4637.50	1280.40	89967.50	40000.00	49967.50	1.249
Untreated control	3357.10		65127.74	30000.00	35127.74	1.171

Rs. 19.40/kg of rice grain

Fig 34. An overiew of BIPM of rice

KAU Thrissur

IV. 1. 2. Large scale validation of BIPM in rice was carried out over a total area of 240 ha with 220 ha in Alathur grama panchayat in Palakkad and 20 ha in Thekkinkara panchayat in Thrissur district.

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 was approximately 50 per cent lower than in non BIPM plots. Similarly, leaf folder damage was approximately 75 per cent lower than in conventionally managed plots, while the rice bug population was less than 65 per cent of that in non-BIPM field. The population of predators and parasitoids too was higher in BIPM plots. Similarly, incidence of bacterial leaf blight was mild in most of the BIPM plots.

The yield obtained from BIPM plots, at 8340 kg/ha was approximately 27 per cent more than that obtained from non BIPM plots (6100 kg/ha). 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. 65245/ha. The cost benefit ratio, at 1.80 for BIPM fields compared quite favorably with 0.99 for non BIPM fields (Table 80).

Table 80. 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	1.58	3
2.	White ear heads	2.43	9
3.	Leaf roller damage	2.86	5
4.	Rice bug	4.79	13.5
5.	Spiders	23.21	10
6.	Other predators	19	9
7.	Parasitoids	11.21	7
8.	Incidence of bacterial leaf blight	Mild to severe	Severe
9.	Yield (kg/ha)	8340	6100

10.	Returns per ha (@ Rs. 28./kg)	233520	170800
11.	Cost of cultivation (Rs/ha)	83275	85800
12.	Net return per ha	150245	85000
13.	Benefit cost ratio	1.80	0.99

Fig 35. A view of BIPM plots at Alathur, Palakkad district

PAU Ludhiana

IV. 1. 3. Large scale demonstrations on the bio-suppression of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted in collaboration with KVKs and Regional Station (Gurdaspur) in field areas of Ludhiana, Amritsar, Patiala, Gurdaspur, Jalandhar and Faridkot districts in organic *basmati* rice (var. Pusa 1121) over an area of 347 acres.

Based on the mean of all locations (Table 81), mean dead heart incidence in biocontrol fields was 1.72 and 1.82 per cent at 45 and 60 DAT, respectively. The corresponding figures in untreated control were 3.60 and 4.18 per cent. The mean reduction of dead heart incidence in release fields was 54.34 per cent over control. Similarly, leaf folder damage was significantly lower in BIPM fields as compared to untreated control. The damage was 2.46 and 2.38 per cent at 45 and 60 DAT, respectively as compared to 5.64 and 6.72 per cent in untreated control with a mean reduction of 60.48 per cent. The mean incidence of white ears was significantly lower in biocontrol field (2.66 %) as against untreated control (5.20 %) resulting in a reduction of 48.85 per cent (Table 82). Grain yield in biocontrol field (28.88 q/ha) was significantly better as compared to 26.00 q/ha in untreated control, respectively. The yield increase in release fields was 11.08 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. 7580/- per hectare over untreated control with cost-benefit ratio of 1:3.03.

Table 81. Large scale demonstrations of biocontrol of rice pests in organic *basmati* rice during 2021

Treatments	Dead hearts (%)				Leaf folder damaged leaves (%)			
	45 DAT	60 DAT	Mean	Reduction over control (%)	45 DAT	60 DAT	Mean	Reduction over control (%)
BIPM*	1.72[a]	1.82[a]	1.78[a]	54.34	2.46[a]	2.38[a]	2.42[a]	60.48
Untreated control	3.60[b]	4.18[b]	3.89[b]	-	5.64[b]	6.72[b]	6.18[b]	-

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

Table 82. Large scale demonstrations of biocontrol of rice pests and yield of organic *basmati* rice during 2021

Treatments	White ears incidence (%)	Reduction over control (%)	Paddy yield (q/ha)	increase over control (%)	Net returns over control (Rs./ha)	BC ratio
BIPM*	2.66[a]	48.85	28.88[a]	11.08	7580.00	1:3.03
Untreated control	5.20[b]	-	26.00[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

Fig 36. Field release of tricho-strips in rice

IIRR, Hyderabad

IV. 1. 4. Large scale demonstration was carried out at Miriyalguda (2 ha) in Rabi 2020-21 and Manchal, Ibrahimpatnam, Rangareddy Kharif 2021 (2 ha)

Rabi 2020 – 21

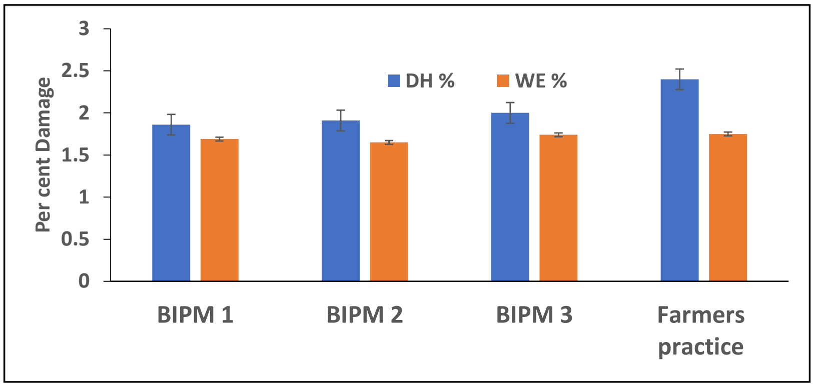

Fig 37. Stem borer Incidence on KNM 118 at Miriyalguda, Telangana, Rabi 2021

Three modules of BIPM interventions were tested which differed in seed treatment with either of three antagonistic microbes *viz*., *Trichoderma asperellum* Strain TAIK1, *Bacillus cabrialesii* BIK3 and *Pseudomonas fluorescens* Strain PIK1 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. The variety grown was KNM118. Pest incidence was lower during this season. Damage caused by stem borer in the form of dead hearts ranged from 1.86 – 2.4 among the treatments. White ear damage 1.65 - 1.75 among the treatments with lowest damage being observed in BIPM 2 (Fig 37).

The mean population of braconids ranged from 3.00 to 40.50 per count (Table 83), the highest recorded in BIPM 3 (40.75) and the least in farmers practice 2 (3.00) (Table 83). With respect to Eulophidae, the group that consists of major egg parasitoids of stem borer, the treatments BIPM 1, BIPM 2, BIPM 3 were on par with a mean population of 17.75 to 20.50 per count. BIPM 1 recorded the highest mean population with 56.00 Scelionids and the lowest in farmers practice with 21.75 insects. The family Trichogrammatidae was represented by two genera *viz., Trichogramma* sp. Westwood, 1833 and *Oligosita* sp. Walker, 1851. The trichogrammatids collected in yellow sticky traps differed significantly among treatments with, BIPM 1 recording the highest mean population of 33.75 insects, followed by BIPM 3 with 29.75. Tachnids are an important group of dipteran parasitoid observed on rice pests such as skippers, long horned caterpillars and cutworms. The highest mean population was recorded from untreated control with 20.25 flies, followed by BIPM 1 (16.00). The mirid bugs are key egg predators of hopper eggs. Population of the green mirid bug *Cyrtorhinus lividipennis,* trapped were on par with a mean population range of 4.00 to 4.75 insects in the BIPM modules while significantly lower in farmers practice with insecticide application.

Table 83. Incidence of natural enemies in different treatments during *rabi* season by yellow sticky trap counts

Order/Family	Natural enemies observed during rabi 2020-21 (No./4 traps)				
	BIPM1	BIPM2	BIPM3	Farmers practice	CD
HYEMNOPTERA					
Braconidae	27.00 (5.29)[b]	26.5 (5.24)[b]	40.50 (6.44)[a]	3.00 (2.00)[e]	0.17
Eulophidae	20.50 (4.64)[a]	17.75 (4.33)[a]	17.75 (4.30)[a]	3.50 (2.10)[c]	0.34
Mymariade	1.00 (1.41)[a]	0.25 (1.10)[bc]	0.00 (1.00)[c]	0.00 (1.00)[c]	0.19
Scelionidae	56.00 (7.55)[a]	52.50 (7.31)[b]	50.00 (7.14)[b]	21.75 (4.77)[e]	0.22
Trichogrammatidae	33.75 (5.98)[a]	27.00 (5.29)[b]	29.75 (5.55)[b]	7.75 (2.94)[e]	0.34
DIPTERA					
Tachinidae	16.00 (4.12)[b]	14.00 (3.87) [c]	10.50 (3.39)[d]	4.00 (2.24)[f]	0.23
HEMIPTERA					
Miridae	2.25 (1.80)[c]	3.50 (2.12)[b]	4.00 (2.24)[b]	0.50 (1.21)[d]	0.23

*Mean of 4 yellow sticky trap counts

Figures in parenthesis are square root transformed values.

Values in the row with same alphabet superscript are not statistically different.

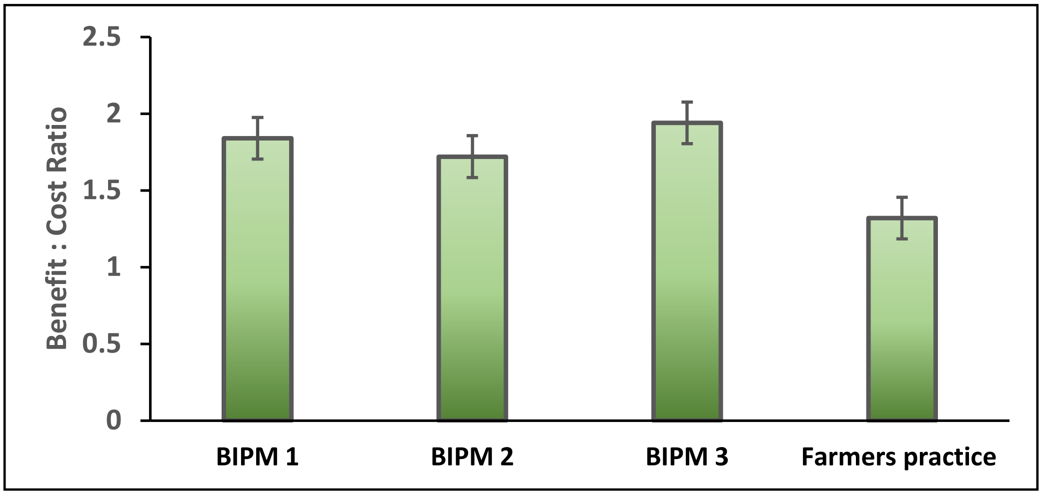

Fig 38. Benefit: Cost Ratio of various treatments in farmer's field, Miriyalguda

The economics of crop production of various treatments in *rabi* season revealed that, the BIPM 2 treatment gave the maximum benefit with a BC ratio of 1.94. (Fig 38).

Kharif 2021

The demonstrations were taken up in Manchal, Ibrahimpatnam, Rangareddy, Telangana. Rice is grown continuously and contiguously in this region. A Farmer interface meeting was held on August 26, 2021 and inputs such as DRR Dhan 48 seeds, Phosphorous solubilising Bacteria, seed bioprimers three antagonistic microbes *viz*., *Trichoderma asperellum* Strain TAIK1, *Bacillus cabrialesii* BIK3 and *Pseudomonas fluorescens* Strain PIK1 were compared with farmer's practices in rice cultivation. The results indicated the reduction in the incidence of stem borer (0.2 to 20 %), sheath blight (20 to 36%) and bacterial leaf blight (18 to 35%). The white ear damage by stem borers ranged from 6.41 % in BIPM 2 to 10.31 % in *Psuedomonas* treated plots (Table 84). Increase in natural enemies *viz*., Spiders (20-35%) was observed. Overall the farmer was able to get increased returns (28 to 35%) due to reduced pesticide (insecticide and fungicide) applications and increase in the yields.

Table 84. Pest and natural enemies' incidence at Manchal, Ibrahimpatnam, Telangana, *Kharif* 2020

Treatments	Stem borer (% WE)	Spiders (No./ hills	Drynids (No./10 hills)	Yield (kg/ ha)
T1- BIPM with *Pseudomonas fluorescens*	10.31 (18.73)	4.20 (2.17)	1.50 (1.41)	8011.00
T2- BIPM with *Trichoderma* IIRR Strain	6.41 (14.67)	3.93 (2.10)	1.50 (1.41)	7125.00
T3 - BIPM with *Bacillus* IIRR Strain	9.12 (17.58)	2.80 (1.81)	3.00 (1.87)	8005.00
T6 - Farmers practice	8.98 (17.43)	1.30 (3.42)	2.00 (1.58)	8110.00
CD (p = 0.05)	NS	0.70	NS	NS

*WE – White Ears

Table 85. Impact of BIPM modules on Sheath blight and Bacterial Blight in farmer's field Kharif 2021

S. No	Isolate name	Percent reduction of disease - Sheath Blight	Percent reduction of disease - BLB
1	*Trichoderma asperellum* TAIK1	35.85 (32.40)	17.96 (16.73)
2	*Bacillus cabrialesii* BIK3	27.13 (25.19)	34.96 (32.73)
3	*Pseudomonas fluorescens* PIK1	20.33 (18.15)	35.56 (33.08)
5	Farmers practices	12.54 (11.00)	10.24 (9.84)
	CD (P = 0.05)	2.34	2.95

Figures in the parentheses are angular transformed values

NRRI, Cuttack

IV. 1. 5. Field evaluation of ICAR-NBAIR entomopathogenic strains against rice stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*), brown planthopper (*Nilaparvata lugens*)

The experiment was under taken at ICAR-NRRI, Cuttack with the treatment details mentioned hereunder

Treatments:

T_1. NBAIR-PEOWN isolate of *Pseudomonas entomophila*

T_2. NBAIR-BtyoPS isolate of *Lysinibacillus sphaericus*

T_3. NBAIR-BATP isolate of *Bacillus albus*

T_4. NBAIR-PFDWD isolate of *Pseudomonas fluorescens*

T_5. NBAIR-TATP isolate of *Trichoderma asperellum*

T_6. Chlorantraniliprole

T_7. Control (Untreated)

The results shown that spray of NBAIR isolates i.e., NBAIR-PEOWN, NBAIR-BATP, NBAIR-BtoYPS, NBAIR-PFDWD and NBAIR-TATP shown less dead heart damage (9.11-12.42%) and white ear-head (2.48-4.29%) compared to untreated control which recorded maximum dead heart (20.73%) and white ear-head incidence (6.40%) caused by yellow stem borer. Least dead heart (1.77%) and white ear-head incidence (1.46%) was observed in the chlorantraniliprole insecticide application treatment (Table 86). Among the isolates sprayed, NBAIR-PEOWN, NBAIR-BATP, NBAIR-BtoYPS were observed to be significantly on par in dead heart and white ear head incidence reduction followed by the isolates NBAIR-PFDWD and NBAIR-TATP. Similarly, with respect to leaf folder damage highest leaf damage (6.57%) was observed in untreated control and significantly less leaf damage (2.08-3.63%) 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. Plant height was significantly high in the plots sprayed with NBAIR isolates (72.46-74.51 cm) than the plants of untreated control (70.12 cm). Though, highest grain yield/plot was obtained in the Chlorantraniliprole insecticide treatment, all the NBAIR isolates found to be significantly superior than the untreated control (Table 86).

Table 86. The bio-control efficacy of NBAIR isolates against rice insect pests

Treatment Name	Yellow stem borer				Leaf folder		Plant parameters and Yield		
	Dead heart (%)	Per cent reduction over control (%)	White ear-head (%)	Per cent reduction over control (%)	Leaf Damage (%)	Per cent reduction over control (%)	Plant height (cm)	Yield (kg/ plot)	Per cent increase over control (%)
NBAIR-BATP	9.81 (18.25)^{C}	52.7	2.85 (9.70)^{C}	55.6	2.08 (8.29)^{C}	68.3	73.51 (8.60)^{A}	10.27 (3.28)^{B}	22.8
NBAIR-BTOYPS	9.72 (18.16)^{C}	53.1	2.48 (9.05)^{C}	61.3	2.04 (8.21)^{C}	68.9	73.19 (8.58)^{A}	10.18 (3.26)^{BC}	22.0
NBAIR-PEOWN	9.11 (17.56)^{C}	56.1	3.14 (10.20)^{C}	51.0	2.05 (8.23)^{C}	68.8	73.01 (8.57)^{A}	10.29 (3.28)^{B}	22.9
NBAIR-TATP	12.42 (20.63)^{B}	40.1	4.28 (11.94)^{B}	33.1	3.33 (10.51)^{B}	49.3	74.51 (8.66)^{A}	9.59 (3.18)^{C}	14.7
NBAIR-PFDWD	12.38 (20.60)^{B}	40.3	4.29 (11.95)^{B}	33.1	3.63 (10.98)^{B}	44.8	72.46 (8.54)^{A}	9.65 (3.19)^{C}	15.4
Chlorantraniliprole	1.77 (7.61)^{D}	91.5	1.46 (6.90)^{D}	77.2	1.00 (5.75)^{D}	84.7	72.96 (8.57)^{A}	12.36 (3.59)^{A}	47.7
Control	20.73 (27.08)^{A}		6.40 (14.65)^{A}		6.57 (14.79)^{A}		70.12 (8.40)^{B}	8.37 (2.98)^{D}	
p-Value	<.0001		<.0001		<.0001		<.0001	<.0001	

*Values in the parenthesis are arcsine transformed values and square root transformed values

KAU, Vellayani

IV. 1. 6. Biointensive pest management in rice

The experiment is ongoing at Vellayani under the Krishibhavan Kalliyoor in an area of 1 ha.

Assessment of leaf roller population revealed that the BIPM treatments are effective in managing the pest. One week after treatment, BIPM and farmers practice (Quinalphos) were on par. During the second and third weeks, population was significantly low in chemical treatment with quinalphos 25 EC @ 2 mL/L. However, after month population in BIPM and framers practice were on par.

Table 87. Population of leaf roller in BIPM rice (On going)

Treatments	Population of leaf roller larvae /plot*				
	Pre count	Post count of leaf roller at weekly intervals			
		1	2	3	4
T1 Biological control	7.0 (2.62)	7.0 (2.62)	4.0 (2.1)	3.0 (1.71)	0.18 (0.78)
T2 Farmer's practice	6.5 (2.59)	4.0 (2.0)	3.0 (1.86)	1.46 (1.36)	0 (0.6)
CD (P = 0.05)	NS	(0.41)	(0.43)	(0.31)	NS
CV (%)	10.55	13.69	17.04	14.75	22.86

*Mean of 10 hills

Table 88. Population of stem borer in BIPM rice

Treatments	Population of stem borer/plot*				Reduction in pest population over control
	Pre count	Post count at weekly interval			
		1	2	3	
T1 Biological control	3.42 (1.84)	3.0 (1.69)	1.71 (1.28)	1.42 (1.37)	58.4
T2 Farmer's practice	3.14 (1.75)	2.42 (1.55)	2.0 (1.40)	1.71 (1.43)	45.54
CD (P = 0.05)	NS	NS	NS	NS	
CV (%)	16.88	22.13	14.39	22.10	

*Mean of 5 sweeps /replication

There was no significant variation in the population of adult moths of stem borer, *Scirpophaga incertulas*, between the BIPM plots and insecticide treated plots, throughout the experiment. The percent reduction over control obtained through BIPM was 58.4, while in Farmers practice it was 45.54. Population of natural enemies was always significantly high in BIPM plot than in farmers practice. The mean count of 5 sweeps was 51.21, 60.28, 67.35, 70.35 and 72.78 at 1. 2. 3. 4. And 5 weeks after treatment. The corresponding population was always significantly lower, the mean count being 43.14,51.42, 59.71,61 and 62.57, respectively on 1, 2, 3, 4 and 5 weeks after initiation of treament.

Comparative efficacy of entomopathogenic fungi against sucking pests of rice, *Leptocorisa acuta* (Through AICRIP Entomology programme, ICAR- IIRR)

The experiment was conducted with following treatments:
T1- *L. saksenae* (KAU, Vellayini strain) @ 10^7 spores ml-1
T2- *B. bassiana* Bb5 @10^8 spores ml-1
T3- *M. anisopliae* @10^8 spores ml-1
T4- Thiamethoxam 0.2 g/L
Locations: Coimbatore, Gangavati and Navsari

Location 1: Navasari, Gujarat

At Navsari, Gujarat, the trial was undertaken with the variety GR -11. Two sprays of the fungal organism were sprayed – first spray at 70 days after transplanting (DAT) and 2nd spray at 85 DAT. Pre-count numbers of bugs ranged from 19.75-20.25/ 10 hills. After first spray population of bugs was lowest in insecticide treatment plot (8.00/ 10 hills) but, *L. saksanae* spray was on par (9.50/ 10 hills) with insecticide treatment (Table 89). Similar trend was observed after second spray. Population of beneficial insects such as mirids, spiders and coccinellids were significantly lower (0.41, 0.48, 0.49 / m^2, respectively) in insecticide treated plots as compared to entomopathogen sprays. The yield was highest in Thiamethoxam treated plots (8763.89 kg/ha) which was on par with yield projected from *L. saksenae* treated plots (8347.22 kg/ ha).

Location 2: Gangavati, Karnataka

Thiamethoxam treated plots recorded the lowest population of ear head bugs (3.1/ 10 hills) after first spray though population was significantly lower in all bioagent treated plots (3.96 -5.20 / 10 hills) (Table 90). Similar trend was observed after second spray and a reduction of 72.08-83.77 percent was observed with the use of entomopathogens. The beneficial insects on the other hand were highest in untreated control followed by entomopathogen treated plots and least in Thiamethoxam treatment., Spider population was 5.36 and 2.25/ 10 hills after first and second spray while it ranged from 8.98 -10.00 / 10 hills in entomopathogens treated plots. The mirid population was 4.35 and 2.05 / 10 hills in insecticide treated plots which was significantly lower than the entomopathogenic fungi treated plots which ranged from 10.0 to 12.86 / 10 hills after treatment.

Table 89. Comparative Efficacy of Entomopathogenic fungi against ear head bug of Rice at Navsari, Gujarat, *Kharif* 2021

Treatments	No. /10 hills			No./ m²			Grain yield (kg/ha)
	Pre count	I spray	II spray	Mirids	Spiders	Cocci-nellids	
		3 DAS	3 DAS				
T1 *Metarhizium anisopliae* @ 10^7 spores ml $^{-1}$	20.00	14.75	19.75	1.03	1.38	0.95	7897.22
T2 *Beauveria bassiana* @ 10^7 spores ml $^{-1}$	20.00	12.00	16.75	1.02	1.38	0.95	7997.22
T3 *L. saksenae* @ 10^7spores ml^{-1}	19.75	9.50	13.25	1.00	1.36	0.93	8347.22
T4 Thiamethoxam 0.2 g/L	20.25	8.00	10.50	0.41	0.48	0.49	8763.89
T5 Untreated Control	20.25	23.25	28.00	1.03	1.49	1.00	6894.44
SED	0.67	0.75	0.72	0.04	0.09	0.07	161.34
CD (P = 0.05)	NS	1.63	1.59	0.09	0.12	0.10	226.19

Table 90. Comparative efficacy of entomopathogenic fungi against gundhi bug, at Gangavati, Karnataka, during *Kharif* 2021

SI. No	Treatments	Dose (*g/l*)	No. of bugs per 10 hills				% ROC
			1st application		2nd application		
			PC	10 DAS	PC	10 DAS	
T_1	*Metarhizium anisopliae* @ 10^7 spores ml $^{-1}$	20	7.58 (2.93)	3.96 (2.22)	3.96 (2.22)	1.68 (1.63)	83.77
T_2	*Beauveria bassiana* @ 10^7 spores ml $^{-1}$	20	7.01 (2.83)	5.20 (2.48)	5.20 (2.48)	2.89 (1.96)	72.08
T_3	*L. saksenae* @ 10^7 spores ml $^{-1}$	20	8.10 (3.01)	4.10 (2.26)	4.10 (2.26)	1.96 (1.72)	81.06
T_4	Thiamethoxam 25 % WG	0.2	7.26 (2.87)	3.10 (2.02)	3.10 (2.02)	0.86 (1.37)	91.69
T_5	Untreated control	-	8.26 (3.04)	8.95 (3.15)	8.95 (3.15)	10.35 (3.35)	-
S.E.M (±)			0.07	0.08	0.08	0.11	
CD (P = 0.05)			NS	0.24	0.24	0.35	
CV (%)			6.03	7.46	7.46	10.30	

Figures in the parenthesis are square root transformed values; PC – Pre-treatment count; DAS– Days after spray; ROC (Reduction over control)

Table 91. Impact of entomopathogenic fungi on natural enemies of paddy at Gangavati, Karnataka, Kharif 2021

SI. No	Treatments	Dose (g/l)	No. of spiders/10 hills				No. of mirids/10 hills			
			1st application		2nd application		1st application		2nd application	
			PC	10 DAS	PC	10 DAS	PC	10 DAS	PC	10 DAS
T_1	T1 *Metarhizium anisopliae*@ 10^7spores ml $^{-1}$	20	9.00 (3.15)	9.86 (3.29)	9.86 (3.29)	10.00 (3.32)	12.00 (3.60)	12.32 (3.65)	12.32 (3.65)	12.45 (3.66)
T_2	T2 *Beauveria bassiana*@ 10^7 spores ml $^{-1}$	20	10.00 (3.31)	8.98 (3.16)	8.98 (3.16)	9.12 (3.18)	12.86 (3.72)	11.24 (3.49)	11.24 (3.49)	10.00 (3.30)
T_3	T3 *L. saksenae* @ 10^7spores ml $^{-1}$	20	10.08 (3.32)	9.65 (3.25)	9.65 (3.25)	9.96 (3.31)	11.98 (3.60)	12.01 (3.60)	12.01 (3.60)	12.01 (3.61)
T_4	*Thiamethoxam 25 % WG*	0.2	9.23 (3.20)	5.36 (2.52)	5.36 (2.52)	2.25 (1.81)	12.05 (3.61)	4.35 (2.31)	4.35 (2.31)	2.05 (1.72)
T_5	Untreated control	-	10.05 (3.32)	10.23 (3.35)	10.23 (3.35)	11.00 (3.46)	12.35 (3.65)	12.89 (3.73)	12.89 (3.73)	13.01 (3.74)
S.EM (±)			0.05	0.08	0.08	0.07	0.10	0.08	0.08	0.15
CD (P = 0.05)			NS	0.26	0.26	0.23	N/A	0.26	0.26	0.46
CV (%)			6.30	7.33	7.33	6.94	6.69	6.98	6.98	9.17

Figures in the parenthesis are square root transformed values; PC – Pre-treatment count; DAS– Days after application

Location 3: Coimbatore, Tamil Nadu

Table 92. Comparative Efficacy of Entomopathogenic fungi against ear head bug of Rice at Coimbatore, Tamil Nadu, *Kharif* 2021

Treatments	I Spray		II spray	% Damaged panicles (%)
	No. of bugs / 10 hills			
	3 DAS	7 DAS	3 DAS	
T1*Metarhizium anisopliae* @ 10^7 spores ml $^{-1}$	16.00	3.50	5.50	12.56 (20.55)
T2 *Beauveria bassiana* @ 10^7 spores ml $^{-1}$	17.50	25.25	14.00	24.55 (29.56)
T3 *L. saksenae* @ 10^7 spores ml $^{-1}$	19.00	20.00	18.25	22.88 (28.43)
T4 *Thiamethoxam* 0.2 g/L	5.25	3.25	7.75	9.70 (18.10)
T5 Untreated Control	35.25	24.50	21.00	29.13 (32.65)
SED	1.93	2.21	1.04	2.22
CD (P = 0.05)	4.19	4.81	2.26	4.83

The population of bugs at Coimbatore ranged from 16.0-19.0/ 10 hills, three days after first spray, while it was 5.25/' 10 hills in insecticide treatment. Similar trend was observed on all dates of observation with significantly lower population being recorded in Thiamethoxam treated plots. A low per cent panicle damage by Ear head bug (9.70 %) was also observed in insecticide treatment.

GBPUA&T, Pantnagar

IV. 1. 7. Development of biointensive IPM package and practices for pest management in basmati rice (Pusa basmati 1121)

Strategies used in the BIPM practices, were use of microbial biocontrol agents, border crops, flowering plants in combination with the release of *Trichogramma* sp., pheromone traps, and the use of botanicals.

Impact of BIPM practices on the incidence of major diseases in rice

Two diseases *viz*. Sheath blight and Brown spot were observed in the experimental field during the cropping season. Incidence of Sheath blight (*Rhizoctonia solani*) disease severity (23.39%) in BIPM practices did not differ significantly from farmer's practice (24.80%) but, significantly superior than control (50.07 %). In BIPM practices, Sheath blight disease reduction was found to be 53.28% while in farmer's practice it was 50.46%. Incidence of Brown spot (*Drechslera oryzae*) infected panicle/hill (10.07%) in BIPM practices was statistically at par with farmer's practice (14.48%). In BIPM practices, Brown spot disease reduction was found to be 47.33% while in farmer's practice it was 24.26%. The grain yield of rice obtained from the BIPM practice (48.00 q/ha) was higher than grain yield of rice recorded from the farmer's practice (43.00 q/ha). In BIPM and farmer's practices, the cost-effectiveness of the various treatments revealed gross returns of Rs 94080.00 and Rs 84280.00 per hectare, respectively. While, net return of rice in BIPM practice was Rs 80130.00/ ha and farmer's practice was Rs 71920.00/ ha.

Table 93. Impact of BIPM practices on the incidence of major diseases in rice

Treatment	Sheath Blight		Brown Spot		Yield (q/ha)	Cost benefit ratio
	Disease Severity (%)	Disease Reduction (%)	Infected panicle /hill (%)	Disease Reduction (%)		
BIPM	23.39 (28.92)	53.28	10.07 (18.50)	47.33	48.00	1:2.44
Farmer's practice	24.80 (29.84)	50.46	14.48 (22.35)	24.26	43.00	1:2.09
Untreated Control	50.07 (45.04)	-	19.12 (25.92)	-	25.04	-
C.D. (P = 0.05)	4.67		1.89		9.30	
C.V. (%)	3.66		0.958		5.25	
SEm ±	2.61		0.178		1.61	

*Figures in parenthesis are angular transformed values

Impact of BIPM practices on the incidence of major insect pests in rice

The incidence of leaf folder in BIPM practices was significantly lower (1.22%) than farmer's practice (2.50%). Whereas, both the treatments were significantly better than untreated control (6.17% leaf damage). In BIPM practices, the mean dead heart damage owing to stem borer differed significantly (1.94%) from farmer's practice (2.56%) as compared to untreated control (12.0%). Similarly, the white ear head damage recorded in BIPM practices (1.78%) was found to be non-significantly different from farmer's practice (2.39 %). However, highest white ear head damage was observed in untreated control (14.11 %). The incidence of BPH per m^2 in the BIPM practices (0.71/m^2) differed substantially from the farmer's practice (1.04/m^2), while, highest incidence of BPH was recorded as 8.72/m^2 in untreated control.

Table 94. Impact of BIPM practices on the incidence of major insect pests in rice

Treatments	Leaf Folder#	Yellow Stem Borer#		Brown plant hopper/m$^{2\#}$
	Leaf damage (%)	Dead hearts (%)	White ears (%)	
BIPM	1.22 (6.31)[c]	1.94 (7.94)[c]	1.78 (7.62)[b]	0.71 (1.39)[c]
Farmer's practice	2.50 (9.08)[b]	2.56 (9.12)[b]	2.39 (8.18)[b]	1.04 (1.70)[b]
Untreated Control	6.17 (14.34)[a]	12.0 (20.25)[a]	14.11 (22.03)[a]	8.72 (2.95)[a]
CV (%)	7.92	6.53	9.33	8.91
CD (P = 0.05)	1.15	1.19	1.74	0.26
SEm ±	0.35	0.36	0.53	0.74

#mean of 10 observations starting from 30 DAT; Data in parentheses are angular transformed values for damaged leaves, dead hearts, and white ears and square root transformed values for brown plant hopper, Means followed by the same letters are not significantly different at 5% significance level.

Impact of BIPM practices on the incidence of natural enemies in rice

Natural enemy population in BIPM practices was found to be significantly higher than in farmer's practice plot. In BIPM practices, the percentage of eggs parasitized by egg parasitoids on yellow stem borer was substantially higher (74.31%) than in farmer's practice (4.30%). The mean population of spiders (4.81/ m^2) and coccinellids (3.84/ m^2) was substantially higher in BIPM practices as compared in farmer's practice (1.88/ m^2) and (1.61/ m^2), respectively.

Table 95. Impact of different management practices on the incidence of natural enemies in rice during 2021-22

Treatments	Mean no. of natural enemies per m^2		
	Egg parasitization (%)	Spiders/m^2	Coccinellids/m^2
BIPM	74.31 (59.55)[a]	4.81 (2.18)[a]	3.84 (1.92)[a]
Farmer's practice	4.30 (11.93)[c]	1.88 (1.45)[c]	1.61 (1.25)[b]
Untreated Control	17.49 (24.67)[b]	3.72 (1.92)[b]	3.24 (1.75)[a]
CV (%)	5.25	6.99	13.73
CD (P = 0.05)	2.45	0.19	0.33
SEm ±	0.75	0.60	0.84

Flowering plants at bunds of BIPM Plot

Fig 39. Field view of Rice trial and border crop around the main field to manipulate the habitat at Crop Research Center, Pantnagar

Pheromone traps

Use of Trichocard

Use of pheromone traps

Placing of Trichocard

Spray of Bioagent

Fig 40. Interventions used to develop biointensive IPM package and practices for pest management in basmati rice at Crop Research Centre, Pantnagar

IGKV Raipur

IV. 1. 8. Effect of BIPM treatments on insect pests of paddy variety "Nagri Dubraj" at Raipur, Chhattisgarh

The trial was conducted with following treatments:

BIPM:-

Seed treatment with *T. harzianum* @ 15g/Kg

Seedling dip with *Pseudomonas fluorescens* 2% solution

Spray of Azadirachtin1500 ppm @ 3 ml/litre at 45 & 65 DAT against foliar and sucking pests

Erection of bird perches

Spray of *P. fluorescens* @ 1.5 Kg/ha against foliar diseases

Release of *T. japonicum* @ 1, 00, 000 /ha (6 releases at 10 days interval starting from 25 DAT)

FARMER'S PRACTICE:

Seed treatment with Bavistin @ 2gm/Kg

Pesticides used commonly by farmers *viz.,* Chloropyriphos 50 + cypermethrin 5 EC (attack) and chlorantraniliprole 18.5% WW SC (coragen) against insect pests infestation, and also that Zineb 68% + Hexaconazol 4% WP (avtar) and tricyclazole 75%WP (sivic) against diseases in farmer's practices.

CONTROL: No treatment

Results showed maximum percent of dead heart in control (9.11) and minimum (3.90) in BIPM treatment with 100% Vermicompost (T5). Similarly maximum white ear head was recorded in control (15.86) and minimum in T5 (BIPM with 100% Vermicompost) (7.87). Maximum damage due to leaf folder was recorded in control (3.77) while it was minimum in T5 (1.28). Maximum damage due to case worm, rice hispa was more in control than T5 (BIPM with 100% Vermicompost).

Yield: Significant maximum grain yield/plot (32.47 kg) and per acre (721.56 kg) was obtained in T5 (BIPM with 100% Vermicompost) followed by farmer's practice (27.91 kg)/plot and (620.22 kg) and control (24.36 kg) and (541.33 kg) per plot and per acre, respectively.

Natural enemies: Significant maximum number of coccinellids (0.66) and spiders (0.65) were observed in T5 (BIPM with 100% Vermicompost) compared to farmers practice (coccinellids: 0.24 & spiders: 0.27) which was on par with control.

Table 96.

Treatments	Stem borer damage			Leaf folder damage		Case worm damage		Rice hispa damage		Gundhi bug damage	
	Pre-treatment	Post-treatment		Pre-treatment	Post treatment	Pre-treatment	Post treatment	Pre-treatment	Post treatment	Pre-treatment	Post treatment
		DH	WEH								
T1 (Control)	1.93 (7.80)	9.11 (17.56)	15.86 (23.46)	0.98 (5.59)	3.77 (11.19)	0.57 (3.06)	0.58 (4.33)	6.29 (14.52)	3.59 (10.92)	0.00	1.90 (1.70)
T2 (Farmer's practice)	1.76 (7.57)	7.04 (15.37)	13.17 (21.27)	0.83 (5.12)	2.96 (9.89)	0.42 (2.63)	0.47 (3.92)	5.42 (13.44)	3.05 (10.05)	0.00	1.56 (1.60)
T3 BIPM (FYM 50%+ Vermicom-post 50%)	1.16 (6.17)	4.43 (12.14)	8.62 (17.07)	0.53 (3.49)	1.62 (7.31)	0.42 (2.61)	0.38 (3.50)	3.72 (11.10)	2.46 (9.02)	0.00	0.88 (1.37)
T4 BIPM (FYM 100%)	1.52 (7.05)	5.07 (13.01)	9.34 (17.79)	0.65 (3.25)	1.89 (7.90)	0.67 (4.55)	0.43 (3.75)	3.90 (11.37)	2.79 (9.60)	0.00	1.11 (1.45)

T5 BIPM (Vermi-compost 100%)	0.93 (5.45)	3.90 (11.39)	7.87 (16.28)	0.43 (2.63)	1.28 (6.50)	0.35 (2.40)	0.25 (2.86)	2.80 (9.56)	1.99 (8.10)	0.00	0.71 (1.31)
SEm ±	0.549	0.110	0.108	1.381	0.148	1.589	0.228	0.351	0.148	-	0.017
C.D. (P = 0.05)	NS	0.341	0.335	NS	0.461	NS	0.709	1.094	0.461	NS	0.054

Table 97. Grain yield of paddy (variety- "Nagri Dubraj") in different treatments

Treatments	Grain yield	
	(Kg/plot)	(Kg/acre)
T1 Control	24.36	541.33
T2 Farmer's practice	27.91	620.22
T3 BIPM (FYM 50% + Vermicompost 50%)	31.63	702.89
T4 BIPM (FYM 100%)	30.69	682.00
T5 BIPM (Vermicompost 100%)	32.47	721.56
SEm ±	0.104	2.320
C.D. (P = 0.05)	0.325	7.229
C.V. (%)	2.841	2.841

Table 98. Natural enemies population

Treatments	Coccinellid population		Spider population	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
T1 (Control)	0.05 (1.02)	0.34 (1.16)	0.25 (1.12)	0.32 (1.15)
T2 (Farmer's practice)	0.03 (1.01)	0.24 (1.11)	0.20 (1.09)	0.27 (1.13)
T3 BIPM (FYM 50% + Vermi-compost 50%)	0.08 (1.04)	0.58 (1.26)	0.33 (1.15)	0.58 (1.26)
T4 BIPM (FYM 100%)	0.05 (1.02)	0.50 (1.23)	0.30 (1.14)	0.53 (1.24)
T5 BIPM (Vermicompost 100%)	0.10 (1.05)	0.66 (1.29)	0.38 (1.17)	0.65 (1.28)
SEm ±	0.023	0.016	0.055	0.013
C.D. (P = 0.05)	NS	0.049	NS	0.042

IV. 2. Biological Control of Maize Pests

AAU, Jorhat

IV. 2. 1. Demonstration of BIPM module against fall army worm, *Spodoptera furgiperda* on rabi maize

Treatments:

T_1= BIPM package

Rogue out of infested plants as early as possible.

Collection and destruction of egg masses.

Erection of bird perches @ 10 nos./ha

Installation of pheromone trap (Faw lure) @ 15 traps/ha

3 sprays of NSKE 5% (3 ml/lit) starting from 25 days after germination.

Six releases of *Trichogramma pretiosum* @ 1,00,000/ha at 10 days interval, starting from 30 days after germination.

T_2 = Farmer's practice (Alternate spray of Lamda cyhalothrin 5% EC @ 1 ml/lit and emamectin benzoate 5% SG @ 0.4 gm/lit were made against FAW)

Observation of larval counts was recorded before and after release of bioagents and application of insecticides from 5 randomly selected plants in each sub plots. The treatments were imposed against FAW at 35, 45 and 55 days after sowing, when the incidence of FAW was observed in the field. Yield of green cobs was also recorded from each plots and record of all pickings were pooled together for average yield.

Table 99. 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	7 DAS	10 DAS		
BIPM plot	1.93	1.74	1.61	15.30	42.91
Chemical	1.87	1.84	1.79	22.83	34.55
"t" value	0.19	0.10	0.71	7.5	5.75
Remarks	NS	S	S	S	S

*Mean of three observations #DAS= Days after spraying

Larval count of *S. furgiperda*, a day after treatment varied from 1.87-1.93 per plant. However, at 7 days after treatment, a significant difference was observed where BIPM module recorded 1.74 larvae per plant against 1.84 larvae in case of farmers practice (chemical plot). Similar trend of result was also recorded at 10 days after treatment with 1.61 and 1.79 larvae per plant in BIPM module and farmers practice, respectively. In terms of per cent plant damage, BIPM module was significantly lower (15.30%) after application of treatment as against farmers practice plot (22.83%). Highest yield was recorded in BIPM module (42.91 q/ha), and was significantly superior to farmers practice plot (34.55 q/ha)

Fig 41. An overeiw of BIPM of maize

ANGRAU, Anakapalle

IV. 2. 2. Large scale demonstration of Management of fall armyworm using biological control agents and biopesticides

Treatments details:

T1: *Trichogramma chilonis* @1,00,000 eggs per ha (2 releases, first release after one week of sowing & second one after one week of first release)+ ICAR- NBAIR *Bacillus thuringiensis* @ 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 chilonis* @1,00,000 eggs per ha (2 releases, first release after one week of sowing & then second one after one week of first release)+ *Metarhizium anisopliae* ICAR- 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 chilonis* @1,00,000 eggs per ha (2 releases, first release after one week of sowing & then second one after one week of first release)+ *Beauveria bassiana* ICAR- 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

During 2021-22, Maize fall armyworm incidence was high in insecticidal check - 3 sprays with Azadirachtin+ Chlorantraniliprole +Emamectin benzoate (35.66%) and low in T1- Two releases of *T.chilonis* and two spays with Bt (21.53 %) followed by T2- Two releases of *T. chilonis* and two sprays of Ma 35 (24.58 %) and T3- *T. chilonis* and two sprays of Bb 45 (29.45 %) (Table 100). No significant difference in cob yield but high yield increase , increased returns with incremental benefit cost ratio was recorded in Tc releases + NBAIR Bt 25 sprays (15.07 % , 4.42 q/acre and 3.1) followed with Tc releases +NBAIR M a 35 sprays (11.39 % , 3.34 q/acre and 2.01) compared to insecticidal check.

Table 100. Large scale demonstration of Management of fall armyworm using biological control agents and biopesticides

Treatment	Fall armyworm incidence (%)			FAW damage reduction over insecticidal check (%)	Cob yield Q/acre	Yield increase over insecticidal check (%)
	After *T. chilonis* releases 20 DAS	After Bio-pesticide two sprays 60 DAS	Upto 60 DAS			
T1 : TC 2 releases + Bt 2 sprays	9.3 (17.69)	12.23 (20.39)	21.53 (27.6)	65.08	33.75	15.07
T2 : TC 2 releases + Ma35 2 sprays	11.53 (19.52)	13.0 (21.18)	24.58 (29.59)	60.14	32.67	11.39
T3 : TC 2 releases + Bb 45 2 sprays	14.18 (22.03)	15.27 (22.87)	29.45 (32.84)	52.24	31.75	8.25
T4: Insecticidal check Azadirachtin+Chlorantraniliprole +Emamectin benzoate as 3 sprays	25.41 (30.06)	10.25 (18.92)	35.66 (45.92)		29.33	
CD (P = 0.05)	4.92	3.44	5.5		NS	
CV% (%)	17.92	11.02	12.59		11.9	

TC : *Trichogramma chilonis* : Bt : *Bacillus thuringiensis*; Ma: *Metarhizium anisopliae*; Bb: *Beauveria bassaina*

Values in parenthesis are arc sin transformed values

Table 101. Yield and economics in management of fall armyworm using biological control agents and Biopesticides

Treatment	FAW Damage (%)	Cob yield (Q/ acre)	Yield increase over insecticidal check	Increased returns over insecticidal check (Rs./acre)	Saving on Cost of Plant protection over Insecticdal check Rs./- per acre	Incremental Benefit cost ratio
T1 : *T. chilonis* 2 releases + Bt 2 sprays	21.53	33.75	15.1% (4.42 q/acre)	7414/-	2389/-	3.10
T2 :*T. chilonis* 2 releases + Ma 35 2 sprays	24.58	32.67	11.39 % (3.34 q/acre)	5678/-	2839/-	2.0
T3 : *T. chilonis* 2 releases + Bb 45 2 sprays	29.45	31.75	8.25% (2.42 q/acre)	4114/-	2839/-	1.45
T4: Insecticidal check: Azadirachtin spray + Chlorantraniliprole spray + Emamectin benzoate spray	35.66	29.33				

Fig 42. Large scale demonstration of Management of fall armyworm using biological control agents and biopesticides in farmers fields -50 acres in rabi, 2021-22

IV. 2. 3. Laboratory bioassay of *Metarhizium (Nomuraea) rileyi* (Anakapalle strain AKP-Nr-1) against maize fall armyworm, *Spodoptera frugiperda* (ANGRAU, Anakapalle)

During, 2021-22, Fall armyworm larval mortality recorded high in *M. rileyi* (AKP-Nr-1) 1x10^{9} spores / ml (93.75%) followed by *M.rileyi* (AKP-Nr-1) 1x10^{8} spores / ml (88.75%) and *M.rileyi* (AKP-Nr-1) 1x10^{8} spores / ml (81.25%) in leaf dip method (Table 102). Similarly, larval treatment of *M.rileyi* at different concentrations recorded high in *M.rileyi* (AKP-Nr-1) 1x10^{9} spores / ml (92.8%) followed by *M.rileyi* (AKP-Nr-1) 1x10^{8}spores / ml (89.5%) and *M.rileyi* (AKP-Nr-1) 1x10^{8} spores / ml (81.0%). *M.rileyi* (AKP-Nr-1) showed LC50 of (1.1 x10^{8} spores/ml) and LT50 at (1 x10^{8} spores/ml) is 85.1 hours (Table 102).

Table 102. Laboratory bioassay of *Metarhizium (Nomuraea) rileyi* (Anakapalle strain AKP-Nr- 1 against maize fall armyworm, *Spodoptera frugiperda.*

Treatment	Larval mortality (%)	
	Leaf dip method	Larval treatment method
T1: *M.rileyi (*AKP-Nr-1) 1x10^4 spores / ml	68.75	70.3
T2:*M.rileyi (*AKP-Nr-1) 1x10^5 spores / ml	71.25	72.0
T3: *M.rileyi (*AKP-Nr-1) 1x10^6 spores / ml	75.0	77.67
T4:*M.rileyi (*AKP-Nr-1) 1x10^7 spores / ml	81.25	81.0
T5: *M.rileyi (*AKP-Nr-1) 1x10^8 spores / ml	88.75	89.5
T6 :*M.rileyi (*AKP-Nr-1) 1x10^9 spores / ml	93.75	92.8

Table 103. Concentration mortality and time mortality response of entomopathogenic fungi against Fall armyworm

Isolates	LC50 spores/ml	95% fiducial limit	Slope±SE	X^2	P value	df
Metarhizium (*Nomuraea rileyi*) Anakapalle strain (Akp- Nr-1)	1.1 x10^8	5.0 x10^7-3.5 x10^8	0.671±0.105	1.04	0.78	2
Isolates	**LT50 spores/ml**	**95% fiducial limit**	**Slope±SE**	**X^2**	**P value**	**df**
Metarhizium (*Nomuraea rileyi*) Anakapalle strain (Akp- Nr-1)	85.10 hours	76.22-109.25	5.105±1.270	1.533	0.455	2

SE- standard error, X^2- Chi square, df- degree of freedom

Fig 43. NBAIR scientists and ANGRAU Head Entomology observed native strain, *Metarhizium (Nomuraea) rileyi* (Anakapalle strain, AKP- Nr-1) laboratory study

IV 2.4 Field efficacy of *Metarhizium (Nomuraea) rileyi* isolate (Anakapalle strain AKP-Nr-1; and UAS, Raichur strain UASR strain KK-Nr-1)) against fall armyworm, *Spodoptera frugiperda* in maize (ANGRAU Anakapalle; UAS Raichur)

ANGRAU: During 2021-22, Fall armyworm damage was significantly low in *M. rileyi* Anakapalle strain (4.83 %) and *M. rileyi*, UAS Raichur (4.82 %) at concentration 1x10^8 spores / ml and on par with all the other concentrations. Percent reduction in Fall armyworm incidence after two sprays of *M. rileyi* was high in *M.*

rileyi (Anakapalle strain) 1x10^8 spores / ml (55.97 %) and *M. rileyi* (UAS Raichur strain)1x10^8 spores/ml (54.14%) and high increase in FAW damage was recorded in untreated control (90.08%). Cob yield recorded high in *M. rileyi* (Anakapalle strain) 1x10^8 spores/ml (67.56 q/ha) and M*etarhizium rileyi* (UAS, Raichur) 1x10^8 spores / ml (67.17 q/ha) and low in control (35.95q/ha) (Table 104).

Table 104. Field efficacy of *Metarhizium (Nomuraea) rileyi* isolate (Anakapalle strain AKP- Nr-1; UAS, Raichur)) against fall armyworm, *Spodoptera frugiperda* in maize

Treatment	FAW damage %				FAW damage reduction (%) after two sprays	Cob yield Q/ ha	Yield increase over control (%)
	Before first spray	After first spray	After second spray	Upto 60 days			
T1: *Metarhizium rileyi* (Anakapalle strain) 1x10^8 spores / ml	10.97 19.02)	9.0 (17.4)	4.83 (12.23)	24.8	42.45	67.56 (55.58)	87.93
T2: *M. rileyi* (Anakapalle strain) 1x10^{10} spores / ml	10.42 18.84)	7.4 (15.57)	4.95 (12.26)	22.77	47.16	56.81 (48.96)	58.03
T3:*M.rileyi (* (Anakapalle strain) 1x10^{12} spores / ml	10.57 20.73)	5.95 (14.12)	5.27 (13.17)	21.72	49.59	51.67 (51.77)	43.73
T4: *M. rileyi* (UAS,Raichur) 1x10^8 spores / ml	10.51 18.89)	7.88 (16.26)	4.82 (12.64)	23.21	45.89	67.17 (55.1)	86.84
T5: *M. rileyi* (UAS,Raichur) 1x10^{10} spores / ml	10.3 18.64)	7.13 (15.07)	5.05 (12.75)	22.48	47.83	60.15 (50.96)	67.32
T6: *M. Rileyi* (UAS,Raichur) 1x10^{12} spores / ml	10.5 18.82)	5.18 (12.9)	5.65 (13.27)	21.33	50.5	55.06 (47.92)	53.16
T7 :Untreated control	9.47 17.76)	15.61 (23.23)	18.01 (24.99)	43.09		35.95 (36.72)	
CD (P = 0.05)	NS	4.9	4.33			8.54	
CV (%)	10.85	16.81	16.28			9.68	

Values in parenthesis are arc sin transformed values

UAS Raichur

Results indicated that one day before spray, FAW larval population ranged from 1.52 to 1.84 larvae per plant which was statistically non-significant. Ten days after third spray lowest larval population (0.18 larva per plant) was noticed in the highest dosage of *Metarhizium rileyi* (KK-Nr-1) @ 1×10^{12} spores/ml (5g/L) and it was at par with *Metarhizium rileyi* (AKP-Nr-1) @ 1×10^{12} spores/ml (5g/L) which recorded 0.26 larva per plant. The highest per cent mycosis (30.15 %) was noticed in the *Metarhizium rileyi* (KK-Nr-1) @ 1×10^{12} spores/ml (5g/L) and at par with *Metarhizium rileyi* (AKP-Nr-1) @ 1×10^{12} spores/ml (5g/L) (29.75 %). Untreated control recorded 3.75 % of mycosis. Lowest plant damage (4.85 %) was noticed in *Metarhizium rileyi* (KK-Nr-1) @ 1×10^{10} spores/ml (5g/L) and it was at par with *Metarhizium rileyi* (AKP-Nr-1) @ 1×10^{12} spores/ml (5g/L) (5.25 %) while in untreated control it was 25.50 %. Highest grain yield of 60.25 q/ha was noticed in *Metarhizium rileyi* (KK-Nr-1) @ 1×10^{12} spores/ml (5g/L) and it was at par with *Metarhizium rileyi* (AKP-Nr-1) @ 1×10^{12} spores/ml (5g/L) which recorded 59.50 q/ha while in untreated control it was 48.75 q/ha grain yield (Table 105).

Table 105. Efficacy of *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1 and *Metarhizium rileyi* (UASR strain KK-Nr-1) against fall armyworm, *Spodoptera frugiperda* (J.E.Smith) in maize ecosystem during 2021-22.

Sl. No.	Treatment Details	Dosage (g/l)	Number of larvae per plant*				Myco-sis (%)#	Plant dam-age (%)#	Grain yield (q/ha)
			IDBS	10 days after each spray					
				I Spray	II Spray	III Spray			
1	*Metarhizium rileyi* (AKP-Nr-1)	1×10^8 spores/ ml (5g/L)	1.68 (1.48)	1.12 (1.27)	0.84 (1.16)	0.68 (1.09)	14.25 (22.18)	11.65 (19.96)	54.50
2	*M. rileyi* (AKP-Nr-1)	1×10^{10} spores/ ml (5g/L)	1.72 (1.49)	0.88 (1.17)	0.52 (1.01)	0.42 (0.96)	26.5 (30.98)	8.5 (16.95)	57.85
3	*M. rileyi* (AKP-Nr-1)	1×10^{12} spores/ ml (5g/L)	1.76 (1.50)	0.56 (1.03)	0.38 (0.94)	0.26 (0.87)	29.7 (33.02)	5.25 (13.25)	59.50
4	*M. rileyi* (KK-Nr-1)	1×10^8 spores/ ml (5g/L)	1.58 (1.44)	1.04 (1.24)	0.78 (1.13)	0.54 (1.02)	15.5 (23.18)	10.5 (18.91)	55.25
5	*M. rileyi* (KK-Nr-1)	1×10^{10} spores/ ml (5g/L)	1.52 (1.42)	1.72 (1.49)	0.44 (0.97)	0.36 (0.93)	27.8 (31.82)	7.75 (16.16)	58.50
6	*M. rileyi* (KK-Nr-1)	1×10^{12} spores/ ml (5g/L)	1.84 (1.53)	0.52 (1.01)	0.32 (0.91)	0.18 (0.82)	30.15 (33.30)	4.85 (12.72)	60.25
7	Untreated control	-	1.78 (1.51)	1.84 (1.53)	1.96 (1.57)	1.82 (1.52)	3.75 (11.17)	25.5 (30.33)	48.75
S Em ±			0.21	0.08	0.02	0.03	1.36	1.01	0.51
CD (P=0.05)			NS	0.25	0.07	0.11	4.08	3.05	1.56

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

MPUAT

IV. 2. 5. Biological Control of Maize Stem Borer, *Chilo partellus* using *Trichogramma chilonis* (MPUAT)

The demonstrations on the releases of *Trichogramma chilonis* were conducted at farmer's fields in an area covering 10 hectares in Udaipur district of Rajasthan.

The dead heart incidence in fields with the releases of *T. chilonis* was 13.42 per cent and in chemical control, it was 10.12 per cent. The reduction in incidence over control was 44.95 and 58.49 per cent in T_1 and T_2, respectively. The yield in *T. chilonis* (T_1) (29.10q/ha) and Spinosad 45 SC (T_2) (32.45 q/ha) fields were significantly more than in untreated control (22.70 q/ha).

Table 106. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in Kharif maize during 2021

S. No.	Treatments	Dead hearts (%)	Incidence (Per cent reduction in over control)	Yield (q/ha)	Yield (Per cent increase over control)
1.	*T. chilonis* @ 100,000/ha (total 3 releases at 15, 22 and 29 days after crop germination)	13.42	44.95	29.10	28.19
2.	Spinosad 45 SC @ 1.0ml/ 3 lit (farmers practice)	10.12	58.49	32.45	42.95
3.	Untreated control	24.38	-	22.70	-

IV 2.6. Field trial against fall armyworm in maize (PJTSAU Hyderabad; WNC IIMR, Maize Hyderabad, TNAU Coimbatore, PAU Ludhiana)

PJTSAU Hyderabad: The trial was carried out in the College Farm, Rajendranagar in an area of 1100 sq.m. and 9 treatments including control were laid out . The Pheromone treatment alone was laid out in the research plots of Maize Research station in Rajendranagar.

Treatments:

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) + *Beauveria 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* NBAIR H38 (1-2 whorl sprays @ 4kg/acre, first spray after 15 days of planting & then the next sprays 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 1%)* (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)

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/L)

T10. Untreated check (control)

Results: Pooled data of 2021-22 and 2021-22 :

Damaged plants/plot (%):

Significantly least no. of damaged plants/plot were seen in *Bt* treated plots (41.09 %) and pheromone treated plots (41.24%) apart from chemical treated plots (35.18 %) and highest were seen in *Pseudomonas* (91.07%) and control plots (88.83%) (74.66%).

No.of dead larvae/plot: *Bt* (8.67/plot) and chemical treated plots (9.83/plot) recorded significantly highest no. of dead larvae, while pheromone plots (1.30) and control plot (0.00) recorded minimum dead larvae.

No.of predators/plot: It was maximum in *Metarhizium* treated plots (29.33), pheromone plots (55.23) and control plots (61.67), while minimum were seen in chemical treated plots (12.50)

Egg parasitisation (%) was highest in *Tc* released plots (57.50 %) followed by 43.00% in *Metarhizium*, while least egg parasitisation was recorded in chemical treated plots (12.67%).

Yield: Significantly highest yield was observed in Trichocards + *Bt* treated plots (27.86q/a) and pheromone treated plots (18.28 q/a) apart from chemical treated plots (32.65 q/a) and least was observed in control plots (10.05 q/a)

Table 107. Field Evaluation of different biocontrol agents against fall armyworm in maize

Treatments	damaged plants/plot* (%)	No.of dead larvae/ plot*	No.of preda-tors/plot*	Egg parasiti-sation* (%)	Yield * (q/acre)
T1 *Tc* cards + NBAIR *Bt 2%* @ 2 ml/L	41.09 (39.62)[a]	8.67 (3.03)[a]	26.67 (5.05)[cde]	22.33 (4.70)[e]	27.86[a]
T2 *Tc* cards + NBAIR *Ma* 35 @ 5 ml/L	63.65 (53.41)[b]	6.33 (2.61)[ab]	29.33 (5.14)[c]	43.00 (6.25)[b]	14.28 [cd]
T3 *Tc* cards + NBAIR *Bb 4*5 @ 5 ml/L	73.64 (60.49)[b]	6.33 (2.61)[bc]	25.00 (5.36)[e]	22.33 (4.70)[e]	16.13[c]
T4 *Tc* cards + NBAIR H38 whorl application @ 4 kg/ acre	83.33 (68.97)[c]	1.33 (1.34)[d]	26.00 (5.15)[de]	38.83 (6.13)[c]	13.45[cd]
T5 *Tc* cards + *Pseudomonas fluorescens* 1% *Pf* @ 20 g/L	91.07 (73.87)[c]	7.67 (2.30)[d]	28.33 (7.43)[cd]	27.17 (5.20)[d]	14.33 [cd]
T6 *Tc* cards + NBAIR *1 Sp* NPV @ 2 ml/l	84.91(70.24)[c]	5.00 (2.85)[ab]	26.00 (3.60)[de]	38.83 (6.13)[c]	21.68[b]
T7 *Tc* cards only	88.54 (75.60)[c]	0.00 (0.71)[e]	54.83 (7.88)[b]	57.50(7.21)[a]	11.67[cd]
T8	41.24(39.72)[a]	1.30 (1.33)[d]	55.22 (7.99)[b]	47.50 (6.40)[b]	18.28[cd]
T9 Emamectin Benzoate @0.4g/L spray	35.18 (35.40)[a]	9.83 (3.18)[a]	12.50 (5.05)[f]	12.67 (3.55)f	32.65[a]
T10 Control	88.83 (75.84)[c]	0.00 (0.71)[e]	61.67 (5.14)[a]	38.83(6.13)[c]	10.05[d]
CD (P = 0.05)	7.40	0.36	0.29	1.37	5.10
CV (%)	17.37	14.37	4.47	18.09	19.32

*Pooled data of 2 years (2020-21 rabi and 2021-22 rabi)

Table 108. Cost benefit analysis

Treatment	Returns (Rs.)/acre	Costs (Rs.)/ acre	Net Returns (Rs.)/acre	Benefit:Cost ratio
T1 *Tc* cards + NBAIR *Bt 2%* @2ml/L	44,576.40	10200.00	36774.40	2.79
T2 *Tc* cards + NBAIR *Ma* 35 @5ml/L	22850.13	7560.00	17690.13	1.68
T3 *Tc* cards + NBAIR *Bb* 45 @5ml/L	25815.47	6900.00	21315.47	2.15
T4 *Tc* cards + NBAIR H38 whorl application @4kg/acre	21513.07	16200.00	7713.07	0.40
T5 *Tc* cards + *Pseudomonas fluorescens* 1% *Pf* @20g/L	22921.07	7400.00	17921.07	1.72
T6 *Tc* cards + NBAIR *1 Sp* NPV @2ml/l	34681.60	997,500.00	27181.60	2.11
T7 *Tc* cards only @ 1cc/acre 6 times	18677.33	4,800.00	13877.33	2.89
T9 Emamectin Benzoate @ 0.4 g/L spray	52240.00	10,000.00	4424.00	4.42
T10 Control	16077.33	-	16077.33	-

Selling price of maize = Rs.1600/q

WNC, ICAR-IIMR, Hyderabad Season : Rabi 2021-22

Field study was conducted to determine the effectiveness of various biopesticides against fall armyworm in maize during *rabi* 2021-22 at WNC, ICAR-IIMR, Hyderabad. Among the treatments, the per cent plant infestation observed was nil in *Trichogramma chilonis* 1 card per acre + EPN *H. indica* NBAIIH38 and *Trichogramma chilonis* 1 card per acre + SpfrNPV (NBAIR1) whereas in control it was 3.74% . The next best treatments were *Trichogramma*

Fig 44. View of the experimental field in College Farm, Rajendranagar Damage by the fall armyworm on maize Severe damage to maize crop by the Fall armyworm

chilonis 1 card per acre + *Beauveria bassiana* NBAIR -Bb 45, *Trichogramma chilonis* 1 card per acre + *Metarhizium anisopliae* NBAIR -Ma 35, *Trichogramma chilonis* 1 card per acre + NBAIR Bt and *Trichogramma chilonis* 1 card per acre + *Pseudomonas fluorescens* (Pf DWD 2%) recorded per cent plant infestation of 0.93%, 1.59%, 2.20 % and 2.29% respectively, at ten days after first spray. Treatment *Trichogramma chilonis* alone recorded per cent plant infestation of 3.33.

Minimum whorl feeding injury rating of 1.00 was observed in *Trichogramma chilonis* 1 card per acre + *Metarhizium anisopliae* NBAIR -Ma 35, *Trichogramma chilonis* 1 card per acre + EPN *H. indica* and NBAIIH38 and *Trichogramma chilonis* 1 card per acre + SpfrNPV (NBAIR1). However, all the remaining treatments recorded LIR in the range of 2.0 to 3.33 including untreated control. The number of larvae observed were nil in *Trichogramma chilonis* 1 card per acre + EPN *H. indica* NBAIIH38 and *Trichogramma chilonis* 1 card per acre + SpfrNPV (NBAIR1) whereas in control it was 1.00. Maximum number of natural enemies (0.33) were observed in *Trichogramma chilonis* 1 card per acre + SpfrNPV (NBAIR1) and untreated control.

Table 109. Evaluation of different bio pesticides/bio control agents against fall armyworm in maize during *rabi* 2021-22

Treatment	Plant Infestation (%)		Whorl feeding injury (1-9 Scale)		No.of egg masses		No.of live larva		No.of predators	
	Pretreatment count	10 DAS	Pre treatment count	10 DAS	Pretreatment count	10 DAS	Pretreatment count	10 DAS	Pretreatment count	10 DAS
T1-*Trichogramma chilonis* 1 card per acre + NBAIR Bt 2%	18.51	2.20	3.11	3.33	1.00	0.00	4.67	0.67	0.00	0.00
T2-*Trichogramma chilonis* 1 card per acre + *Metarhizium anisopliae* NBAIR -Ma 35, 0.5%	10.98	1.59	2.55	1.00	0.33	0.00	3.00	0.33	0.00	0.00
T3-*Trichogramma chilonis* 1 card per acre + *Beauveria bassiana* NBAIR -Bb 45, 0.5%	10.29	0.93	4.24	2.00	0.33	0.00	3.00	0.33	0.00	0.00
T4-*Trichogramma chilonis* 1 card per acre + EPN *H. indica* NBAIIH38	5.89	0.00	3.67	1.00	0.00	0.00	2.00	0.00	0.33	0.00
T5-*Trichogramma chilonis* 1 card per acre + *Pseudomonas fluorescens* (Pf DWD 2%)	14.88	2.29	3.50	3.00	0.00	0.00	3.67	0.67	1.33	0.00
T6-*Trichogramma chilonis* 1 card per acre + SpfrNPV (NBAIR1)	19.19	0.00	2.57	1.00	0.33	0.00	3.33	0.00	0.67	0.33
T7-*Trichogramma chilonis* alone (1 card per acre)	11.19	3.33	2.51	2.33	0.33	0.00	4.00	1.67	0.00	0.00
T8-Insecticidal check (Emamectin Benzoate 5 SG @ 0.4g /L)	5.67	0.83	2.06	1.00	0.00	0.00	1.33	0.33	0.00	0.00
T9-Untreated check (control)	19.70	3.74	3.16	2.67	1.00	0.00	6.67	1.00	0.00	0.33
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	39.35	111.07	17.16	33.05	23.69	-	29.09	37.71	43.33	17.69

Note: Yield data to be recorded after harvest of the crop

TNAU:

A field trial was conducted in Eastern farm, TNAU, Coimbatore. Among the biocontrol agents, lowest plant damage of 39.67 per cent was observed in *Trichogramma chilonis*+ NBAIR Bt 2% followed by *Trichogramma chilonis*+ *Metarhizium anisopliae* Ma (41.52%), *Trichogramma chilonis*+ *Beauveria bassiana* NBAIR -Bb 45 (43.27%), *Trichogramma chilonis*+Spfr NPV(NBAIR1) (43.31%) and *Trichogramma chilonis*+EPN

H. indica NBAIR H38 (47.59%) on 7th day after first spraying of entomopahogens and insecticide, while in insecticide treated plots 38.62 per cent damage was observed. Similar trend was observed on 15th day after first spraying also. Numbers of larvae in different treatments ranged between 0.30 (*Trichogramma chilonis*+ *Beauveria bassiana* NBAIR -Bb 45) and 0.44 (*Trichogramma chilonis*+*Spfr*NPV (NBAIR1) in biocontrol treatments whereas in untreated control 0.32 numbers of larvae were observed on7th day after first spraying of entomopahogens and insecticide.

A maximum of 35.48 per cent egg parasitisation by *Telenomus* sp was observed in *Trichogramma chilonis*+NBAIR Bt 2%. Coccinellid beetle were seen in all the treatments indicating the neutrality of the treatments (Table 110). Tassel damage ranged between 13.47 and 39.84 per cent in different treatments. Yield was maximum (3563Kg/ha) in *Trichogramma chilonis*+NBAIR Bt 2% plots followed by *T. chilonis*+ *Metarhizium anisopliae* Ma35(3420Kg/ha) and these two treatments statistically onpar with each other while in the insecticide treated plots the yield was 3883Kg/ha (Table 112). There was no significant difference in egg parasitisation and population of predators in different treatments.

Table 110. Effect of biocontrol agents on fall armyworm in maize

Treatments	Damaged plants* (%)				Numbers of larvae /plant**			
	I Spray		II Spray		I Spray		II Spray	
	7DAT	15DAT	7DAT	15DAT	7DAT	15DAT	7DAT	15DAT
T1 *Trichogramma chilonis*+ NBAIR Bt 2%	39.67 (49.09)b	56.76 (52.43)b	44.39 (41.75)cb	48.77 (44.30)dc	0.39 (0.62)e	0.49 (0.70)c	0.21 (0.46)b	0.55 (0.73)ba
T2 *Trichogramma chilonis+ Metarhizium anisopliae* Ma 35	41.52 (54.76)b	58.87 (58.)d	38.48 (38.30)cba	44.31 (41.74)b	0.31 (0.56)ba	0.39 (0.63)a	0.23 (0.48)c	0.63 (0.80)ba
T3 *Trichogramma chilonis+ Beauveria bassiana* NBAIR -Bb 45	43.27 (50.74)b	53.49 (54.27)c	43.14 (41.02)cb	47.11 (43.34)c	0.30 (0.55)a	0.46 (0.68)b	0.23 (0.48)c	0.63 (0.79)ba
T4 *Trichogramma chilonis*+ EPN *H. indica* NBAIR H38	47.59 (47.71)b	57.55 (54.73)c	47.66 (43.63)dc	54.71 (47.71)e	0.35 (0.59)c	0.45 (0.67)b	0.27 (0.52)f	0.59 (0.77)ba
T5 *Trichogramma chilonis+Pseudomonas fluorescens (Pf DWD 1%)*	51.36 (51.58)b	66.18 (57.60)d	48.29 (44.01)dc	54.61 (47.64)e	0.55 (0.74)g	0.63 (0.79)f	0.26 (0.51)fe	0.61 (0.78)ba
T6 *Trichogramma chilonis*+Spfr NPV(NBAIR1)	43.31 (56.46)b	70.59 (62.14)e	40.53 (39.51)cb	47.69 (43.68)dc	0.44 (0.66)f	0.52 (0.72)d	0.25 (0.50)d	0.71 (0.84)cb
T7 *Trichogramma chilonis* alone	50.16 (49.95) b	63.31 (53.84)cb	34.67 (36.05)ba	42.34 (40.60)b	0.37 (0.61)d	0.48 (0.69)c	0.299 (0.55)g	0.92 (0.95)c
T8 Pheromone traps	53.21 (52.01)b	70.07 (55.46)c	46.56 (43.01)dc	49.18 (44.53)d	0.32 (0.57)b	0.52 (0.72)d	0.249 (0.50)ed	0.37 (0.77)ba
T9 Insecticide Emamectin benzoate	38.62 (34.76) a	38.58 (37.75)a	29.26 (32.67)a	31.49 (34.13)a	0.31 (0.56)ba	0.57 (0.75)e	0.127 (0.36)a	0.50 (0.71)a
T10 Control	54.23 (52.15)b	63.78 (62.38)e	56.23 (48.59)d	66.99 (54.93)f	0.32 (0.57)b	0.45 (0.67)b	0.355 (0.59)h	0.72 (0.85)cb
SEd	5. 196	0.808	3.208	0.558	0.006	0.009	0.005	0.058
CD (P=0.05)	10.911	1.696	6.736	1.172	0.012	0.017	0.011	0.122

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

Table 111. Effect of biocontrol agents on natural enemies of fall armyworm

Treatments	*Egg parasitisation (%) (*Telenomus* sp.)				**Numbers of coccinellid beetle / plot			
	I Spray		II Spray		I Spray		II Spray	
	7DAT	15DAT	7DAT	15DAT	7DAT	15DAT	7DAT	15DAT
T1 *Trichogramma chilonis*+ NBAIR Bt 2%	35.48 (36.56)	37.25 (37.62)[b]	0.00 (2.87)[e]	0.00 (2.87)[e]	3.33 (1.79)	2.00 (1.29)	3.67 (1.89)	1.00 (1.20)
T2 *Trichogramma chilonis*+ *Metarhizium anisopliae* Ma 35	19.35 (26.10)	0.00 (2.87)[e]	35.29 (36.45)[b]	0.00 (2.87)[e]	4.67 (1.63)	1.33 (1.19)	3.67 (1.88)	1.67 (1.19)
T3 *Trichogramma chilonis*+ *Beauveria bassiana* NBAIR -Bb 45	30.30 (33.40)	33.59 (35.42)[d]	30.67 (33.63)[d]	37.29 (37.64)[d]	1.67 (1.11)	1.67 (1.11)	3.33 (1.54)	1.67 (1.19)
T4 *Trichogramma chilonis*+ EPN *H. indica* NBAIR H38	0.00 (2.87)	0.00 (2.87)[e]	30.12 (33.28)[d]	47.95 (43.82)[a]	3.67 (1.87)	1.67 (1.36)	2.67 (1.80)	1.00 (1.34)
T5 *Trichogramma chilonis*+*Pseudomonas fluorescens (Pf DWD 1%)*	0.00 (2.87)	35.00 (36.27)[c]	40.74 (39.67)[a]	0.00 (2.87)[e]	1.67 (1.50)	1.00 (1.20)	3.67 (1.80)	1.33 (1.16)
T6 *Trichogramma chilonis*+Spfr NPV(NBAIR1)	26.14 (30.75)	33.73 (35.51)[d]	32.26 (34.61)[c]	0.00 (2.866)[e]	2.67 (1.21)	1.67 (1.14)	4.33 (1.75)	2.00 (1.33)
T7 *Trichogramma chilonis* alone	36.84 (37.37)	37.04 (37.49)[b]	35.29 (36.45)[b]	44.00 (41.55)[b]	1.00 (1.59)	1.33 (1.36)	1.67 (1.66)	1.67 (1.25)
T8 Pheromone traps	0.00 (2.87)	0.00 (2.87)[e]	35.82 (36.76)[b]	0.00 (2.87)[e]	1.00 (1.76)	1.00 (1.25)	3.67 (1.79)	1.67 (1.19)
T9 Insecticide Emamectin benzoate	0.00 (2.87)	0.00 (2.87)[e]	0.00 (2.87)[e]	0.00 (2.87)[e]	1.67 (1.30)	1.33 (1.15)	2.00 (1.77)	1.00 (1.28)
T10 Control	48.89 (44.36)	39.74 (39.08)[a]	34.69 (36.09)[b]	40.63 (39.60)[c]	2.67 (1.29)	2.33 (1.24)	2.67 (1.66)	3.00 (1.34)
SEd	0.29	0.33	0.41	0.40				
CD (P=0.05)	0.61	0.70	0.87	0.83	NS	NS	NS	NS

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

Table 112. Effect of biocontrol agents on Tassel damage of fall armyworm and yield of maize

Treatments	*Numbers of dead larva /plot				**Tassel damage %	*Yield Kg/ha	CB ratio
	I Spray		II Spray				
	7DAT	15DAT	7DAT	15DAT			
T1 *Trichogramma chilonis* + NBAIR Bt 2%	2.00 (1.58)[b]	3.00 (1.87)[a]	0.0 (0.71)[e]	0 (0.71)[b]	31.38 (34.07)[f]	3564 (59.70)[b]	1.92
T2 *Trichogramma chilonis* + *Metarhizium anisopliae* Ma 35	0.00 (0.71)[d]	0.00 (0.71)[d]	1.0 (1.23)[a]	0 (0.71)[b]	13.47 (21.52)[a]	3420 (58.48)[c]	1.61
T3 *Trichogramma chilonis* + *Beauveria bassiana* NBAIR -Bb 45	0.00 (0.71)[d]	0.00 (0.71)[d]	0.0 (0.71)[e]	0.33 (0.91)[a]	39.84 (39.13)[h]	3290 (57.36)[cd]	1.52
T4 *Trichogramma chilonis* + EPN *H. indica* NBAIR H38	0.00 (0.71)[d]	0.00 (0.71)[d]	1.0 (1.22)[a]	0 (0.71)[b]	19.33 (26.08)[d]	3405 (58.35)[c]	1.60

T5 *Trichogramma chilonis* + *Pseudomonas fluorescens (Pf DWD 1%)*	2.00 (1.58)[b]	2.00 (1.58)[b]	0.7 (1.08)[b]	0 (0.71)[b]	15.04 (22.81)[b]	3250 (57.01)[d]	1.48
T6 *Trichogramma chilonis* + Spfr NPV(NBAIR1)	1.00 (1.23)[c]	1.00 (1.23)[c]	0.0 (0.71)e	0 (0.71)[b]	16.25 (23.77)[c]	3418 (58.46)[c]	1.65
T7 *Trichogramma chilonis* alone	3.00 (1.)[a]	3.00 (1.87)[a]	0.3 (0.91)d	0 (0.71)[b]	31.11 (33.90)[f]	3315 (57.58)[cd]	1.53
T8 Pheromone traps	0.00 (0.71)[d]	0.00 (0.71)[d]	0.5 (1.00)c	0 (0.71)[b]	21.52 (27.64)[e]	3205 (56.61)d	1.59
T9 Insecticide Emamectin benzoate	2.00 (1.58)[b]	2.00 (1.58)[b]	0.3 (0.91)d	0 (0.71)[b]	35.48 (36.56)[g]	3883 (62.31)a	1.96
T10 Control	0.00 (0.71)[d]	0.00 (0.71)[d]	0.0 (0.71)e	0 (0.71)[b]	39.84 (39.14)[h]	2853 (53.41)e	
SEd	0.011	0.007	0.004	0.001	0.36		
CD (P=0.05)	0.023	0.015	0.008	0.002	0.77	1.184	

DAT – Days After Treatment;
Figures in parentheses are square root transformed values* and arcsine transformed values**;
Means followed by a common letter in a column are not significantly different
Values are mean of three replications

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Based on the pooled mean of two sprays, significantly lower plant infestation (2.62 %) was recorded in chemical control. Among bioagents, lowest plant damage was observed in *Tc* + NBAIR-Bt 25 (T1) (11.26 %). It was followed by *Tc* + NBAIR-SpfrNPV (T5) (14.68 %), *Tc* + NBAIR-EPN (T6) (16.02 %), *Tc* + NBAIR-Ma 35 (17.11 %) (T2) and *Tc* + NBAIR-Bb 45 (T3) (17.82 %), all four did not differ significantly among each other. The plant infestation in treatments, *Tc* + Pf DWD (T4) and *Tc* alone (T7) was 24.84 and 25.92, respectively. Significantly higher plant damage (28.0 %) was recorded in untreated control (Table 113). Similarly, lowest larval population (0.83/ 10 plants) was recorded in chemical control. It was followed by *Tc* + NBAIR-Bt 25 (4.83/ 10 plants), *Tc* + NBAIR-SpfrNPV (6.00/ 10 plants), *Tc* + NBAIR-EPN (6.67/ 10 plants), *Tc* + NBAIR-Ma 35 (6.83/ 10 plants) and *Tc* + NBAIR-Bb 45 (7.33/ 10 plants). However, the larval population was significantly higher in untreated control (11.17/ 10 plants). Grain yield was also significantly higher in chemical control (56.60 q/ ha) followed by *Tc* + NBAIR-Bt 25 (50.63 q/ ha), *Tc* + NBAIR-SpfrNPV (48.33 q/ ha), *Tc* + NBAIR-EPN (46.27 q/ ha), *Tc* + NBAIR-Ma 35 (44.81 q/ ha) and *Tc* + NBAIR-Bb 45 (44.55 q/ ha). Significantly lower grain yield was recorded in untreated control (40.18 q/ ha).

Fig 45. Field trial against fall armyworm in maize

Table 113. Field evaluation of biocontrol agents against fall armyworm in *Kharif* maize during 2021

Treat-ments	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**	
T_1	15.63	12.30 (20.42)	10.22 (18.52)	11.26 (19.47)	7.67	5.33 (2.50)	4.33 (2.31)	4.83 (2.40)	50.63
T_2	14.93	16.61 (23.99)	17.60 (24.77)	17.11 (24.38)	7.00	6.67 (2.76)	7.00 (2.82)	6.83 (2.79)	44.81
T_3	15.28	17.53 (24.71)	18.10 (25.12)	17.82 (24.92)	7.33	7.00 (2.81)	7.67 (2.94)	7.33 (2.88)	44.55
T_4	16.02	23.15 (28.73)	26.53 (30.98)	24.84 (29.85)	7.00	9.33 (3.21)	10.33 (3.36)	9.83 (3.29)	43.67
T_5	16.07	15.15 (22.89)	14.20 (22.04)	14.68 (22.47)	7.67	6.33 (2.71)	5.67 (2.56)	6.00 (2.63)	48.33
T_6	15.67	15.91 (23.49)	16.13 (23.64)	16.02 (23.56)	8.00	6.67 (2.76)	6.67 (2.76)	6.67 (2.76)	46.27
T_7	15.14	23.16 (28.75)	28.67 (32.35)	25.92 (30.55)	7.33	9.00 (3.16)	11.33 (3.51)	10.17 (3.33)	42.54
T_8	17.23	3.79 (11.18)	1.44 (6.83)	2.62 (9.01)	9.33	1.33 (1.52)	0.33 (1.14)	0.83 (1.33)	56.60
T_9	17.96	25.62 (30.39)	30.38 (33.43)	28.00 (21.91)	8.33	10.33 (3.37)	12.00 (3.60)	11.17 (3.48)	40.18
CD (P = 0.05)	NS	(2.90)	(3.16)	(2.92)	NS	(0.40)	(0.40)	(0.38)	5.78
CV %	8.96	7.04	7.55	7.30	8.07	8.31	8.43	8.37	7.20

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

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IV. 2. 7. Large scale demonstration of proven biocontrol technologies against maize stem borer, *Chilo partellus* using *Trichogramma chilonis*

The demonstrations on the biological control of maize stem borer, *Chilo partellus* using *T. chilonis* releases were conducted at farmer's fields on an area of 5 acres in Hoshiarpur, Kapurthala, Roop Nagar and Gurdaspur districts of Punjab in collaboration with KVKs and Regional Station (Gurdaspur). Each demonstration area was divided into three blocks representing three treatments, viz. two releases of *T. chilonis* @ 1,00,000 parasitoids/ ha, chemical control (farmers' practice) and untreated control. Tricho-cards each having approximately 1000 parasitized eggs were cut into 100 strips and were stapled uniformly to the underside of the central whorl leaves on 10 and 17 days old crop in biocontrol treatment. In chemical control, chlorantraniliprole 18.5 SC @ 75 ml/ ha was sprayed using 150 litres of water per ha. The observations were recorded on dead heart incidence and the yield was recorded at harvest on whole plot basis.

Based on the mean of all locations (Table 114), dead heart incidence in fields with the releases of *T. chilonis* was 1.85 per cent and in chemical control, it was 0.63 per cent. However, both the treatments were significantly better than untreated control (4.27 %). The reduction in incidence over control was 56.67 and 85.25 per cent in biocontrol and chemical control, respectively. Similarly, yield in biocontrol (48.00 q/ha) and chemical control

(51.80 q/ha) fields were significantly more than in untreated control (44.20 q/ha). The yield increase over control was 8.60 per cent in biocontrol as compared to 17.19 per cent in chemical control. The net returns over control in biocontrol package were Rs. 6530/- as compared to Rs.12885/- in chemical control (Table 115).

Table 114. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2021

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 and 17 days old crop)	1.85[b]	56.67	48.00[b]	8.60
Chlorantraniliprole 18.5 SC @ 75 ml/ha	0.63[a]	85.25	51.80[a]	17.19
Untreated control	4.27[c]	-	44.20[c]	-

Table 115. Cost Benefit analysis (2021)

Plate 1

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*)	48.00	3.80	7030.00	500.00	6530.00
Chlorantraniliprole 18.5 SC @ 75 ml/ha	51.80	7.60	14060.00	1175.00	12885.00
Untreated control	44.20				

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

Fig 46. Field releases of tricho-cards in maize

NIPHM

IV. 2. 8. Isolation, molecular characterization and mass production of *M. rileyi* collected on fall armyworm, *S. frugiperda* during 2021-22 (UAS Raichur)

Totally 29 isolates of *M. rileyi* were cultured and named for each isolate (Table 116).

Colonies of the fungus were white initially and later turn pale green to malachite green. Conidiophores are long (160μ), and consist of dense compacted clusters of phialides and branches in whorls on the upper section.

The branches are short and swollen. Phialides are short and cylindrical to globose, with very swollen base tapering abruptly to a narrow neck (Table 117).

The sequences were aligned using the ClustalW (http://www.ebi.ac.uk/clustalw) program and compared those with GenBank data. The accession number of the isolates is presented in (Table 118).

Table 116. Culturing and isolation of *M. rilyei* infected cadavers collected from different locations and crops during 2021-22

Sl. No.	Crop	Host	Location	Isolate number
1	Maize	*S. frugiperda*	UAS, campus Raichur	UASRBC Mr- 1
2	Cotton	*S. litura*	UAS, campus Raichur	UASRBC Mr-2
3	Maize	*S. frugiperda*	Askhal, Raichur	UASRBC Mr -3
4	Groundnut	*S. litura*	UAS, campus Raichur	UASRBC Mr -4
5	Maize	*S. frugiperda*	Udamgal, Raichur	UASRBC Mr -5
6	Maize	*S. litura*	Udamgal, Raichur	UASRBC Mr-6
7	Pigeon pea	*S. litura*	Askhal, Raichur	UASRBC Mr -7
8	Groundnut	*S. litura*	Kallur, Raichur	UASRBC Mr -8
9	Maize	*S. frugiperda*	Kallur, Raichur	UASRBC Mr-9
10	Groundnut	*A. modicella*	UAS, campus Raichur	UASRBC Mr -10
11	Maize	*S. frugiperda*	Kalmal, Raichur	UASRBC Mr -11
12	Groundnut	*S. litura*	Kalmal, Raichur	UASRBC Mr-12
13	Cabbage	*P. xylostella*	Chandrabhanda	UASRBC Mr -13
14	Pigeon pea	*S. litura*	Kalmal, Raichur	UASRBC Mr 14
15	Maize	*S. frugiperda*	Gondbal, Koppal	UASRBC Mr -15
16	Maize	*S. frugiperda*	Chukkankal, Koppal	UASRBC Mr -16
17	Maize	*S. frugiperda*	Muddaballi, Koppal	UASRBC Mr -17
18	Maize	*S. frugiperda*	Konchigeri, Ballari	UASRBC Mr -18
19	Maize	*S. frugiperda*	ARS, Siruguppa,	UASRBC Mr – 19
20	Maize	*S. frugiperda*	Tekkalakote, Ballari	UASRBC Mr -20
21	Maize	*S. frugiperda*	Mallapura, Bidar	UASRBC Mr -21
22	Maize	*S. frugiperda*	Halekote, Ballari	UASRBC Mr- 22
23	Sorghum	*S. frugiperda*	Pothnal, Raichur	UASRBC Mr -23
24	Groundnut	*S. litura*	Askhal	UASRBC Mr -24
25	Maize	*S. frugiperda*	Manvi	UASRBC Mr -25
26	Black gram	*S. frugiperda*	Kardchalami	UASRBC Mr-26
27	Groundnut	*S. litura*	Kardchalami	UASRBC Mr- 27
28	Maize	*S. frugiperda*	Meenkhera	UASR BC Mr-28
29	Groundnut	*A. modicella*	Kardchalami	UASRBC Mr- 29

Table 117. Morphological characteristics of *Metarhizium rileyi* isolates collected from Northeastern Karnataka during 2021-22

Sl. No.	Isolate	Shape	Colour of the Spores	Length (µm) (40X)	Width (µm) (40X)	Ratio*	Mycelial width (µm)*
1	UASRBC Mr-3	Oval to globose	Pale green	8.09 ± 0.05	5.48 ± 0.04	1.48 (1.41)[ab]	4.36 (2.20)[c]
2	UASRBC Mr-4	Cylindrical to elliptical	Pale green	8.98 ± 0.02	5.98 ± 0.02	1.50 (1.41)[ab]	2.53 (1.74)[d]
3	UASRBC Mr-7	Oval to cylindrical	Pale green	6.74 ± 0.13	6.15 ± 0.04	1.09 (1.26)[bc]	3.82 (2.07)[cd]
4	UASRBC Mr-10	Oval to cylindrical	Pale green	11.73 ± 0.08	5.00 ± 0.49	2.34 (1.69)[a]	4.68 (2.27)[c]
5	UASRBC Mr-14	Cylindrical to elliptical	Pale green	7.90 ± 0.12	5.98 ± 0.01	1.50 (1.41)[ab]	4.06 (2.14)[c]
6	UASRBC Mr-15	Oval to cylindrical	Pale green	9.57 ± 0.09	4.57 ± 0.02	2.09 (1.61)[a]	2.84 (1.83)[d]
7	UASRBC Mr-18	Cylindrical	Pale green	7.44 ± 0.05	3.79 ± 0.09	1.96 (1.57)[ab]	4.41 (2.23)[c]
8	UASRBC Mr-19	Elliptical to oval	Pale green	9.82 ± 0.17	6.05 ± 0.48	1.62 (1.46)[bc]	1.94 (1.56)[e]
9	UASRBC Mr-20	Oval to cylindrical	Pale green	9.55 ± 0.17	4.36 ± 0.50	2.19 (1.64)[a]	6.46 (2.64)[a]
10	UASRBC Mr-22	Cylindrical	Pale green	8.14 ± 0.42	4.33 ± 0.20	1.87 (1.54)[ab]	5.73 (2.49)[ab]
11	UASRBC Mr-24	Elliptical to oval	Pale green	8.29 ± 0.02	5.52 ± 0.50	1.50 (1.41)[ab]	5.12 (2.37)[ab]
12	UASRBC Mr-29	Cylindrical to oval	Pale green	9.26 ± 0.01	5.08 ± 0.06	1.82 (1.52)[ab]	5.61 (2.47)[ab]
SEm ±						0.03	0.015
CD @ 0.01						0.083	0.041

*. Figures in the parenthesis indicate transformed values
Means followed by same letters in a column not significantly different by DMRT

Table 118. Details of accession number for *M. rileyi* isolates collected from Northeastern Karnataka region during 2021-22

Sl. No.	Isolate number	Accession number	Crop	Host	Latitude and longitude	Location
1	UASRBC Mr -3	-	Maize	*S. frugiperda*	16.19639 77.32708	Askihal Raichur
2	UASRBC Mr -4	-	Groundnut	*S. litura*	16.19893 77.32715	UAS Raichur
3	UASRBC Mr -7	OK178862	Redgram	*S. litura*	16.19936 77.32708	Askihal Raichur
4	UASRBC Mr -10	-	Groundnut	*A. modicella*	16.19893 77.32715	UAS Raichur
5	UASRBC Mr 14	OK184900	Redgram	*S. litura*	16.198889, 77.216222	Kalmal Raichur

6	UASRBC Mr -15	-	Maize	*S. frugiperda*	15.28551 76.14853	Gondbal Koppal
7	UASRBC Mr -18	OK184898	Maize	*S. frugiperda*	15.419964 76.875882	Konchigeri Ballari
9	UASRBC Mr -20	OK184899	Maize	*S. frugiperda*	15.5248, 76.8793	Tekkalakote Ballari
11	UASRBC Mr -24	OK184897	Groundnut	*S. litura*	15.3485, 76.17812	Askihal Raichur
12	UASRBC Mr- 29	OK177835	Groundnut	*A.modicella*	15.764867, 76.538698	Kardchalami Sindhnoor

IV 2.9. Bioassay of *Metarhizium rileyi* collected from North Eastern Karnataka against fall armyworm, *S. frugiperda* in laboratory during 2021-22 (UAS Raichur)

Bio-assay studies exhibited the lowest LC_{50} and LT_{50} in UASR BC Mr-18 which was followed by UASR BC Mr-15 which recorded 2.7×10^8 and 3.1×10^8 LC_{50} while lowest LT_{50} was noticed in UASR BC Mr-18 (6.73 days) followed by UASR BC Mr-19 (6.81 days) (Table 119 and 120).

Table 119. Probit analysis of *M. rileyi* isolates *S. frugiperda* during 2021-22

Sl. No.	Isolates	LC_{50} (spores per ml)	Fiducial limit	Heterogenity (χ^2)	Regression equation
1	UASR BC Mr-3	7.25×10^8	7.4×10^2 5.9×10^8	1.28	Y= 1.32 +0.27X
2	UASR BC Mr-4	4.1×10^8	1.7×10^3 2.5×10^{10}	0.66	Y = 1.56+0.23X
3	UASR BC Mr-7	2.63×10^8	1.0×10^2 6.2×10^{10}	1.24	Y= 1.41 +0.19X
4	UASR BC Mr-10	5.9×10^8	1.9×10^4 1.7×10^9	0.75	Y= 1.66 +0.28X
5	UASR BC Mr-14	7.4×10^7	0.6×10^2 6.9×10^8	1.13	Y= 1.31 +0.27X
6	UASR BC Mr-15	3.1×10^8	8.5×10^3 1.4×10^9	2.18	Y= 1.47 +0.26X
7	UASR BC Mr-18	2.7×10^8	2.1×10^4 1.3×10^{10}	2.10	Y= 1.61 +0.25X
8	UASR BC Mr-19	3.4×10^7	0.1×10^2 4.9×10^8	1.13	Y= 1.22 +0.27X
9	UASR BC Mr-20	4.1×10^7	2.9×10^2 5.9×10^{10}	1.61	Y= 1.39 +0.21X
10	UASR BC Mr-22	4.1×10^9	6.6×10^3 4.5×10^{12}	0.81	Y =1.66 +0.19X
11	UASR BC Mr-24	3.1×10^8	4.8×10^2 4.8×10^{10}	0.73	Y= 1.47 +0.19X
12	UASR BC Mr-29	9.6×10^9	4.6×10^6 9.1×10^{12}	1.01	Y = 1.82+0.23X
13	NrSf-1	5.4×10^7	9.8×10^2 6.8×10^{10}	1.29	Y = 1.24+0.26X

Fiducial limits are calculated by using equivalent deviate at P= 0.01 level with the help of SPSS (Statistical Package for the Social Science)

Table 120. Time mortality response of *S. frugiperda* to *M. rileyi* isolates during 2021-22

Sl. No.	Isolates	LT_{50} at 1× 10 ^{8} spores per ml (days)	Fiducial limit (Lower limit-upper limit) (days)	Heterogeni-ty (χ^2)	Regression equation (Y)
1	UASR BC Mr-3	7.78	5.33 - 8.89	1.06	1.21 + 2.84x
2	UASR BC Mr-4	9.10	1.28 - 10.60	2.69	1.04 + 2.25x
3	UASR BC Mr-7	8.86	2.09 - 10.46	0.76	1.35 + 0.85x
4	UASR BC Mr-10	10.69	6.70 - 15.38	0.53	2.50 + 1.37x
5	UASR BC Mr-14	10.18	9.15 - 12.09	1.09	1.97 + 0.19x
6	UASR BC Mr-15	8.65	5.24 - 9.99	0.80	1.73 + 2.04x
7	UASR BC Mr-18	6.73	3.24 -8.21	0.22	2.52 + 3.48x
8	UASR BC Mr-19	6.81	2.44 - 8.50	0.37	2.23 + 1.07x
9	UASR BC Mr-20	7.01	2.45 -8.80	2.53	1.02 + 1.15x
10	UASR BC Mr-22	7.47	4.61 -8.74	0.36	1.68 + 2.36x
11	UASR BC Mr-24	9.36	3.08 - 11.13	0.35	2.16 + 1.29x
12	UASR BC Mr-29	10.90	8.58 - 15.41	0.13	1.34 + 2.18x
13	NrSf-1	6.45	4.97-7.44	0.87	3.8 + 4.7x

Fiducial limits are calculated by using equivalent deviate at P= 0.01 level with the help of SPSS (Statistical Package for the Social Science)

UAS Raichur

IV. 2. 10. Evaluation of BIPM module for fall armyworm, *Spodoptera frugiperda* in maize ecosystem during 2020-21

Results indicated that one day before treatment imposition, egg patches ranged from 2.52 to 2.75 egg patches per plant. Ten days after second release of the trichocards lowest egg patch of 0.52 per plant was noticed in BIPM while in FP and control it was 2.25 and 2.85 egg patches per plant. Ten days after treatment imposition lowest larval population of 0.28 larva per plant was noticed in FP which was followed by BIPM (0.92 larva /plant) while untreated control recorded 1.82 larvae per plant. Similar trend was noticed with plant damage where in FP recorded lowest plant damage of 3.25 per cent which was followed by BIPM (11.54 %) while untreated control recorded highest per cent plant damage of 18.52. Highest parasitisation of 41.25 per cent was noticed in BIPM while in FP it was 1.54 and untreated control recorded 10.25 per cent. Highest per cent mycosis was noticed in BIPM (30.52 %) which was followed by untreated control which recorded 4.85 while FP recorded lowest of 1.54 per cent mycosis. Highest grain yield of 58.50 q/ha was noticed in FP and it was followed by BIPM (56.25 q/ha) while untreated control recorded lowest of 41.75 q/ha grain yield (Table 121).

Table 121. Evaluation of BIPM module for fall armyworm, *Spodoptera frugiperda* in maize ecosystem during 2021-22

Sl. No.	Treatment Details	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 *Trichogramma chilonis* @ 1,00,000 lakh/ha @ 10 and 20 DAS *Metarhizium rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5 g/L) @ 30 DAS *Heterorhabditis indica* (ICAR-NBAIIH-138) @ 4 kg/acre at 40 and 50 DAS	2.61 (1.76)	0.52 (1.00)	1.78 (1.51)	0.92 (1.19)	11.54 (19.82)	41.25 (39.96)	30.52 (33.52)	56.25
T_2	Farmers Practice Application of Emamectin benzoate 5 SG @ 0.2 g/lit at 30 and 40 DAS	2.75 (1.80)	2.25 (1.66)	1.62 (1.46)	0.28 (0.88)	3.25 (10.39)	1.54 (7.03)	0.00 (0.00)	58.50
T_3	Untreated control	2.52 (1.73)	2.85 (1.83)	1.74 (1.50)	1.82 (1.52)	18.52 (25.47)	10.25 (18.67)	4.75 (12.59)	41.75
S Em ±		0.17	0.05	0.11	0.07	0.13	0.31	0.48	0.65
CD (P=0.05)		NS	0.15	NS	0.21	0.41	0.95	1.45	1.89

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

Biological Control of Millets Pests

IV. 3. SORGHUM

IIMR-Hyderabad

IV. 3. 1 Management of FAW in Sorghum using biocontrol agents – Rabi 2021

Treatment details:

T1: Release of *Trichogramma chilonis* 1 card/acre twice (first release was after one week of planting & second release was after one week of first release + spray of *Metarhizium anisopliae* (ICAR-NBAIR isolate Ma 35) 0.5 % at 20, 35 DAE

T2: Control

Observations: The data on egg patches, was recorded on 30 DAE i.e 10 days post first spray, whereas larvae per 10 plants and whorl damage was recorded at 45 DAE i.e 10 days post 2nd spray. The yield data was recorded at harvest.

There was reduction in egg patches/ 10 plants (35.7%), no. of larvae/ 10 plants (51.4 %) and reduction in whorl damage (64.4 %) in plot which received the bio-control module treatment (T1). There was 11.85 and 19.17 % increase in the grain and fodder yield over control in treatment T1 (Table 122, Fig 47).

Table 122. Efficacy of bio-control module for management of Fall armyworm in Sorghum (Rabi, 2021-22)

Treatment	Egg patches /10 Plants (30 DAE)	Larvae/10 Plants (45 DAE)	Whorl damage (%) (45 DAE)	Grain Yield (t/ha.)	Fodder yield (t/ha)
T1	1.2[a]	1.07[a]	8.067[a]	4.186[a]	7.389[a]
T2	1.867[b]	2.2[b]	22.66[b]	3.743[b]	6.2[b]
CD (P = 0.05)	0.503	0.463	7.56	0.133	0.193

DAE: Days after crop emergence

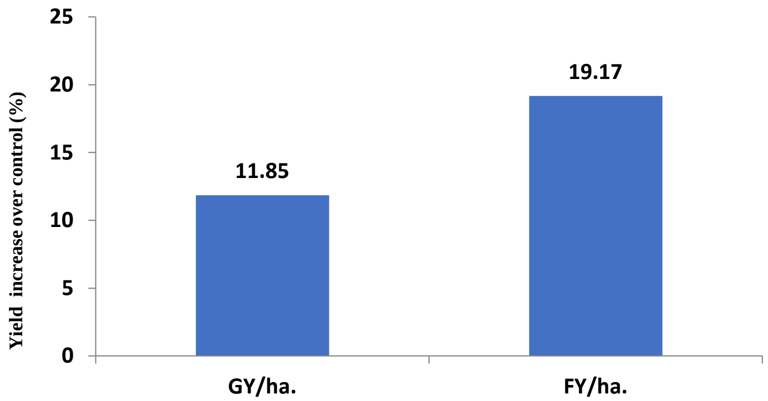


Fig 47. Grain and fodder yield increase over control in treatment with biocontrol inputs in Sorghum

IV 3.2. Studies on abundance of natural enemies of borers in Millets, (Kharif, 2021) (IIMR, Hyderabad)

Chilo partellus was predominant (8 - 10%) as compared to *Sesamia inferens* (< 5 %) in Sorghum. About 10% larval parasitization by *Cotesia flavipes* was observed.

Surveys for incidence of *Spodoptera frugiperda* showed 5 – 6 % damage on Sorghum. About 2-3 % larval parasitization was observed by *Chelonus* sp.

In Barnyard, Proso, Little, Kodo millets the incidence of shoot flies were recorded at seedling, panicle stages causing dead hearts (>30%) and white ears (20%), respectively.

IV. 4. FINGER MILLET

IIMR, Hyderabad

IV. 4. 1. Evaluation of entomopathogenic fungi formulations against Pink borer (*Sesamia inferens*) in Finger millet, Kharif, 2021

Three isolates of *Beauveria bassiana* (ICAR-NBAIR Bb 5a, Bb 23 and Bb 45), three isolate of *Metarhizium anisopliae* (ICAR-NBAIR Ma 4, Ma 6 and Ma 35) were evaluated for their efficacy against Pink borer of Finger millet (*Sesamia inferens*) during Kharif 2021 at ICAR-IIMR, Hyderabad.

The spray treatments were imposed twice at 20 and 40 DAE of the crop. The data on dead hearts, White earheads due to Pink borer infestation and yield were recorded.

Table 123. Efficacy of entomofungal formulations against Pink borer (*Sesamia inferens*) in Finger millet (Kharif 2021), ICAR-IIMR, Hyderabad

Sl. No	Treatment	Deadhearts (%)			White earhead (%)			Yield (Kg/ plot)	Yield increase over control (%)
		Pre (20DAE)	40 DAE	Reduction over Control	Pre (50 DAE)	At harvest	Reduction over Control		
T1	Bb-5a @ 10 gm /lt	9.3	6.12[c]	52.3	9.6	3.383[ab]	78.7	3.583[bc]	45.8
T2	Bb-23 @ 10 gm/lt	9.1	6.01[c]	53.2	9.3	3.813[ab]	76.0	3.125[c]	27.1
T3	Bb-45 @ 10 gm /lt	8.8	4.78[abc]	62.8	9.9	3.583[ab]	77.5	3.450[bc]	40.4
T4	Ma-35 @ 10 gm /lt	9.2	4.01[abc]	68.8	8.9	2.887[ab]	81.8	3.500[bc]	42.4
T5	Ma 4 @ 10 gm /lt	8.6	4.42[abc]	65.6	9.1	2.33[ab]	85.3	4.058[ab]	65.1
T6	Ma 6 @ 10 gml /lt	9.1	3.84[ab]	70.1	9.0	2.13[ab]	86.6	4.000[ab]	62.7
T7	Fipronil 3 G @ 17.5 kg / ha) at sowing + whorl application of Fipronil 3 G @ 7.5 kg at 30 DAE	8.8	3.21[a]	75.0	9.7	1.99[a]	87.5	4.333[a]	76.3
T8	Untreated/Control	9.2	12.84[d]		10.6	15.89[c]		2.458[d]	
	Mean	9.0	5.7		9.5	4.4		3.563	
	CD (P = 0.05)	N/A	2.1		N/A	1.9		0.626	

Deadhearts (DH): There were significant differences in the treatments in terms of dead hearts (DH) at 40 DAE of crop. The DH caused due to Pink borer was significantly least in T_7 (3.21%) which was on par with T_6 (3.84%), T_5 (4.42%), T_4 (4.01%) and T_3 (4.78%). There was 70.1, 68.8, 65.6 % reduction in DH over the control in T_6 (Ma 6), T_4 (Ma 35) and T_5 (Ma 4), respectively while T_7 (Application of Fironil) resulted in 75.0% reduction in DH over the untreated control (Table 123)

White ear heads (WEH): WEH were least in T_7 (Application of Fironil) (1.99 %) and it was statistically on par with T6, T5, T4, T3, T2 and T1. There was 86.6, 85.3 and 81.8 % reduction in DH over the control in T_6 (Ma 6), T_5 (Ma 4) and T_4 (Ma 35), respectively while T_7 (Application of Fironil) resulted in 87.5% reduction in WEH over the untreated control (Table 123).

Grain yield (Kg/plot): Highest grain yield was obtained in T_7 (4.333 kg/plot) which was on par with T_5 (4.058 kg/plot) and T_6 (4.0 kg/plot). There was 65.1 % and 62.7 % increase in grain yield over the control in T_5 (Ma 4) and T_6 (Ma 6). Soil application of Fipronil 3G @ 17.5 kg /ha) at sowing + whorl application of Fipronil 3G @ 7.5 kg at 30 DAE resulted in 76.3% increase in yield over the untreated control.

Overall based upon the reduction in damage and increase in yield realized, the bio-control agents T5 (application of talc formulation of *Metarhizium anisopliae* (Ma 4) @10gm /lt at 20 & 40 DAE) and T6 (application of talc formulation of *Metarhizium anisopliae* (Ma 6 @10gm /lt) at 20 & 40 DAE) were the best and on par with T7 (application of Fipronil 3G @ 17.5 kg /ha) at sowing + whorl application of Fipronil 3G @ 7.5 kg at 30 DAE).

PULSES

MPUAT, UDAIPUR

IV. 5. Chickpea

IV. 5. 1. Biological Suppression of Pod Borer, *Helicoverpa armigera* (Hubner) Infesting Chickpea.

Variety: Location specific recommended variety

Design: Randomized Block Design

Replications: 5

Treatments: 5

Treatment details: T1: *Beauveria bassiana* @ 1×10^8 conidia /gm @ 5 gm/l 2 sprays at 7 days interval at pod initiation stage

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

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

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 124. Effect of different treatments on population of *H. armigera* and pod damage of Chickpea during *Rabi*, 2021-22

S. No.	Treatments	Larval count (Mean number/plant)					Pod damage (%)	Grain Yield (q/ha)
		PTP	3 DAS	7 DAS	10 DAS	15 DAS		
1.	*B. bassiana* @ 1×10^8 conidia /gm @ 5 gm/l	4.1	3.9	3.5	3.0	3.5	16.22	10.60
2.	Bt @ 1 Kg/ha	3.2	3.0	3.1	2.8	2.8	13.88	12.50
3.	Quinalphos 25 EC @ 250 g a.i/ha	3.6	3.3	2.6	2.0	2.4	10.12	15.70
4.	HaNPV (1.5 × 10^{12} POBS/ha)	4.2	3.9	3.4	2.6	3.3	12.68	14.20
5.	Untreated control	3.8	4.0	4.8	5.5	6.0	24.38	8.90

Each block was divided into five plots and each plot was considered as a replication to record the incidence of pod borer, per cent pod damage, grain yield. Before treatment, the larval population ranged from 3.2 to 4.2 larvae per plant which was statistically non-significant. The maximum reduction was recorded in quinalphos 25 EC @ 250 g a.i/ha treatment (2.0 larvae per plant) and the minimum reduction was observed in *B. bassiana* @ 1×10^8 conidia / gm @ 5 gm/l (3.0 larvae per plant) at ten days after spray; whereas, the untreated control plot recorded the least reduction in larval population (5.5 larvae per plant) at ten days after spray. Minimum per cent pod damage was recorded in treatment of quinalphos 25 EC @ 250g a.i/ha (10.12%) and maximum was in *B. bassiana* @ 1×10^{8} conidia /gm @ 5 gm/l (16.22%).

ICAR - NCIPM, New Delhi

IV. 5. 2. Evaluation of Biointensive Integrated Pest Management against pod borer in chickpea in Bundelkhand region

'BIPM module was implementedat farmer's field in village Chokari (25°35'15.4"N 79°13'00.5"E) of district Jhansi (UP) with the help of district KVK during *Rabi* 2021 in five ha area in farmers participatory mode.

BIPM MODULE

1. Deep summer ploughing and field sanitation
2. Sowing in the first fortnight of November
3. Selection of tolerant/resistant variety (RVG202)
4. Seed Treatment with *Trichoderma harzianum* (NCIPM-TH1) 10 g/kg seed
5. Intercropping with mustard
6. Installation of pheromone trap for monitoring 5/ha in November and 30/ha for mass trapping on 10 Feb 2022.
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^{8}cfu 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.

Mean larval population (Mean±SD) was significantly lower ($p<0.05$) in BIPM fields during peak activity period i.e. 7th to 11th SMW with 0.84±0.04 larvae per meter row (Table 125) compared to FP (2.85± 0.14 larva per meter row). In BIPM field the pest population could not cross the ETL most of the time except SMW10 (Fig. 48) therefore sprayed Azadirachtin 1500 ppm and Bt but did not sprayed the chemical insecticides. Whereas in FP fields'pest population crossed ETL during most of the SMW (Fig. 48). In FP one spray of emamectin benzoate was carried out by the farmers after the pest crossed ETL and damaged the crop. In BIPM field mass trapping with pheromone trap and installation of light trap (12/acre) played crucial role in reducing the larval population.

Collar rot (*Sclerotium rolfsii)* appeared during 48th SMW in one month old crop. The incidence of collar rot was significantly lower ($p<0.05$) in BIPM (3.8%) compared to FP (16.8%). *Fusarium* wilt was also significantly lower in BIPM (3.2) compared to FP (12.2%). Similarly dry root rot in BIPM (3.75) was significantly lower than FP (10 %). Seed treatment with *Trichoderma harzianum* found to reduce incidence of wilt disease complex in chickpea significantly.

Over all BIPM fields recorded significant reduction in infestation of pod borer (70.52%) and disease incidence of collar rot (77.4%), *Fusarium* wilt (73.77%) and dry root rot (62.5%) over FP fields and remained below ETL. Use of pheromone traps, installation of bird perches and foliar spray of *B. thuringiensis* and neem were found effective against pod borer and seed treatment with *T. harzianum* also effective in management of wilt disease. Economic analysis (tanle-2) indicated that BIPM field recorded average yield of chickpea 18.60 q/ha with B: C ratio 3.87 whereas, 14.40 q/ha yield was recorded in FP fields with B: C ratio of 3.06. Implementation of BIPM strategy provided >29% increase in seed yield and >42% increase in net return in

BIPM over FP consequently farmers earned >Rs 20000/ha extra net income over farmers practice. 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.

Table 125. Incidence of pod borer and wilt disease in BIPM and FP fields of chickpea

Pest	BIPM	FP	Reduction over FP (%)	P value at t 0.05
H. armigera Larvae/meter row	0.84 ± 0.04	2.85 ± 0.14	-70.5	0.00001
Collar Rot (%)	3.8 ± 0.95	16.8 ± 1.3	-77.4	0.00001
Fusarium wilt (%)	3.2 ± 0.79	12.2 ± 1.0	-73.8	0.00001
Dry root rot (%)	3.75 ± 0.38	10 ± 2.0	-62.5	0.00006

Table 126. Economic analysis of BIPM and FP fields of chickpea

Variable	BIPM	FP	Increase over FP (%)
Cost (Rs/ha)	24000	23500	-2.13
Yield (Q/ha)	18.6	14.4	29.17
Gross Income (Rs/ha)	93000	72000	29.17
Net Income (Rs/ha)	69000	48500	42.27
BC Ratio	3.87	3.06	26.47

Price of chickpea was Rs.5000/qt

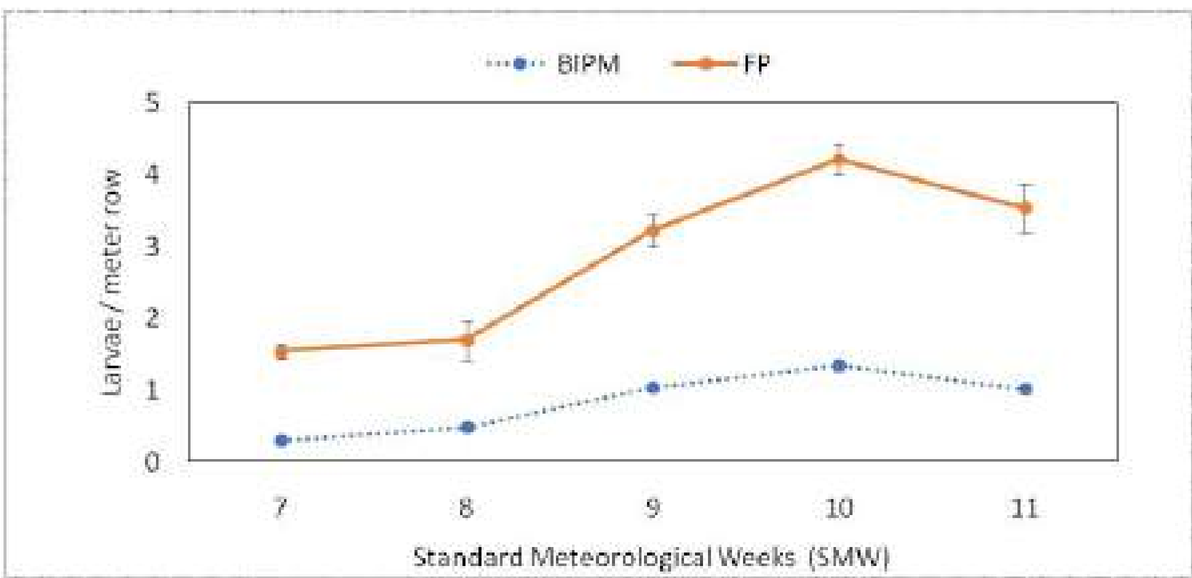


Fig 48. Larval population of *H. armigera* during peak activity periodin chickpea at Jhansi UP

MPKV, Pune

IV. 5. 3. Biological suppression of pod borer, *Helicoverpa armigera* (Hubner) infesting chickpea

The experiment was laid out on the AICRP on Biocontrol Farm, Agril. Entomology Section, College of Agriculture, Pune. The chickpea cv. "Phule Vijay" was sown on 23.11.2021 in 3 ×3 m plot size with 30 × 10 cm spacing in randomized block design with five treatments and four replicates. Two applications of sprays were given on 10.2.2022 and 25.2.2022 at 14 days interval. The treatment details are as follow.

Treatment details:

T1: *Beauveria bassiana* @ 1×10^8 conidia /gm @ 5 g /l at 14 day interval at pod initiation stage, 2 sprays

T2: *Bacillus thuringiensis* @ 1 Kg/ha 2 sprays at 14 days interval

T3: Spinosad 45 SC @ 150 ml/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

Method of recording observation:

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

Total and damaged pods at harvest.

Pod yield was recorded on whole plot basis.

Results showed that the *Helicoverpa armigera* incidence was low during this year. Two applications were given at flowering and pod initiation stage of the crop.

Larval population: larval population ranged from 0.99 to 1.36 larvae/meter and no significant difference among the treatments was observed before application of the treatment. After application of treatments, the pooled mean of larval count of two sprays was ranged from 0.34 to 2.41 larvae/meter. The lowest larval population 0.34 larvae/meter was observed in spinosad 45 SC @ 150ml/ha @ 0.3 ml/l which is significantly superior over rest of the treatments.

Pod damage (%): the per cent pod damage was ranged from 3.55 to 12.03%. The lowest pod damage (3.55%) was recorded in spinosad 45 SC @ 150ml/ha @ 0.3 ml/L whereas in *Bacillus thuringiensis* @ 1 kg/ha @ 2g/l sprayed plot 4.88% pod damage was recorded, which on par withspinosad sprayed plot.

Grain yield (q/ha) and BC ratio: The grain yield ranged between 9.42 to 17.83 q/ha. Highest grain yield 17.83 q/ha was recorded in spinosad 45 SC @ 150ml/ha@ 0.3 ml/L whereas in *Bacillus thuringiensis* @ 1 Kg/ha @ 2g/L sprayed plot16.03 q/ha was recorded with B: C ratio 2.26 and 2.01, respectively as against untreated control with grain yield of 9.42 q/ha and B C ratio was 1.34.

Table 127. Effect of Biocontrol agents against *Helicoverpa armigera* in gram during 2021-22

Treatment	Larval count / sq.mt						Pod damage (%)	Yield (q/ha)	B: C ratio
	Pre count	Post Count				Mean			
		First spray		Second spray					
		Days after spraying							
		7	14	7	14				
T_1:B. bassiana @ 1×10^8 conidia /gm @ 5 gm/L.	1.36 (1.54)	1.15 (1.46)	1.71 (1.64)	1.13 (1.46)	1.16 (1.47)	1.29 (1.51)	8.74 (17.15)	14.17	1.85
T_2:*Bt.* @ 1 Kg/ha @ 2g/L	1.26 (1.50)	0.69 (1.30)	0.89 (1.37)	0.84 (1.35)	0.62 (1.27)	0.76 (1.33)	4.88 (12.59)	16.03	2.01
T_3:Spinosad 45 SC @ 150ml/ ha@ 0.3 ml/L.	0.99 (1.39)	0.27 (1.25)	0.47 (1.20)	0.23 (1.11)	0.38 (1.17)	0.34 (1.16)	3.55 (10.84)	17.83	2.26
T_4:Spray of *Ha*NPV(1.5 × 10^{12} POBs/ha)@1ml/L	1.20 (1.48)	1.09 (1.44)	1.59 (1.61)	0.91 (1.38)	1.15 (1.47)	1.18 (1.48)	5.78 (13.89)	14.45	1.87
$T_{5:}$ Untreated control	1.00 (1.39)	2.03 (1.74)	2.14 (1.77)	2.53 (1.87)	2.95 (1.99)	2.41 (1.84)	12.03 (20.27)	9.42	1.34
SE ±	0.08	0.05	0.10	0.05	0.03	0.04	0.75	0.30	
CD (P = 0.05)	NS	0.15	0.31	0.16	0.10	0.12	2.34	0.94	
CV (%)		6.91	15.73	7.10	4.76	5.23	10.07	4.20	

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

IGKV, RAIPUR

IV. 5. 4. Testing of two BIPM modules for management of *Helicoverpa armigera* on chickpea

Table 128. Economics of bioagent treatments in gram

Treatments	Mean larval population of *H.armigera* in Chikpea	Mean pod damage due to *H.armigera* in Chikpea	Mean grain damage (%)	Mean grain yield (kg/plot)
T1 - HaNPV	1.29 (1.50)	7.90 (16.30)	12.47 (20.65)	15.46 (4.06)
T2 – Bt	1.64 (1.62)	8.15 (16.57)	14.68 (22.49)	14.80 (3.98)
T3 - Chemical	1.36 (1.53)	7.81 (16.21)	12.25 (20.47)	15.34 (4.04)
T4 - Control	3.65 (2.15)	21.77 (27.80)	21.59 (27.67)	10.07 (3.32)
SEm ±	0.034	0.129	0.412	0.042
C.D. (P = 0.05)	0.047	0.419	1.254	0.128

Farmer visits from Madhya Pradesh and Chickpea field visit of Dr. Deepa Bhagat Principal Scintist, ICAR - NBAIR, Bengaluru

Fig 49. Hon'ble Governor of Chhattisgarh, Her Excellancy, Ms.Anusuiya Uikey,visting the "State level workshop on Chhattisgarh Agricultural Education System" in line with National Education Policy 2020 on 01/01/2021 at IGKV, Raipur.

Table 129.

Tr. No.	Treatment	Cost of Culti-vation/ ha (Rs)	Cost of Spray-ing (Rs)	Total cost (Rs.)	Yield (q/ha)	Rate/Q (Rs)	Gross returns (Rs. / ha)	Net return (Rs. / ha)	BC ratio
T_1	*Beauveria bassiana* @ 1×10^8 conidia /gm @ 5 g/L	35000	3244	38244	14.17	5000	70850	32606	1.85
T_2	*Bacillus thuringiensis* @ 1 Kg/ha @ 2g/L	35000	4804	39804	16.03	5000	80150	40346	2.01

T_3	Spinosad 45 SC @ 150ml/ ha@ 0.3 ml/L	35000	4344	39344	17.83	5000	89150	49806	2.26
T_4	Spray of *Ha*NPV (1.5×10^{12} POBs/ha) @1ml/L	35000	3644	38644	14.45	5000	72250	33603	1.87
T_5	Untreated control	35000	-	35000	9.42	5000	47100	12100	1.34

G.B.P.U.A. &T., Pantnagar

IV. 5. 5. Development of biointensive IPM package and practices for pest management in pulse (chickpea)

Achievement:

Impact of BIPM practices on seed germination in chickpea

Maximum seed germination (82.66%) and plant stand (15.00/m^2) was observed in BIPM practices as compared to farmer's practice, seed germination (73.33%) and plant stand (12.33/m^2) was observed.

Table 130. Impact of BIPM practices on seed germination in chickpea

Treatments	Germination Percentage (%)	Plant stand/ m^2@ 60 DAS
BIPM	82.66	15.00
Farmer's practice	73.33	12.33
Control	70.12	11.33
CV (%)		6.84
CD (P = 0.05)		1.99
SEm ±		0.77

Trial is under progress Chickpea crop

Chickpea (PG-186) - 20 ha

Location: Farmers fields of District Nainital of Uttarakhand.

Treatments	Use of Bioagent
T1= Biocontrol (microbial) Package	Seed bio-priming through Pant Bioagent formulation, PBAT-3 (*T. harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) @ 10g/kg of seeds.
	Spray of PBAT 3 @ 10 g/ liter on standing crop at 10-12 days intervals.
T2 = Farmers Practice	(Carbendazim, Copperoxychloride, Streptocycline, Nuvan, Imidachlorpid pesticides used by farmers)
Observations:	Disease incidence
	Yield of crop (q/ha)
	Cost-benefit ratio.

Large scale field demonstrations of biocontrol agents were conducted in the field of 80 farmers belongs to 10 villages of Nainital, covering an area of 20 ha. The farmer's acreage ranged was from 0.1–0.5ha. Five quintals PBAT-3 (*Trichoderma harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) was distributed to the farmers for seed treatment through biocontrol agents to counter the soil borne diseases.

Package of practices advised to the farmers for chickpea crop were as under:

Crop	Chickpea
Diseases	Wilt
Components with dose, concentration, frequency and method of application	Soil treatment with value added compost (enriched with biocontrol agent @1 kg /q compost) Seed treatment with bioagent @10 g/kg seed. Four foliar sprays with PBAT-3 @10 g/lit water at 15 days interval.

*Season of chickpea is under progress.

UAS, Raichur

IV. 5. 6. Large Scale Demonstration of *Ha*NPV Kalaburgi strain against chickpea pod borer during 2021-22

One day before spray, larval population ranged from 4.50 to 5.25 per plant. Ten days after spray lowest of 0.45 larva per plant was noticed in FP followed by *Ha*NPV (2.12 larvae/plant). FP recorded lowest pod damage (5.04 %) followed by *Ha*NPV (15.52 %). Highest grain yield of 16.25 q/ha was recorded in FP followed by *Ha*NPV (14.54 q/ha) while untreated control recorded 10.58 q/ha (Table 131).

Table 131. Large Scale Demonstration of *Ha*NPV Kalaburgi strain against chickpea pod borer during 2021-22

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	*Ha*NPV @ 100 LE/acre	5.25 (2.40)	2.75 (1.80)	2.12 (1.61)	15.52 (23.18)	14.54
T_2	Farmers Practice	4.5 (2.24)	0.85 (1.16)	0.45 (0.97)	5.04 (12.92)	16.25
T_3	Untreated control	4.75 (2.29)	5.25 (2.40)	4.75 (2.29)	25.25 (30.17)	10.58
S Em ±		0.08	0.04	0.07	0.44	0.35
CD (P = 0.05)		NS	0.13	0.21	1.33	1.06

*Figures in parentheses are square root transformed values

#Figures in parentheses are arcsine transformed values

AAU, Jorhat

IV. 5. 7. Evaluation of entomopathogenic biopesticide against *Aphis craccivora*in cowpea
Targetpests: *Aphis craccivora*

Location: Experimental farm, Dept.of Horticulture, Season: *Kharif*, 2021, Date of Sowing: 29.10.2021, Variety: Chakra, Plotsize: 400m^2, Experiment design: 4 RBD

Treatments include:

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

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

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

T_4: Spinosad 45 SC @ 0.3ml/lit.

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

T_6: Untreated control

Aphid population in five randomly selected plants (terminal shoots) for each plot were recorded before and3, 7and 10days after treatment. Three rounds of spray were made.The first spray was applied on the basis of initial occurrence of aphid and rest was based on abundance of pests.

Table 132. 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	28.00	16.92	12.09	8.09	12.36 [b]	44.17	34.61
T_2	26.33	22.25	15.34	10.33	15.97 [c]	27.87	30.16
T_3	27.33	15.33	10.17	7.00	10.83 [a]	51.08	38.75
T_4	26.67	15.41	11.67	8.33	11.80 [ab]	46.70	36.39
T_5	26.33	15.42	11.75	8.67	11.95 [ab]	46.03	33.21
T_6	27.33	23.42	23.17	19.84	22.14 [d]		26.84
CD (P = 0.05)	NS	3.30	1.91	1.20	1.49		1.70
CV (%)		12.08	9.05	7.71	6.96		3.39

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

It is evident from the Table 132 that three round of spraying of microbial agents and conventional insecticides revealed that the mean number of *A. craccivora* per terminal shoots of cowpea was significantly lower than untreated control plot. However, minimum number of *A. craccivora* (10.83/ terminal shoots) was recorded in the treatment T_3 *Verticilium lecanii* 1×10^8 cfu/ml @ 5gm/lit followed by treatment T_4 (spinosad 45 SC @ 0.3 ml/lit) with 11.80/ terminal shoot) with a yield of 38.75 and 36.31 q/ha, respectively. Maximum infestation (22.14 aphids/ terminal shoot) was recorded at untreated control plot. However, it was observed that except *Metarhizium anisopliae* (T_2) all the tested biopesticides showed more or less equal effectiveness with the chemical treatment plot (malathion 50 EC @ 2ml/lit) in suppressing the *A. craccivora*.

KAU, Thrissur

IV. 6. COWPEA

IV. 6. 1. Evaluation of entomopathogenic fungi against pod bug *Riptortus pedestris* on cowpea

Evaluation of two entomopathogenic fungi against the pod bug, *Riptortus pedestris* on cowpea (*Vigna unguiculata*) is in progress at farmer's field in Kuruvai, Vadakkenchery as per the technical programme given below.

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 50. Experimental plot for evaluation of entomopathogenic fungi against pod bug

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

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 November 2021 to March 2021. The results of the experiment is presented in Table 133.

Design: RBD Variety: Anaswara

Replications: 4 Plot size: $40m^2$/replication

Treatments:

T1: Bb-5a isolate of *Beauveria bassiana* $1x10^8$cfu/ml (5g/litre) at 15 days interval

T2: Ma-6 isolate of *Metarhizium anisopliae* $1x10^8$cfu/ml (5g/litre) at 15 days interval

T3: Vl-8 isolate of *Lecanicillium lecanii* $1x10^8$cfu/ml (5gl/litre) at 15 days interval

T4: Imidacloprid 50g ai/ha at 15 days interval

T5. Untreated control

Fig 51. Experimental plot for evaluation of entomopathogenic fungi against cowpea aphid

Table 133. Effect of entomopathogenic fungi on cowpea aphid (*Aphis craccivora*)

Treatment	Mean number of aphids								Yield (kg/ plot)
	Pre-count	5 DAS1	10 DAS1	15 DAS1	5 DAS2	10 DAS2	15 DAS2	Cumu-lative mean	
T1: Bb-5a	104.77 (10.02)	76.82 (8.67)[a]	39.35 (6.23)	28.00 (4.83)	3.10 (1.43)	0.60 (1.00)	0.00 (0.71)	24.64 (4.93)	2.37[b]
T2: Ma-6	75.875 (8.62)	73.17 (8.53)[a]	47.30 (6.73)	35.97 (5.95)	4.90 (1.65)	0.82 (1.02)	0.57 (0.95)	27.12 (5.20)	3.00[b]
T3: Vl-8	84.99 (9.00)	82.35 (8.89)[a]	43.95 (6.50)	25.40 (4.54)	1.25 (1.12)	0.60 (0.95)	0.00 (0.71)	25.59 (4.98)	3.20[b]
T4:Imidaclo-prid	73.65 (8.40)	7.50 (2.08)[b]	38.67 (5.69)	36.92 (6.01)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	13.85 (3.57)	8.67[a]
T5: Control	85.54 (9.19)	72.80 (8.27)[a]	39.07 (5.55)	78.87 (7.82)	7.77 (2.35)	2.10 (1.27)	0.00 (0.71)	33.44 (5.46)	2.77[b]
CD @ 5 %	NS	2.64	NS	NS	NS	NS	NS	NS	2.149

* Values in parenthesis are square root transformed values

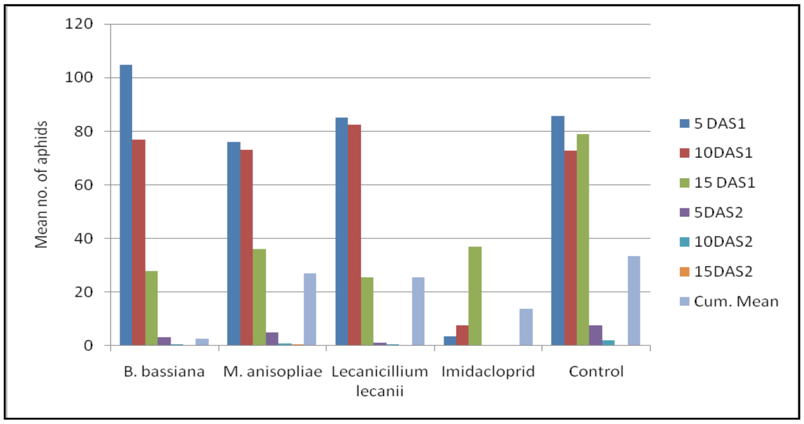


Fig 52. Effect of different entomopathogens on cowpea aphid

Significant difference between the treatments was observed only five days after first spray. Five days after the first spray, imidacloprid, with a mean number of 7.50 aphids, was significantly superior to the remaining treatments, which were on par with each other as well as untreated control.

Significant difference was recorded among different treatments in terms of yield. Imidacloprid treated plot recorded a mean yield of 8.67 kg per plot and was significantly superior to other treatments. This was followed by *Lecanicillium lecanii* with mean yield of 3.20 kg/plot, which however, was on par with other treatments including control. The lowest mean yield was recorded from control plots (2.77 kg/plot).

KAU Vellayani

IV. 6. 2. Evaluation of oil formulationof *Lecanicillium* spp against sucking pests of cowpea

Table 134 reveals the effect of biopesticides on population of *A. craccivora*. Significant reduction in population was noted two weeks after treatment, wherein maximum reduction in aphids was noted in thiamethoxam treated plots. The mean population was 235 per plant. Among the bioagent treatments, lowest population was noted in plots treated with chitin enriched oil formulations of *L. saksenae* and *L. lecanii*. The mean population noted in theseplotswas on par with each other (570-680) per plant. The spore suspensions of both the fungi performed equally with a mean population of 760 to 810 aphids per plot, while the corresponding population in control was 940. The results followed the same trend after second spraying also. After thrid spraying, *L. saksenae* oil formulation was found to be superior to thiamethoxam and *L. lecanii. L. lecanii* oil formulation was superior to spore suspension.

Table 134. Effect of improved formulations of *Lecanicillium* spp in the management of pea aphid *Aphis cracivora*in cowpea

Treatments	Post count/plant					
	First spray		Second spray		Third spray	
	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
T1- Chitin enriched oil formulation of *L. lecanii* Vl8 (NBAIR isolate)	385 (19.51)	572.5 (23.79)	307.5 (17.34)	112.5 (10.48)	57.5 (7.57)	44.2 (6.64)
T2- Chitin enriched oil formulation of *L. saksenae* (KAU isolate)	275 (16.08)	680 (26.0)	297.5 (17.23)	115 (10.70)	42.75 (6.51)	33.2 (5.76)
T3- Spore suspension of *L. lecanii* Vl8 (NBAIR isolate)	690 (25.59)	760 (27.47)	442.5 (20.96)	193.75 (13.74)	73 (8.53)	51.8 (7.01)
T4- Spore suspension of *L. saksenae* (KAU isolate)	455 (20.10)	810 (28.43)	426.25 (20.59)	203.5 (14.24)	59.75 (7.71)	38.45 (6.20)
T5-Thiamethoxam 25 WDG 2gm/10L	195 (13.89)	235 (15.28)	100 (9.94)	64 (7.92)	49.3 (6.96)	40.8 (6.37)
T6- Untreated check	322.5 (17.71)	940 (30.57)	507.5 (22.47)	237.5 (15.36)	89.75 (9.47)	57.9 (7.59)
CD (P = 0.05%)	NS	(3.18)	(2.69)	(2.33)	(0.96)	(0.48)
CV (%)	28.83	8.37	9.86	12.85	8.22	4.87

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

Table 135. Effect of improved formulations of *Lecanicillium* spp. in the management of *Riptortus pedestris* in cowpea

Treatments	Post count/plant						
	Pre Count	First spray			Second spray		
		3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T1- Chitin enriched oil formulation of *L.lecanii* Vl8 (NBAIR isolate)	2.75 (1.75)	1.5 (1.50)	1 (1.18)	5 (2.23)	4 (1.99)	2 (1.56)	0.75 (1.05)
T2- Chitin enriched oil formulation of *L. saksenae* (KAU isolate)	3 (1.84)	1 (1.00)	0.5 (0.96)	3.75 (1.86)	2.5 (1.51)	1.25 (1.25)	0.25 (0.83)
T3- Spore suspension of *L. lecanii* Vl8(NBAIR isolate)	1.25 (1.21)	3.5 (3.50)	3.25 (1.91)	4.75 (2.17)	2.25 (1.49)	1.5 (1.40)	1 (1.18)

T4- Spore suspension of *L. saksenae* (KAU isolate)	3 (1.84)	3.25 (3.25)	3.25 (1.92)	4.75 (2.16)	3 (1.67)	2.5 (1.70)	0.5 (0.96)
T5-Thiamethoxam 25 WDG 2gm/10L	4.75 (2.12	2.75 (2.75)	1.5 (1.40)	6.5 (2.49)	3.25 (1.76)	1.75 (1.47)	1 (1.18)
T6- Untreated check	3.75 (2.04)	3 (3.00)	2.75 (1.68)	4.75 (2.14)	3 (1.64)	2 (1.56)	1.5 (1.40
CD (P = 0.05%)	NS	NS	(0.58)	NS	NS	NS	NS
CV (%)	30.50	53.83	25.78	18.99	25.75	15.78	23.017

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

Seven days after first spraying, lowest population of bugs was noted in plots sprayed with oil formulation of *L. saksenae*, but was on par with the efficacy of *L. lecanii* oil formulation. Thereafter, the variation in population was not significantly different, though the lowest count was with *L. saksenae* oil (0.25 bugs per plant). The corresponding population in *L. lecanii* oil is 0.75 and those with spore suspensions it was 1.0 bug per plant, which was on par with thiamethoxam (1.0 bug).

Natural enemy population did not vary between the untreated and treated plots. However, after the second spraying significant variation was noticed. Thiamethoxam and *L. lecanii* oil formulation slightly reduced the population (11.75 and 7.75). But at the end of the experimental period none of the treatments were found to be inhibitory when compared to untreated control (19). Analysis of data on yield revealed that, there was significant increase in yield in the plots treated with oil formulation of *L. saksenae* and spore suspensions of *L. lecanii* and *L. saksenae* compared to untreated and chemical control.

MPKV, Pune

IV. 6. 3. Field evaluation of ICAR-NBAIR entomopathogenic strains against cowpea aphid, *Aphis craccivora*

The experiment was laid out in All India Coordinated Research Farm, Agril. Entomology Section, College of Agriculture, Pune. The cowpea *var*. "PhuleSonali" was sown on 06.07.2021 in plot size 5.00 × 4.00 m with 45 × 10 cm spacing in Randomized Block Design with five treatments replicated four times. The first spray was applied on 20.8.2021 while 2nd spraying on 3.9.2021. The crop was harvested on 30.9.2021.

Treatment Details:

The data (Table 136) on efficacy of ICAR-NBAIR entomopathogenic strains against cowpea aphids was statistically nonsignificant and it was in the range of 44.10 to 51.81 number of aphids/3 leaves before application.The post count data was found significant at 10 and 14 days after first and second sprays. The treatment imidacloprid @ 17.8 SL @ 0.40ml per litre of water was significantly superior with 30.60 and 28.50 aphids per 3 leaves over rest of the treatments at 10 and 14 days after first and second spray. The treatment *L.lecanii* @ 1×10^{8}cfu/ml @ 5.00 gm/ litre of water was second effective treatment with 39.80 and 37.36 aphids/ 3 leaves at 10 and 14 days after first spray and was at par with the Bb-5a isolate of *B. bassiana* 1 × 10^{8}cfu/ml @ 5.00 gm and Ma-6 isolate of *M. anisopliae* @ 1×10^{8}cfu/ml @ 5.00 gm per litre of water with 42.30 and 41.95 and 42.10 and 40.87 aphids/3 leaves at 10 and 14 days, respectively. Similar results were obtained at 10 and 14 days after second spray. The treatment imidacloprid 17.8 SL @ 0.40 ml per litre of water was significant over rest of the treatments. Among the entomopathogenic strains, Vl-8 isolate of *L. lecanii* @ 1×10^{8}cfu/ml @ 5.00 gm per litre of water was found superior with 25.00 and 17.20 aphids/3 leaves. The pooled data of two sprays showed that the treatment imidacloprid 17.8 SL significantly suppressed the population of cowpea aphids (18.80 mean aphid population/3 leaves) than other treatments. The treatment Vl-8 isolate of *L.lecanii* @ 1×10^{8}cfu/ml @ 5.00 gm liter of water was second superior with 29.84 aphids/3 leaves. Highest mean population of aphids (54.17 aphids/3 leaves) was recorded in untreated control.

The significant highest yield was recorded from the treatment imidacloprid 17.8 SL @ 0.40 ml/litre of water (13.76 q/ha) which was followed by 12.58 qt/ha in the treatment Vl-8 isolate of *L. lecanii* @ 1×10[8]cfu/ml @ 5.00 gm per litre of water

Table 136. Efficacy of ICAR-NBAIR strains of entomopathogens against Cowpea Aphids

Details of treatment	Dose (gm or ml/lit)	Aphid population/ 3 leaves (Nos)						Yield (Q/ha)
		Pre count	Days after spraying					
			First Spray		Second Spray		Mean	
			10	14	10	14		
T1:Bb-5a isolate of *Beauveria bassiana* 1 × 108 cfu/ml	5.00	44.10 (6.72)	42.30 (6.58)	41.95 (6.55)	33.60 (5.88)	28.20 (5.40)	35.61 (6.01)	11.14
T2: Ma-6 isolate of *Metarhizium anisopliae* @ 1×10[8]cfu/ml	5.00	50.10 (7.15)	42.10 (6.57)	40.87 (6.47)	32.20 (5.76)	25.98 (5.19)	36.19 (6.10)	11.71
T3:Vl-8 isolate of *Lecanicillium lecanii* @ 1×108 cfu/ml	5.00	44.60 (6.75)	39.80 (6.39)	37.36 (6.19)	25.00 (5.10)	17.20 (4.27)	29.84 (5.55)	12.58
T4: Imidacloprid 17.8 SL	0.40	47.40 (6.96)	30.60 (5.62)	28.50 (5.43)	12.06 (3.61)	4.02 (2.24)	18.80 (4.45)	13.76
T5: Control (Untreated)	-	51.81 (7.27)	59.19 (7.76)	57.36 (7.64)	60.80 (7.86)	39.33 (6.35)	54.17 (7.43)	9.22
SEm ±		0.42	0.27	0.17	0.33	0.18	0.13	0.54
CD (P = 0.05)		N.S.	0.83	0.54	1.02	0.55	0.39	1.65
CV (%)		15.12	10.27	6.78	14.81	9.69	5.36	9.19

*Figures in parenthesis are x+0.5 transformed values.

GREENGRAM PEST

ANGRAU at RARS, Anakapalle

IV. 7. 1. Integration of botanicals, microbials and insecticide spray schedule for the management of pod borer complex in Greengram

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

First and second sprays at pod formation stage at 15 days interval

During 2021-22, *Maruca virtata* leaf webs per plant recorded was significantly low in Spinosad two sprays (0.057) and on par with Bt+ Spinosad (0.113); Bt + Bt (0.125) ; Spinosad + Bt (0.143); and Bt + azadirachtin

(0.152) and high in control (0.277) (Table 137). Similarly, Pod damage was significantly low in spinosad two sprays (14.69%) and on par with treatments having *Bacillus thuringiensis* as first spray i.e., Bt + spinosad (21.82%) ; Bt two sprays (22.76 %) ; Bt + azadirachtin (24.68%) and spinosad + Bt (22.66 %) whereas pod damage was significantly high in untreated control (59.02 %). Green gram yield recorded significantly high in Spinosad two sprays (10.27 q/ha) and on par with Bt or spinosad in one spray i.e., Spinosad +Bt (9.93 q/ha); Bt two sprays (9.45 q/ha); Bt + spinosad (9.21 q/ha) ; azadirachtin + Bt (8.23 q/ha); Bt + azadirachtin (7.72 q/ha) compared to azadiractin two sprays (5.67 q/ha) and control (3.79 q/ha)

Table 137. 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 /plant	Pod damage (%)	Grain Yield (q/ha)
	After 1st spray	After 2nd spray	After two sprays				
T1- *Bt* + Azadirachtin	0.127[ab]	0.1[bc]	0.152[cd]	39.11	9.65	24.68 (29.78)[cd]	7.72 (16.09)
T2- *Bt* + Bt	0.063[cd]	0.073[bc]	0.125[bc]	39.89	9.08	22.76 (27.11)[c]	9.45 (17.69)
T3- *Bt* + Spinosad	0.1[abc]	0.027[c]	0.113[cd]	33.27	7.25	21.82 (25.42)[bc]	9.21 (17.45)
T4- Azadirachtin+ Bt	0.057[cd]	0.11[bc]	0.167[bc]	36.11	11.58	32.07 (34.32)[bc]	8.23 (16.63)
T5-Azadiractin + Azadirachtin	0.11[abc]	0.12[b]	0.227[ab]	40.89	17.29	42.29 (40.33)[bc]	5.67 (12.61)
T6- Azadirachtin + spinosad	0.097[abc]	0.04[bc]	0.134[bcd]	47.11	12.65	26.86 (30.86)[cd]	6.90 (15.10)
T7-Spinosad + Azadirachtin	0.067[bcd]	0.09[bc]	0.154[bc]	43.44	12.2	28.08 (31.81)[bc]	8.56 (16.93)
T8- Spinosad + Bt	0.067[bcd]	0.08[bc]	0.143[bcd]	31.55	7.15	22.66 (26.98)[cd]	9.93 (18.35)
T9- Spinosad +Spinosad	0.03[d]	0.03[c]	0.057[d]	32.44	4.77	14.69 (22.27)[d]	10.27 (18.69)
T10 - Control	0.147[a]	0.24[a]	0.277[a]	35.89	21.18	59.02 (50.21)[a]	3.79 (11.17)
CD (P = 0.05)	0.061	0.085	0.097		6.401	8.79	4.16
CV (%)	41.11	34.27	35.69		33.02	15.38	14.87

Bt: *Bacillus thuringiensis* and values in parenthesis are arc sin transformed values

IV. 8. SOYBEAN PEST

UAS, Raichur

IV. 8. 1. Large scale demonstration of entomopathogenic fungi, *Metarhizium rileyi* (KK-*Nr-1*) against soybean defoliators in Bidar district

A day before treatment imposition the defoliator larval population ranged from 7.36 to 7.94 per meter row length (mrl). Ten days after spray, *M. rileyi* (KK-Nr-1)1×10^8 spores/g @ 5.0 g/l recorded 1.84 larvae per meter row length while in untreated control it was 7.38 larvae per mrl. *Metarhizium rileyi* (KK-Nr-1)1×10^8 spores/g @ 5.0 g/l recorded 7.26% foliage damage while untreated control recorded 25.75%. *Metarhizium rileyi* (KK-Nr-1)1×10^8 spores/g @ 5.0 g/l recorded 16.50 q/ha grain yield which was superior over untreated control which recorded 12.50 q/ha grain yield (Table 138).

Table 138. Large scale demonstration of entomopathogenic fungi, *Metarhizium rileyi* (KK-Nr-1) against soybean defoliators in Bidar district

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	7.36 (2.80)	3.18 (1.92)	1.84 (1.52)	12.82 (20.98)	14.75
T_2	Emamectin benzoate 5 SG @ 0.2 gm/lit	7.94 (2.91)	2.06 (1.61)	1.02 (1.21)	7.26 (15.62)	16.50
T_3	Untreated control	7.82 (2.88)	8.12 (2.94)	7.38 (2.81)	25.75 (30.48)	12.50
SEm ±		0.18	0.10	0.07	1.71	0.34
CD (P = 0.05)		NS	0.31	0.21	5.13	1.03

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

IV. 9. PIGEON PEA PEST

PDKV, Akola

IV. 9. 1. Evaluation of NBAIR Bt formulation on pigeon pea against pod borer complex

Sowing was done by dibbling following similar recommended agronomic practices to all the treatments from sowing to harvesting. Application of treatments was initiated at 50% flowering by spraying of Bt and chemical insecticide as per the treatments. The consecutive sprays were undertaken at 15 days interval. Observations were recorded on Pod borer complex (*Helicoverpa*, Plume moth) (5 plants per plot), per cent pod damage (5 plants per plot) and grain yield of each treatment application was worked out.

The mean observation of 2 sprays on pod damage revealed that significantly minimum damage was recorded in insecticidal treatment (T2) with 3.85% pod damage due to lepidopteran pod borers. However, this treatment was found statistically at par with Bt treatment (T1) with 4.88% pod damage. Both this treatments were significantly superior over untreated control (10.28%). The data on pod borer damage at harvest also revealed significant differences between rest of the treatments with untreated control, recording significantly minimum damage of 19.00% in insecticidal treatment (T2), followed by treatment T1 with Bt sprays recording 19.38% 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 31.13%.

The grain damage due to pod fly was recorded by split opening the pods at harvest and it was found that treatment T2 with minimum grain damage (21.91%) followed by Bt treatment (T1) with 23.04% grain damage and both the treatments were significantly superior over untreated control which recorded maximum per cent grain damage 36.27%.

Table 139. Effect of different treatments on pod damage due to pod borers on pigeonpea (2021-22)

Treatments	Pod damage (%)		Mean pod damage (%)	Damage at harvest (%)	Grain damage (%)
	I spray	II spray			
T1- 3 sprays - NBAII BtG4 2% @ 2.0 ml/lt - at pre flowering, post Flowering and pod formation stage.	4.86 (12.74)	4.90 (12.79)	4.88 (12.76)	19.38 (26.11)	23.04 (28.68)
T2 Chemical control 1st Spray – Thiodicarb 75 WP @ 625 gm/ha 2nd spray – Chlorantraniliprole 18.5 SC @ 150 ml/ha 3rd spray - Monocrotophos 36 SL @ 625 ml/ha	3.89 (11.38)	3.80 (11.24)	3.85 (11.31)	19.00 (25.84)	21.91 (27.91)
T3 Control	11.03 (19.39)	9.54 (17.99)	10.28 (18.70)	31.13 (35.44)	36.27 (37.03)
SE(m) ±	0.88	0.39	0.49	1.11	1.06
CD (P = 0.05)	2.67	1.17	1.50	3.38	3.23
CV(%)	17.32	7.80	9.82	10.91	9.68

Note: Figures in parentheses are Arcsin transformation values.

COMMERCIAL CROPS

IV. 10. COTTON PEST

PJTSAU, Hyderabad

IV.10.1. Biointensive management of pink bollworm in *Bt* cotton (PJTSAU, Hyderabad, TNAU, Coimbatore)

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 were 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 were made and each quadrant served as replication.

Replications : Five (quadrants)

No.of modules : Three

Module Size : 200 Sq. mt

Variety : Bt Hybrid RCH 659

Season : *Kharif*, 2021-22
Location : ARI Farm, Rajendranagar

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 were dissected once a week from mid-October to mid-December at economic threshold level of 10% damage with live pink bollworm larvae and/or 8 pink bollworm moths per pheromone trap per 3 consecutive nights in at least 2 traps per field.

Number 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.

In *kharif* 2021-22, more number of good opened bolls and lesser number of bad opened bolls recorded in the BIPM and Farmers' practise plots while untreated control recorded higher bad opened bolls and lesser no,of good opened bolls. Yield was highest in the Farmers' practices (12.69q/acre) followed by BIPM (10.64 q/acre) compared to Untreated plots (4.50q/acre).

Table 140. Bio-intensive management of Pink Bollworm in *Bt* cotton

Treatment	Good opened bolls (no./plant)	Rosette flowers (no./plant)	Green bolls (no./plant)	Parasitised larvae (no./plant)	Infestation (%) by Boll dissection	Yield (q/acre)
BIPM	0.70	1.18	5.90	6.45	51.34	10.64
FP	0.87	1.02	5.26	0.67	31.38	12.69
Control	0.14	6.55	4.19	3.44	71.12	4.50
CV (%)	12.98	12.35	20.31	20.15	19.91	15.27
CD (P = 0.01)	0.15	0.22	NS	0.83	13.58	0.53

TNAU, Coimbatore

IV. 10. 2. Biointensive management of pink bollworm on *Bt* cotton

Location: Maththireddi palayam

Geographical coordinates: 11.251521° N, 77.152139° E

Variety: Boll guard II
Date of sowing: 11.06.21

In the field trial conducted in a farmer's field at Mathireddy palayam, Annur Block, Coimbatore Dt, rosette flowers due to pink boll worm was 1.22 per cent in BIPM plots while it was 2.87 per cent in the control plot on 110 Days After Sowing (DAS). On 110 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. Observations on bad open bolls were taken on 130, 140 and 150 DAS. There was 17.52 per cent reduction in the bad open bolls in BIPM module whereas 30.65 per cent reduction in bad open bolls was observed in insecticides treated plots. The yield was maximum in insecticide sprayed plots (2215 Kg/ha) followed by 1890Kg/ha and 1598 Kg/ha in BIPM and control plots respectively. CB ratio was higher in insecticide treated plots (1:2.57) than in BIPM plot (1:2.52) (Table 141).

Table 141. Bio-intensive management in Pink bollworm on Bt cotton

Treatments	Rosette flowers (%) * 110DAS	Green boll damage (%) * 110DAS	Bad open bolls (%)			Mean Bad open bolls (%)	Percent decrease from control	Yield Kg/ha**	Percent increase over control	CB ratio
			130 DAS	140 DAS	150 DAS					
T1: *Trichogrammatoidea bactrae* @ 2cc/ac + pheromone traps	1.22 (6.34)[b]	9.2 (17.65)[b]	23.0 (28.65)[b]	26.5 (30.98)[b]	31.0 (33.83)[b]	26.83	17.52	1890 (43.47)[b]	18.24	2.52
T2: Insecticides spray	0.81 (5.16)[a]	7.1 (15.45)[a]	20.7 (27.06)[a]	22.0 (27.97)[a]	25.0 (29.99)[a]	22.56	30.65	2215 (47.05)[a]	38.58	2.57
T3: Control	2.87 (9.75)[c]	12.8 (20.96)[c]	28.0 (31.94)[c]	34.0 (35.66)[c]	35.6 (36.62)[c]	32.53	-	1598 (39.97)[c]	-	1.90
SEd	0.02	0.20	0.22	0.27	0.48	-	-	0.56	-	
CD (P = 0.05)	0.04	0.41	0.47	0.56	1.02	-	-	1.17	-	

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

Large scale biointensive management of pink bollworm on *Bt* cotton - 10 acres

The following BIPM module has been demonstrated in 10 acres Bt cotton fields in comparison with farmers practice (insecticide spraying) and untreated control in Mathireddypalayam, Annur Block, Coimbatore Dt.

BIPM Module:

Standard practice of plant protection till 55th day or appearance of PBW. The following inputs were provided for PBW.

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

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

Application of azadirachtin 1500 ppm at ETL

Result: In BIPM module pink bollworm incidence bad open boll was 22.0 per cent while it was 32 per cent in control. The yield increase in BIPM plots was 20.00 per cent over control plots.

IV. 10. 3. Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton (PJTSAU, HYDERABAD, MPKV, PUNE & UAS, RAICHUR)

TREATMENT DETAILS

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 : RCH 659 Bt Hybrid
Season : *Kharif* 2021-22
Location : ARI Research plots, Rajendranagar

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

Average number of sucking pest population / 3 leaves, *viz.*, aphids, leafhoppers, whiteflies and thrips were counted and recorded.

Number of whitefly adults from 3 leaves (top, middle and lower canopy) of 5 randomly selected plants in each plot were 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.

In *kharif* 2022, 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 recorded lesser sucking pest population at 3rd and 7th day count after each of the three sprays ranging from 1.13 to 4.25/leaf after first spray, 2.80 to 3.88 hoppers/leaf after the second spray and from 1.15 to 2.21/leaf after the third spray. Yield was higher in *Lecanicillium lecanii*, Neem oil 1500 ppm and chemical treated plots and ranged from 11.37-12.86 q/acre, while the other registered lesser yields (5.90-8.69 q/acre).

Table 142. Effect of entomopathogenic fungi against leaf hoppers on cotton

Treatment	Population of leaf hoppers									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 (1.59)	2.62 (1.61)^b	6.81 (2.61)c	13.25 (3.63)	12.50 (3.19)^b	5.10 (2.25)^d	5.35 (2.31)	3.93 (1.98)^b	2.2 (1.47)	8.69^c
T2 *L. lecanii* (1x 10^8)CFU/ml	1.90 (1.37)	1.19 (1.09)^a	4.25 (2.05)^{ab}	13.53 (3.64)	8.38 (2.85)^a	3.88 (1.97)^{bc}	9.56 (2.88)	2.21 (1.48)^a	1.65 (1.25)	11.37^b
T3 *B. bassiana* (1x 10^8)CFU/ml	1.30 (1.02)	3.15 (1.77)^c	5.95 (2.36)^{ab}	12.48 (3.05)	10.53 (3.17)^{ab}	4.60 (2.14)^{cd}	5.18 (2.27)	3.93 (1.98)^b	2.1 (1.45)	8.65^c
T4 Azadirachtin 1500 ppm	2.40 (1.53)	1.13 (1.06)^a	3.25 (1.75)^a	13.51 (3.61)	8.60 (2.91)^a	2.80 (1.66)^a	5.31 (2.30)	2.68 (1.63)^a	1.15 (1.04)	11.62^b
T5 Acetamiprid 20% SP	3.73 (1.92)	1.16 (1.08)^a	4.33 (2.05)^{ab}	13.53 (3.64)	7.69 (2.76)^{ab}	3.13 (1.77)^{ab}	6.08 (2.46)	2.63 (1.62)^a	1.83 (1.22)	12.86^a
T6 Untreated Control	4.47 (1.66)	4.08 (2.01)^d	6.49 (2.55)^b	14.9 (3.86)	13.58 (3.56)^b	5.50 (2.33)^d	4.49 (2.11)	5.98 (2.44)^c	2.50 (1.58)	5.90^d
CD (P = 0.05)	NS	0.16	0.44	NS	0.71	0.23	NS	0.25	NS	1.24
CV (%)	20.25	7.28	13.07	12.85	14.83	7.50	23.81	9.08	20.65	7.43

Table 143. Effect of entomopathogenic fungi on the population of Leaf hoppers, *Amrasca biguttula biguttula*

Treatment	Population of aphids (mean no/leaf)		
	Pre count	3 day count	7 day count
T1 *M. anisopliae* (1x 10^8) CFU/ml	6.50 (3.73)	3.59 (2.02)[c]	0 (0.71)
T2 *L. lecanii* (1 x 10^8) CFU/ml	6.27 (3.66)	3.53 (2.01)[c]	0 (0.71)
T3 *B. bassiana* (1 x 10^8) CFU/ml	6.47 (3.71)	4.20 (2.16)[d]	0.16 (0.81)
T4 Azadirachtin 1500 ppm	6.47 (3.71)	1.03 (1.23)[b]	0.2 (0.82)
T5 Acetamiprid 20% SP	6.49 (3.72)	0 (0.71)[a]	0 (0.71)
T6 Untreated Control	6.39 (3.70)	5.40 (2.42)[e]	0.12 (0.78)
CD (P = 0.01)	NS	0.15	NS
CV (%)	9.04	5.68	13.73

The experiment was laid out on the AICRP Farm of Agril. Entomology Section, College of Agriculture, Pune. *Bt* cotton var - ACH199 - BG - II from Ajeet Seeds Pvt. Ltd., was sown on 25.07.2021 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 intervalon 16.12.2021, 31.12.2021 and 15.1.2022.

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

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

T3: *Beauveria bassiana* (1 x 10^8 conidia /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

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

Sucking pests population (aphids, jassids, thrips, white flies) on 3 leaves (terminal shoots)/ plant was recorded and seed cotton yield per plot was recorded and converted into q/ha.

The pooled data of sucking pest population are presented in Table 144, revealed that amongst the biopesticides, *Lecanicillium lecanii* (1 x 10^8conidia /g) @ 5 g/litre recorded lowest population of sucking pests *viz.,* aphids (3.83), jassids (2.67), and white flies (1.33) on 3 leaves per plant compared to the untreated control which recorded aphids (46.72), jassids (8.83), and white flies (6.05) 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 10^8 conidia/g) @ 5 g/litre recorded seed cotton yield of 12.38 q/ha and the next promising treatment was imidachloprid 17.8 % SL (14.01 q/ha) 1.32. Untreated control recorded lowest seed cotton yield of 6.63 q/ha.

Table 144. Effect of bioagent against sucking pests in *Bt* cotton 2021-22

Treatment	Av. population / 3 leaves / plant						Yield (q/ha)
	Aphids		Jassids		Whiteflies		
	Pre-count	Post count	Pre-count	Post count	Pre-count	Post count	
T1: *M. anisopliae* (1x 10^8 conidia /g) @ 5 g/lit.	72.11 (8.54)	13.43 (3.79)	9.55 (3.24)	3.61(2.13)	3.79 (2.18)	0.99 (1.4)	10.46
T2: *L. lecanii* (1 x 10^8 conidia /g) @ 5 g/lit.	72.56 (8.56)	3.83 (2.19)	7.28 (2.97)	2.67 (1.91)	4.21 (2.25)	1.33 (1.5)	12.38
T3: *B. bassiana* (1 x 10^8 conidia /g) @ 5 g/lit.	70.99 (8.58)	11.99 (3.6)	7.11 (2.8)	3.7 (2.16)	5.04 (2.33)	2.37 (1.83)	11.74
T4:Azadirachtin 1500 ppm @ 2 ml/lit	77.45 (8.39)	3.76 (2.18)	7.43 (2.86)	4.26 (2.28)	3.98 (2.4)	1.98(1.71)	12.22
T5: Imidachlopride 17.8 % SL @ 0.2 ml/lit	77.00 (8.96)	0.55 (1.25)	7.27 (2.95)	0.00 (1.00)	4.03 (2.32)	2.1 (1.74)	14.01
T6: Untreated control	72.96 (8.82)	46.72 (6.90)	8.31 (2.87)	8.83 (3.11)	5.08 (2.24)	6.05 (2.65)	6.63
SE ±	0.16	0.09	0.10	0.11	0.09	0.11	0.05
CD (P = 0.05)	NS	0.28	NS	0.33	NS	0.33	0.15
CV (%)	6.80	5.57	6.80	10.30	7.51	11.96	2.76

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

UAS, Raichur

IV. 10. 4. Evaluation of entompthogenic fungi, *Beauveria bassiana* (ICAR- NBAIR-Bb-5a) against sucking insect pests of cotton during 2021-22

Leafhopper population ranged from 14.12 to 15.75 per plant a day before spray. Among the biocontrol agents, *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l recorded highest reduction of leafhopper population over control (58.60 %) and it was at par with *L. lecanii* (ICAR-NBAIR-VL-15)1×10^8 @ 5gm/l (55.73 %). Reduction of thrips population over control was highest in *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l (61.39 %) and it was at par with *L. lecanii* (ICAR-NBAIR-VL-15)1×10^8 @ 5gm/l recorded (58.32 %). Per cent reduction of aphid population was highest in *L. lecanii* (ICAR-NBAIR-VL-15)1×10^8 @ 5gm/l and *I. fumosorosea* (ICAR-NBAIR strain)) 1×10^8 @ 5 gm/l which recorded 63.19 and 65.69 per cent, respectively. Highest seed cotton yield of 29.64 q/ha was noticed in *B. bassiana* (ICAR- NBAIR-Bb-5a)1×10^8 @ 5gm/l and it was at par with *L. lecanii* (ICAR-NBAIR-VL-15)1×10^8 @ 5 gm/l and *I. fumosorosea* (ICAR-NBAIR strain)) 1×10^8 @ 5gm/l recorded 29.36 and 28.54 q/ha, respectively (Table 145).

Table 145. Effect of entomopathogenic fungi on the population of aphids (mean no./ leaf)

Sl. No.	Treatment Details	Dosage (g/l)	No. of leafhoppers/plant				No. of thrips/plant				No. of aphids/plant				Seed cotton yield (q/ha)
			1 DBS	7 DAS	10 DAS	ROC (%)	1 DBS	7 DAS	10 DAS	ROC (%)	1 DBS	7 DAS	10 DAS	ROC (%)	
T_1	*B. bassiana* (ICAR- NBAIR-Bb-5a)	1×10^8 @ 5gm/l	15.50 (4.00)	7.14 (2.76)	5.28 (2.40)	58.60 (49.95)	6.14 (2.58)	3.02 (1.88)	2.18 (1.64)	61.39 (51.58)	10.64 (3.34)	7.32 (2.80)	5.18 (2.38)	47.83 (43.76)	29.64
T_2	*L. lecanii* (ICAR-NBAIR-VL-8)	1×10^8 @ 5gm/l	14.25 (3.84)	8.18 (2.95)	6.36 (2.62)	51.53 (45.88)	6.36 (2.62)	3.68 (2.04)	2.62 (1.77)	53.39 (46.95)	11.28 (3.43)	8.46 (2.99)	5.32 (2.41)	42.49 (40.68)	26.12

T_3	*L. lecanii* (ICAR-NBAIR-VL-15)	1×10^8 @ 5gm/l	15.75 (4.03)	7.74 (2.87)	5.54 (2.46)	55.73 (48.29)	5.84 (2.52)	3.24 (1.93)	2.36 (1.69)	58.32 (49.79)	11.36 (3.44)	5.68 (2.49)	3.14 (1.91)	63.19 (52.65)	29.36
T_4	*M. anisopliae* ICAR-NBAIR-Ma 4)	1×10^8 @ 5gm/l	15.22 (3.96)	9.86 (3.22)	7.62 (2.85)	41.73 (40.24)	5.98 (2.55)	4.72 (2.28)	4.18 (2.16)	30.29 (33.39)	10.74 (3.35)	9.28 (3.13)	7.18 (2.77)	31.30 (34.02)	24.28
T_5	*I. fumosorosea* (ICAR-NBAIR strain)	1×10^8 @ 5gm/l	14.12 (3.82)	7.62 (2.85)	5.38 (2.42)	56.67 (48.83)	6.06 (2.56)	3.14 (1.91)	2.82 (1.82)	53.15 (46.81)	11.08 (3.40)	5.18 (2.38)	3.04 (1.88)	65.69 (54.15)	28.54
T_6	Azadirachtin 1500ppm	2 ml/lit	14.75 (3.91)	10.38 (3.30)	8.42 (2.99)	37.33 (37.66)	6.12 (2.57)	4.58 (2.25)	3.64 (2.03)	37.40 (37.70)	10.82 (3.36)	8.76 (3.04)	6.84 (2.71)	34.89 (36.21)	22.28
T_7	Fipronil 5 SC	1 ml/lit	15.56 (4.00)	5.52 (2.45)	3.72 (2.05)	69.20 (56.29)	6.34 (2.62)	2.14 (1.62)	1.98 (1.57)	67.37 (55.16)	11.84 (3.51)	9.74 (3.20)	8.92 (3.07)	22.12 (28.06)	31.58
T_8	Untreated control	-	14.74 (3.90)	14.84 (3.92)	15.16 (3.96)	0.00 (0.00)	5.88 (2.53)	5.92 (2.53)	6.28 (2.60)	0.00 (0.00)	10.68 (3.34)	11.82 (3.51)	12.14 (3.56)	0.00 (0.00)	20.14
S Em ±			0.17	0.08	0.05	-	0.11	0.02	0.06	-	0.26	0.07	0.05	-	0.41
CD (P = 0.05)			NS	0.25	0.15	-	NS	0.06	0.18	-	NS	0.21	0.16	-	1.24

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

IV. 11. Sugarcane

ANGRAU at RARS, Anakapalle

IV. 11. 1. Field evaluation of ICAR-NBAIR endophytic entomopathogenic strains against shoot borers (*Chilo infuscatellus* and *Chilo sacchariphagus indicus*) in sugarcane

Treatments:

T1: NBAIR - *Beauveria bassiana* Bb-23@ 5 g/lt

T2: NBAIR - *Beauveria bassiana* Bb-45@ 5 g/lt

T3: NBAIR - *Metarhizium anisopliae Ma*-4@ 5 g/lt

T4: NBAIR – *Metarhizium anisopliae* Ma-35@ 5 g/lt

T5: Recommended Insecticide application (Chlorantraniliprole @ 0.3 ml/lt)

T6: Untreated Control

Sett treatment at planting and spraying of endophytic entomopathogenic fungi 3 times at 14 days interval from 25 days after germination.

During 2021-22 kharif planted crop, sett treatment at planting and spraying of endophytic entomopathogenic fungi three times at 14 days interval from 25 days after germination was effective in the management of shoot borers. Cumulative incidence of early shoot borer incidence upto 120 days after planting was high in untreated control (31.69 % DH) and significantly low in cholorantraniliprole treatment (7.64 %DH) followed by entomopathogenic fungal treatments i.e., Bb23 (12.59 %DH); Bb 45 (12.62 %DH) ; Ma 4 (14.39%DH); Ma 35 (10.28 % DH) which is below ETL (Table 146). Internode borer incidence and intensity was high in control (80 % and 6.28 %) and significantly low in cholorantraniliprole (45 % and 3.23%) and on par with

Beauveria bassiana NBAIR Bb-45 (45% and 3.47 %) and *Metarhizium anisopliae* NBAIR Ma-35 (50% and 3.45%). Cane yield recorded high in cholorantraniliprole treatment (90.74 t/ha) and on par with Bb45 (80.53 t/ha) and Ma35 (78.84t/ha) and Ma4 (78.72 t /ha) and low in control (53.92 t/ha (Table 147)

Studies on efficacy of endophytic strains of entomopathogenic fungi for the management of early shoot borer and internode borer in sugarcane improve the cane yield and reduce the cost on plant protection.

Field evaluation of ICAR-NBAIR endophytic entomopathogenic strains against shoot borers (*Chilo infuscatellus* and *Chilo sacchariphagus indicus*) in sugarcane

Table 146. Field evaluation of ICAR-NBAIR endophytic entomopathogenic strains in sugarcane

Treatment	ESB incidence (%DH)				
	45 DAP *	60 DAP *	90 DAP	120 DAP	Upto 120 DAP*
T1- Bb23 (ST + 3 sprays)	2.89 (0.45)	9.06 (0.944)	0.87 (5.17)	0.0	12.59 (1.09)
T2- Bb45 (ST + 3 sprays)	2.99 (0.48)	8.78 (0.94)	0.57 (4.32)	0.0	12.62 (1.1)
T3- Ma4 (ST + 3 sprays)	2.73 (0.43)	10.37 (1.0)	0.79 (5.08)	0.0	14.39 (1.15)
T4- Ma35 (ST + 3 sprays)	2.61(0.41)	4.64 (0.84)	0.53 (4.14)	0.0	10.28 (1.01)
T5– Chlorantraniliprole (3 sprays)	2.68 (0.38)	5.19 (0.63)	0.52 (4.12)	0.0	7.64 (0.88)
T6- Control	6.28 (0.81)	20.59 (1.31)	2.52 (9.12)	2.3	31.69 (1.49)
CD (P = 0.05)	0.11	0.13	1.05		0.092
CV (%)	15.21	9.16	13.13		10.46

Table 147. Field evaluation of ICAR-NBAIR endophytic entomopathogenic strains in sugarcane

Treatment	Internode borer incidence (%)	Internode borer intensity (%)	Cane Yield (t/ha)
T1- Bb23 (ST + 3 sprays)	65.0 (1.81)	5.46 (13.48)	74.51
T2-Bb45 (ST + 3 sprays)	45.0 (1.65)	3.47 (10.72)	80.53
T3-Ma4 (ST + 3 sprays)	63.75 (1.8)	5.5 (13.5)	78.72
T4 - Ma35 (ST + 3 sprays)	50.0 (1.69)	3.45 (10.68)	78.84
T5 – Chlorantraniliprole (3 sprays)	45.0 (1.65)	3.23 (10.32)	90.74
T6 - Control	80.0 (1.90)	6.28 (14.5)	53.92
CD (P = 0.05)	0.167	1.69	14.5
CV (%)	20.15	9.212	12.37

Bb : Beauveria bassiana ; Ma : Metarhizium anisopliae ; ST : Sett Treatment ; *Values in parenthesis are logarithmic transformed values ; Values in parenthesis are arc sin transformed values

Sugarcane sett treatment and planting with Entomopathogenic fungi

Spraying Entomopathogenic fungi at 25,40,60 DAP

Monitoring by NBAIR scientists on 26.08.2021

Fig 53.

IV. 11. 2. Field evaluation of *Metarhizium anisopliae* against sugarcane white grub *Holotrichia serrata* (PJTSAU, Hyderabad, PAU, Ludhiana)

Treatment details

Treatments are applied twice, once in June after rains and again in July.

Treatments

T1: Metarhizium anisopliae SBIMa-16 (1x10^8 spores/ ml) 5 ml/L

T2: *Metarhizium anisopliae* NBAIR Ma4 (1x10^8 spores/ ml) 5 ml/L

T3: Lesenta

T4: Control

Design RBD

Treatments : 4

Replications 6

Season *Kharif*

Plot size 50 sq.m

Observations on the following parameters will be recorded. No. of grubs observed in 10 m row length of the crops

Cane yield in each treatment

PJTSAU

In *kharif* 2021, demonstration plots recorded 47.22 precent of damaged plants, while the check plots registered 29.66% of damaged plants. No.of grubs /10m row length and Cane yield was 12.99 and 33.67 t/acre, respectively in demonstration plots compared to 10.90 and 46.25 t/acre, respectively in the check plots.

Table 148. Evaluation of *Metarhizium anisopliae* against sugarcane white grub *Holotrichia serrata*

S.No	Treatments	Damaged plants (%)		No.of grubs/ 10 m row length		Cane Yield (t/acre)
		Before treatment	60 DAT	Before treatment	60 DAT	
1	Demonstration *(Metarhizium anisopliae* NBAIR *Ma* 4 strain @ 5.0 kg/ha) used twice mixed in 250 kg of FYM)	67.45	47.22	15.56	12.99	33.67
2	Check (Fipronil 40% + imidacloprid 40 WG @ 0.5 ml/L)	68.99	29.66	16.03	10.9	46.25

PAU, Ludhiana

IV. 11. 3. Large scale demonstrations of proven biocontrol technologies against sugarcane stalk borer, *Chilo auricilius*

Large scale demonstrations on the effectiveness of *T. chilonis* against stalk borer, *Chilo auricilius* were carried out over an area of 5989 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) in Ludhiana, Patiala, Hoshiarpur, Jalandhar, Kapurthala, Gurdaspur, SBS Nagar, Roop Nagar, Faridkot, Fatehgarh Sahib, Amritsar, Moga and Mansa districts. 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 (2.71 %) was comparatively less than untreated control (6.18 %). The yield was also relatively more in released fields (752.40 q/ha) and as against untreated control (694 q/ha) with higher additional returns (Rs. 19774/- per ha) (Table 149). 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 56.21 per cent (Table 150).

Table 149. Large-scale demonstrations using *T. chilonis* against *Chilo auricilius* in sugarcane during 2021

Demonstrations	Mean incidence of *C. auricilius* (%)		Reduction over control (%)
	Biocontrol*	Untreated control	
PAU in collaboration with four sugarcane mills of Punjab (4)	2.74	6.12	55.23
PAU, Ludhiana	2.58	6.44	59.94
Overall Mean	2.71[a]	6.18[b]	56.21

*10-12 releases of *T. chilonis* @ 50,000 per ha at 10 days interval during July to October

Table 150. Cost Benefit analysis (2021)

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)
Biocontrol	752.40	58.40	21024.00	1250.00	19774.00
Untreated control	694.0	-	-	-	-

Price of sugarcane: Rs. 360/- per quintal during 2021; * includes tricho-card cost

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

Large scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *C. infuscatellus* were carried out over an area of 839 acres in collaboration with KVKs and Regional Station (Gurdaspur) in Hoshiarpur, Jalandhar, Gurdaspur, Patiala, Kapurthala and Muktsar districts. The parasitoid, *T. chilonis* was released 8 times at 10 days interval from mid-April to end-June @ 50,000 per ha and was compared with chemical control, i.e.chlorantraniliprole (Coragen 18.5 SC) @ 375 ml/ha applied 45 days after planting and untreated control. The incidence of early shoot borer in released fields (2.52 %) and chemical control (0.96%) was significantly better than untreated control (5.60 %). The reduction in incidence over control was 55.0 and 81.79 per cent in released fields and chemical control, respectively (Table 151). The yield in control (682.0 q/ha) was significantly lower than released fields (738.2 q/ha) and chemical control (861.8 q/ha). It can be concluded that eight releases of *T. chilonis* at 10 days interval during mid-April to mid-June @ 50,000 per ha were better than untreated control, however, these were inferior to chemical control against early shoot borer. However, the cost: benefit ratio (1: 19.23) was high in biocontrol as compared to chemical control (1: 10.51) (Table 152).

Table 151. Large scale demonstrations using *T. chilonis* against *C. infuscatellus* in sugarcane during 2021

Treatments	Incidence (%)	Reduction over control (%)	Yield (q/ha)
Biocontrol*	2.52[b]	55.0	738.2[b]

Chlorantraniliprole 18.5 SC @ 375 ml/ ha	1.02[a]	81.79	861.8[a]
Untreated control	5.60[c]	-	682.0[c]

*8 releases of *T. chilonis* @ 50,000 per ha at 10 days interval during Mid-April to end-June

Table 152. Cost Benefit analysis (2021)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
Biocontrol	738.2	56.2	20232.0	1000.0	19232.0	1:19.23
Chlorantraniliprole 18.5 SC @ 375 ml/ ha	861.8	179.8	64728.0	5625.0	59103.0	1: 10.51
Control	682.0	-	-	-	-	-

Price of sugarcane: Rs. 360/- per quintal during 2021; * includes trichocard/insecticide + labour cost; Price of Coragen (chlorantraniliprole 18.5 SC) @ Rs. 1850/- per 150 ml

Large scale demonstrations of proven biocontrol technologies against sugarcane top borer, *Scirpophaga excerptalis*

Large-scale demonstrations on the effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 460 acres in collaboration with KVKs in Hoshiarpur, Jalandhar, Patiala, Kapurthala and Muktsar districts. The parasitoid, *T. japonicum* was released 8 times at 10 days interval from mid-April to end-June @ 50,000 per ha and was compared with chemical control, i.e.chlorantraniliprole (Ferterra 0.4 GR @ 25 kg/ha applied during last week of June). The incidence of top borer in release and chemical control fields was 2.78 and 1.12 per cent, respectively. However, both the treatments were significantly better than untreated control (5.84 %). The reduction in incidence over control was 52.40 and 80.82 per cent in released fields and chemical control, respectively (Table 153). The yield in control (678.0 q/ha) was significantly lower than release fields (731.0 q/ha) and chemical control (858.0 q/ha). It can be concluded that eight releases of *T. japonicum* at 10 days interval during mid-April to mid-June @ 50,000 per ha proved as effective for the management of top borer. The cost benefit ratio (Table 154) was high in biocontrol (1: 18.08) as against chemical control (1: 12.47).

Table 153. Large scale demonstrations using *T. japonicum* against *Scirpophaga excerptalis* during 2021

Treatments	Incidence (%)	Reduction over control (%)	Yield (q/ha
Biocontrol*	2.78[b]	52.40	731.0[b]
Chlorantraniliprole 0.4 GR @ 25 kg/ha	1.12[a]	80.82	858.6[a]
Control	5.84[c]	-	678.0[c]

*8 releases of *T. japonicum* @ 50,000 per ha at 10 days interval during Mid-April to end-June

Table 154. Cost Benefit analysis (2021)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
Biocontrol	13.0	53.0	19080.0	1000.0	18080.0	18.08
Chlorantraniliprole 0.4 GR @ 25 kg/ha	858.6	180.6	65016.0	4825.0	60191.0	12.47
Control	678.0	-	-	-	-	-

Price of sugarcane: Rs. 360/- per quintal during 2021; * include trichocard/insecticide + labour cost; Price of Fetrerra (chlorantraniliprole 0.4 GR) @ Rs 185/- per kg

MPKV, Pune

IV. 11. 4. Field efficacy of EPN strains against white grubs in sugarcane

This experiment was conducted from 2019-20 to 2021-22 and the conclusion with the recommendation is given at the end. The details are as given below.

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 was 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. Harvesting of sugarcane was completed on 21.10.2021.

Year 2021-22:

The experiment was laid out on the farmer's field at Sonkaswadi Tal. Baramati of Pune district. The planting of sugarcane variety Co. 86032 was done on 30.06.2021 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 8.9.2021 and 11.10.2021.

Treatments details:

The details of treatments are as follows:

T_1 - *H. indica* @ 1.0 x10^5/ 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 - Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L

T_6 - Control

Results

Year 2021-22:

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 155. It is seen that, pre count clump mortality due to white grub varied from 4.98 to 7.21/ 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 of two applications is pooled and mean clump mortality is worked out. Mean clump mortality ranged from 2.39 to 9.62 per cent. Lowest clump mortality (2.39 %) was recorded in T_5 – chemical control (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/l) treatment the next promising treatment found EPN strains *H. indica* @ 1.0x10^5/ m^2 (NBAIR WP formulation) and recording 4.13 per cent clump mortality as against untreated control recorded (9.62%). Amongst EPN, the promising treatment $T_{3\text{ -}}$ *S. carpocapsae* @ 1.0x10^5/ m^2 (NBAIR WP formulation) with followed by T_2 – *H. bacteriophora* @ 1.0x10^5/ m^2 (NBAIR WP formulation) with clump mortality of 4.18, 4.20 per cent, respectively.

White grub per cent reduction over control after two applications: Highest (75.14 %) white grub reduction was recorded in 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 (57.09 %), T_3 *S. carpocapsae* @ 1.0x10^5/ m^2 (56.57), T_2 - *H. bacteriophora* @ 1.0x10^5/ m^2 (56.34), and T_4- S. *abbasi* @ 1.0x10^5/ m^2 (31.50 %).

Pooled data of three years (2019-20 to 2021-22):

The three years pooled data (2019-20, 2020-21 and 2021-22) on efficacy of different EPN strains against white grubs in sugarcane (Table 156) revealed that the significant difference among treatments were recorded in clump mortality due to application of entomopathogens .

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 156, data on costs of spraying and economic of treatment are given in Table 157. It is seen from Table 156 that, pre countclump mortality due to white grub was ranged from 4.22 to 5.59 per cent. The post count observations at 30 and 60 days after first and second applications recorded significant differences amongst all the treatments.The treatment Fipronil 40% + imidacloprid 40 WG @ 0.4 g/l was found significantly superior over rest of the treatment with 6.22 per cent clump mortality. The treatment *Heterorhabditis indica* @ 1 x 10^5 (NBAIR WP formulation) @ 12.50 kg/ha was second superior treatment in clump mortality due to white grub (8.03%) and was at par with the treatment *Heterorhabdis bacteriophora* @ 1 x 10^5 (NBAIR WP formulation with 9.04 per cent clump mortality. Highest clump mortality (19.67%) was recorded in untreated control.

White grub per cent reduction over control after two applications: Highest white grub reduction (68.38%) was recorded in chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/L). The next best treatments are *H. indica* @ 1.0x10^5/ m^2 (59.18 %), *H. bacteriophora* @ 1.0x10^5/ m^2, *S. carpocapsae* @ 1.0x10^5/ m^2, and *S. abbasi* @ 1.0x10^5/ m^2 (54.04, 49.56 and 45.55 %), respectively.

Cane Yield (Mt/ha): The cane yield was ranged from 104.28 to 145.65 MT/ha. The highest cane yield of 145.65 MT/ha was recorded in chemical check Fipronil 40% + imidacloprid 40 WG @ 0.4 g/lthe next best treatment was *H. indica* @ 1.0x10^5/ m^2 was at par with all the EPN treatments recording yield of 131.55 Mt/ha followed by *H. bacteriophora* @ 1.0x10^5/ m^2) with 126.72 Mt/ha, *S. abbasi* @ 1.0x10^5/ m^2 with 125.70 Mt/ha and *S. carpocapsae* @ 1.0x10^5/ m^2 with 124.48 Mt/ha.

Benefit Cost ratio: The B: C ratio was ranged from 1.41 to 1.88. The Highest B: C ratio 1.88 was recorded in chemical treatment T_5 (Fipronil 40% + imidacloprid 40 WG @ 0.4 g/L) as against 1.44 in untreated control. Chronologically, T_1 - *H. indica* @ 1.0x10^5/ m^2recorded B: C ratio 1.61.

Recommendation: It is recommended to apply *Heterorhabditis indica* @ 1 x 10^5 (NBAIR WP formulation) @12.50 kg/ha twice in two months interval for control of sugarcane whitegrub.

Table 155. Efficacy of entomopathogenic nematodes against white grub in sugarcane 2021-22

Tr. No.	Treatment Details	Dose (kg or l/ ha)	Clump Mortality (%)						Clump Mortali-tyafter two applica-tions (%)
			Pre-count	Days after application				Mean	
				First application		Second application			
				30	60	30	60		
T1	*Heterorhabditis indica* @ 1 x 10^5 (NBAIR WP formulation)	12.50	5.87 (14.02))	5.50 (13.56)	4.59 (12.37)	3.12 (10.17)	3.02 (10.01)	4.13 (11.72))	57.06
T2	*H.bacteriophora* @ 1 x 10^5 (NBAIR WP formulation)	12.50	6.24 (14.47)	6.12 (14.32)	4.41 (12.12)	2.96 (9.91)	2.90 (9.80)	4.20 (11.83)	56.34
T3	*Sercospora carpocapsae*@ 1 x 10^5 (NBAIR WP formulation)	12.50	4.98 (12.89)	5.12 (13.08)	5.00 (12.92)	3.78 (11.21)	3.50 (10.78)	4.18 (11.79)	56.54
T4	*S. abbasi* @ 1 x 10^5 (NBAIR WP formulation)	12.50	7.21 (15.58)	6.34 (14.58)	7.11 (15.46)	6.80 (15.12)	6.11 (14.31)	6.59 (14.87)	31.49
T5	Fipronil 40% + Imidacloprid 40 WG	500 ml	5.55 (13.63)	4.97 (12.88)	2.10 (8.33)	1.56 (7.18)	0.93 (5.53)	2.39 (8.89)	75.15
T6	Control		6.79 (15.10)	6.85 (15.17)	9.78 (18.22)	11.27 (19.62)	10.57 (18.97)	9.62 (18.07)	
	SE		1.29	0.84	0.99	1.08	0.47	0.39	
	CD (P = 0.05)		N. S.	N.S.	2.98	3.26	1.41	1.17	
	CV (%)		18.34	12.05	15.10	17.95	8.09	6.03	

*Figures in parenthesis are arc sin transformed values.

Table 156. Efficacy of entomopathogenic nematodes against whitegrub in sugarcane (Three years pooled data 2019-22 to 2021-22)

Tr. No.	Treatment Details	Dose (kg or l/ha)	Clump Mortality (%)						Clump Mortality over control (%)	Cane Yield MT/ ha.	B:C Ratio
			Pre-count	Days after application				Mean			
				First application		Second application					
T1	*Heterorhabditis indica* @ 1 x 10^5 (NBAIR WP formulation)	12.50	4.85 (12.73)	5.37 (13.40)	7.58 (15.98)	8.05 (16.48)	11.10 (19.46)	8.03 (16.46)	59.18	131.55	1.71
T2	*H.bacteriophora* @ 1 x 10^5 (NBAIR WP formulation)	12.50	4.44 (12.16)	5.67 (13.78)	8.50 (16.95)	9.28 (17.73)	12.72 (20.90)	9.04 (17.50)	54.04	126.72	1.65

T3	*Sercospora carpocapsae*@ 1 x 10^5 (NBAIR WP formulation)	12.50	4.22 (11.85)	6.45 (14.72)	8.54 (16.99)	10.45 (18.86)	14.24 (22.17)	9.92 (18.36)	49.56	124.84	1.62
T4	*S. abbasi* @ 1 x 10^5 (NBAIR WP formulation)	12.50	5.36 (13.39)	6.59 (14.88)	9.78 (18.22)	11.52 (19.84)	14.96 (22.76)	10.71 (19.11)	45.55	125.70	1.63
T5	Fipronil 40% + Imidacloprid 40 WG	0.500	5.22 (13.21)	5.03 (12.96)	5.41 (13.45)	5.92 (14.09)	8.50 (16.95)	6.22 (14.44)	68.38	145.65	1.88
T6	Control		5.59 (13.68)	10.28 (18.70)	16.27 (23.79)	21.27 (27.46)	30.85 (33.74)	19.67 (26.33)	-	104.28	1.44
	SE		0.51	0.32	0.57	0.77	0.78	0.42		3.78	
	CD (P = 0.05)		N.S.	0.97	1.71	2.33	2.34	1.27		11.40	
	CV (%)		7.95	4.38	6.49	8.13	6.85	4.51		5.98	

*Figures in parenthesis are arc sign transformed values.

Table 157. Cost and Economics of Efficacy of entomopathogenic nematodes against white grub in sugarcane (Pooled of Two years):

Treatment	Cost EPN & insecticide	Qty	Qty. used	Cost	Labour charges	Total cost	Cost of Cultivation	Cost of application	Total cost	Yield Ton/ha	Rate	Gross returns	Net return	B: C ratio
	Per Ha													
	Kg or l	kg or l	2 appl	Rs.	Rs.	Rs.	Rs	Rs	Rs	(t/ha)	Rs/t.	Rs.	Rs.	
T_1: *H. indica* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	400	12.50	25	10000	2000	12000	203000	12000	215000	131.55	2800	368340	153340	1.71
T_2: *H. bacteriophora* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	400	12.50	25	10000	2000	12000	203000	12000	215000	126.72	2800	354818	139818	1.65
T_3: *S. carpocapsae* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	400	12.50	25	10000	2000	12000	203000	12000	215000	124.48	2800	348544	133544	1.62
T_4: *S. abbasi* @ 1.0x10^5/ m^2 (NBAIR WP formulation)	400	12.50	25	10000	2000	12000	203000	12000	215000	125.70	2800	351960	136960	1.63
T_5: Fipronil 40% + imidacloprid 40 WG @ 0.4/L)	12000	0.500	1.00	12000	2000	14000	203000	14000	217000	145.65	2800	407820	190820	1.88
T_6: Untreated control							203000	-	203000	104.28	2800	291984	88984	1.44

MPKV

IV. 11. 5. Pune Field efficacy of dose application of EPN against white grubs in sugarcane

The experiment was laid out on the farmers' field at Sonkaswadi village of Baramati Tahasil of Pune district. The planting of sugarcane variety CoM. 265 was done on 30.06.2021, 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 8.9.2021 and 10.10.2021.

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: Fipronil 40% + imidacloprid 40 WG @ 0.4 g/liter of water

T8: Control

Clump Mortality/15 clumps in plot due to white Grub: The data on efficacy of different EPN strains against white grubs in sugarcane observed that clump mortality was in the range of 6.60 to.9.89 per cent before application of entomopathogenic nematodes and it was statistically non-significant. While, it was statically significant at 30 and 60 days after first and second applications.The pooled data regarding clump mortality due to white grub was found statistically significant and the treatment T_5 (Fipronil 40% + imidacloprid 40 WG @ 0.500g/ha) was found significantly superior over rest of the treatment with 0.93 per cent clump mortality. The treatment T_3 *Heterorhabditis indica* @ 3 x 10^5 (NBAIR WP formulation) @ 12.50 kg/ha was second superior treatment in clump mortality due to white grub (3.11%) and was at par with the treatment T_6 *Heterorhabditis bacteriophora* @ 3 x 10^5 (commercial formulation) and *H. indica* @2 x 10^5 (NBAIR WP formulation) @ 12.50 kg/ha with 3.28 and 3.29 per cent clump mortality, respectively. Highest mean clump mortality (11.31%) was recorded in (Untreated control)

Table 158. Efficacy of doses of entomopathogenic nematodes against white grubs on sugarcane (2021-22)

Tr. No.	Treatment Details	Dose (kg or l/ha	Clump Mortality (%)					Reduction over control Clump %
			Pre-count	Days after treatment			Mean	
				30 DAA	60 DAA	90 DAA		
T1	*H. indica* @ 1.0 x10^5/ m^2 (NBAIR WP formulation)	12.50	8.72 (17.00)	8.47 (16.90)	2.89 (9.56)	2.11 (8.34)	4.49 (12.21)	60.30
T2	*H. indica* @ 2.0 x 10^5/ m^2 (NBAIR WP formulation)	12.50	8.81 (17.15)	7.33 (15.55)	1.50 (7.03)	1.03 (5.82)	3.29 (10.39)	70.91
T3	*H. indica* @ 3.0 x10^5/ m^2 (NBAIR WP formulation)	12.50	9.89 (18.26)	6.88 (15.21)	1.48 (6.98)	0.98 (5.66)	3.11 (10.16)	72.50
T4	*H. indica* @ 1.0 x10^5/ m^2 (Commercial WP formulation)	12.50	7.68 (15.69)	8.93 (17.27)	3.60 (10.89)	2.95 (9.87)	5.16 (13.12)	54.37

T5	*H. indica* @ 2.0. x10^5/ m^2 (Commercial WP formulation)	12.50	9.76 (18.15)	7.59 (15.71)	1.51 (7.05)	1.08 (5.94)	3.39 (10.52)	70.00
T6	*H. indica* @ 3.0 x10^5/ m^2 (Commercial WP formulation)	12.50	8.63 (17.01)	7.11 (15.26)	1.60 (7.24)	1.11 (6.03)	3.28 (10.38)	70.99
T7	Fipronil 40% + imidacloprid 40 WG	0.400	6.60 (14.49)	1.89 (7.82)	0.49 (3.29)	0.41 (3.56)	0.93 (5.51)	91.77
T8	Untreated Control		8.04 (16.27)	9.78 (18.20)	10.30 (18.71)	13.86 (21.77)	11.31 (19.64)	-
	SE ±		1.82	1.44	0.88	0.68	0.65	
	CD (P = 0.05)		N. S.	4.37	2.66	2.07	1.97	
	CV (%)		18.86	16.37	17.20	14.09	9.77	

*Figures in parenthesis are arc sin transformed values.

MPKV, Pune

IV. 11. 6. Large scale demonstration of *Trichogramma chilonis* species against sugarcane borer (MPKV, Pune, UAS, Raichur)

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-seasonal 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 was 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 was conducted. During 2021-22, the release of *T. chilonis* was done in March, 2021 in the in farmers' field at Fursungi and Ohalwadi Tal: Haveli Dist. Pune district.

The plots with variety Co-265 planted in November 2021 and 20 sugarcane growers were selected for this demonstration. The trichocards were released for six times at 10 days interval. The shoot infestation was recorded before and after imposing treatements.Nucleus culture of the parasitoid *T. chilonis* (Temperature tolerant strain-TTS) was obtained from the ICAR-NBAIR, Bangalore and mass cultured in the Biocontrol laboratory at AC, Pune.

The treatments comprised six releases of *T. chilonis* @ 50,000 adults/ha at 10 days interval, farmers' practice of three sprays of chlorpyriphos 0.05% and untreated control. A control plot maintained at 200 m distance from parasitoid released plot. Each treatment plot was divided into 10 subplots as replicates. Releasing of parasitoids was started from 26.3.2021. The pre-release observations on infestation of ESB (% dead hearts) and number of tillers per clump were recorded at 10 spots in each subplot. Similarly, post counts of dead hearts and number of tillers at each spot were recorded at 15 days interval from initiation of parasitoids' release up to 4 months old crop.

The results of shoot borer infestation given in Table 159 indicated that six releases of *T. chilonis* TTS @ 50,000 parasitoids/ha at 10 days interval starting from 40 days after emergence of shoots found significantly superior to untreated control in reducing the ESB infestation (from 15.90 to 8.01 % dead hearts) and cane yield (144.37 MT/ha).

Table 159. Efficacy of *Trichogramma chilonis* TTS against ESB on sugarcane

Treat. No.	Treatment Details	Dead Hearts (%)		Yield (MT/ha)
		Pre-count	Post count	
T1:	Eight releases of *Trichogramma chilonis* TTS at weekly interval	15.90 *(23.46)	8.01 (16.37)	144.37
T2:	Fipronil 40% + imidacloprid 40 WG	16.40 (23.86)	9.90 (18.31)	139.12
T3:	Untreated Control	16.48 (23.91)	28.28 (32.10)	123.33
	SE ±	0.77	0.48	1.49
	CD (P = 0.05)	NS	1.54	4.76
	CV (%)	5.64	5.32	2.70

UAS, Raichur

Before treatment imposition dead hearts ranged from 17.25 to 19.50 per cent. Two months after treatment imposition minimum of 1.51 per cent dead hearts were noticed in farmers practice which was followed by release of *T. chilonis* (TTS) recorded 2.75 per cent while untreated control recorded 12.50 per cent dead hearts. The highest cane yield of 121.75 t/ha was recorded in farmers practice and it was followed by *T. chilonis* (TTS) release plot 118.50 t/ha while untreated control recorded 105.50 t/ha (Table 160).

Table 160. Large Scale demonstration of *Trichogramma chilonis* (TTS) against sugarcane early shoot borer during 2021-22

Sl. No.	Particulars	Dead hearts (%)* Before release	Dead hearts (%)* After final release	Cane yield (t/ha)
T_1	Releases of *T. chilonis* (TTS)	19.50 (26.21)	2.75 (9.55)	118.50
T_2	Farmer's practice	17.25 (24.54)	1.51 (7.04)	121.75
T_3	Untreated control	18.50 (25.48)	12.50 (20.72)	105.50
S Em ±		0.28	0.38	0.79
CD (P = 0.05)		NS	1.14	2.37

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

IV. 11. 7. Large scale demonstration of *Trichogramma* spp. against sugarcane borers

Area covered: 5 ha of sugarcane

Variety : (SABITA)

Location: Jharapada, Aonlamada & Ranipada of Nayagarh District.

No. of beneficiaries: 12

T1: BIPM package

T2: Farmers practice (spraying of insecticides like chlorantraniliprole 18.5SC or Fipronil 5%SC or Chlorpyriphos 50% + cypermethrin 5% basing on appearance of DH%.

T3: Untreated control

Replications: 8

The crop was sown in last week of February to 1st week of March 2021. 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 10.86% and 2.04% as against 11.20% and 2.10% in FP indicating comparable level of infestation. But, much higher levels of infestation due to ESB (11.08%) and TSB (2.20%) were recorded in untreated control in pre release condition. Both the BIPM package and FP were at par in Post release observations. Highest cane yield (78.94 t/ha) and B: C ratio (1.68) were recorded in BIPM package which is comparable to FP (73.80 t/ha) with B: C ratio (1.61). Lowest yield (58.22 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	10.86	5.95 (2.44)	2.04	0.77 (0.87)	78.94	1.68
Farmer's practice (Pesticide application)	11.20	5.10 (2.26)	2.10	0.70 (0.84)	73.80	1.61
Untreated control	11.08	14.50 (3.80)	2.20	3.38 (1.83)	58.22	1.38
S.E. (m) ±	-	0.27	-	0.12	1.75	
C.D (P = 0.05)	NS	0.80	NS	0.36	5.31	

Figures in the parentheses are square root transformation values

OIL SEEDS

IV. 12. Ground nut

UAS, Raichur

IV. 12. 1. Evaluation of locally isolated potential entomopathogenic fungi, *Metarhizium rileyi (KK-Nr-1)* against groundnut leaf miner and tobacco caterpillar in ground nut ecosystem during 2021-22

One day before spray leafminer population ranged from 13.24 to 14.84 active mines per 20 leaflets and it was statistically non-significant. 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 69.57 per cent and it was at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) which recorded 68.64 per cent. Defoliator, *Spodoptera* population ranged from 4.18 to 4.84 per meter row length among the treatments at one day before treatment imposition. The highest per cent reduction of defoliator was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) (67.45%) and at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) 63.75%). Among the biocontrol agents highest pod and halum yield of 24.68 q/ha and 33.52 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 22.54 q/ha and 30.84 q/ha pod and halum yield (Table 162).

Table 162. Evaluation of locally isolated potential entomopathogenic fungi, *Metarhizium rileyi (KK-Nr-1)* against groundnut leaf miner and tobacco caterpillar in ground nut ecosystem

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	14.50 (3.87)	5.38 (2.42)	3.76 (2.06)	69.57 (56.52)	4.84 (2.31)	1.58 (1.44)	1.18 (1.30)	67.45 (55.21)	24.68	33.52
T_2	*Metarhizium rileyi* (UAS- Dharwad)	1×10^8 @ 5gm/l	13.84 (3.79)	6.28 (2.60)	3.14 (1.91)	68.64 (55.95)	4.18 (2.16)	1.72 (1.48)	1.36 (1.41)	63.73 (52.34)	22.54	30.84
T_3	*Beauveria bassiana* (ICAR- NBAIR-Bb-5a)	1×10^8 @ 5gm/l	13.76 (3.78)	7.12 (2.76)	5.38 (2.42)	58.39 (49.83)	4.36 (2.20)	2.68 (1.78)	2.52 (1.74)	38.68 (38.46)	20.16	28.32
T_4	*Metarhizium anisopliae* (ICAR-NBAIR-Ma 4)	1×10^8 @ 5gm/l	14.84 (3.92)	7.24 (2.78)	5.84 (2.52)	56.46 (48.71)	4.24 (2.18)	2.54 (1.74)	2.28 (1.67)	43.16 (41.07)	20.58	28.64
T_5	Bt G4 2% (ICAR-NBAIR)	2.0 ml/lt	14.78 (3.91)	9.38 (3.14)	7.46 (2.82)	43.94 (41.52)	4.74 (2.29)	3.18 (1.92)	3.04 (1.88)	26.65 (31.08)	18.42	26.18
T_6	Emamectin benzoate 5 SG	0.2 g/lt	13.24 (3.71)	3.56 (2.01)	1.78 (1.51)	82.22 (65.06)	4.68 (2.28)	1.12 (1.27)	0.78 (1.13)	77.59 (61.75)	25.38	34.82
T_7	Untreated control	-	14.18 (3.83)	15.24 (3.97)	14.8 (3.91)	0.00 (0.00)	4.52 (2.24)	4.36 (2.20)	4.12 (2.15)	0.00 (0.00)	16.84	21.58
S Em ±			0.31	0.11	0.05	-	0.13	0.04	0.03	-	0.31	0.51
CD (P=0.05)			NS	0.34	0.16	-	NS	0.12	0.10	-	0.93	1.53

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

UBKV

IV. 12. 2. Field evaluation of bio-pesticides against mustard aphid.

Location: Instructional Farm, UBKV, Pundibari, Cooch Behar, West Bengal.

Agro-climatic zone: Terai zone of West Bengal.

Season: Rabi, 2021-22.Variety: B-9, Plot size: 5 × 4 m.Layout: RBD, Replication: Three.

Date of sowing: 09.12.2021

Treatment details:

T1-*Beauveria bassiana* NBAIR Bb-5a (1 × 10^8 spores/g) @ 5g/lit

T2-*Metarhizium anisopliae* NBAIR Ma-4 (1×10^8spores/g) @ 5 g /lit

T3- *Lecanicillium lecanii* NBAIR Vl-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:

Date of first spray: 18.02.2022

The present experiment revealed that the treatments were superior over control. Imidacloprid 17.8 SL @ 0.4 ml/lit was found to be the best treatment resulting the lowest number of aphids per shoot (2.17 aphid per at 15DAS). Among the selected bio-pesticides, azadirachtin 3000 ppm @ 2.5 ml/lit treated plots showed the lowest number of aphids per shoot followed by *B. bassiana*.

The highest yield was recorded from imidacloprid 17.8 SL treated plots (11.87 q/ha). Among the bio-pesticides tested, maximum yield was obtained from azadirachtin 3000 ppm treated plots (8.73 q/ha) and it was 39.27% increase over control. *Beauveria bassiana* was the second-best treatment after azadirachtin and it showed 25.56% increase in yield over control. *Metarhizium anisopliae* was the least effective treatment in terms of yield increase over control (10.29%).

Fruit crops

IV. 13. Banana

IV. 13. 1. Bio-efficacy of entomopathogens against Banana fruit and leaf scarring beetles, *Nodostoma subcostatum*

A field trial to assess the Banana bio-efficacy of entomopathogens against Banana fruit and leaf scarring beetles, *Nodostoma subcostatum* was laid out. 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 chlorpyrifos 20 EC were applied thrice at 15 days interval.

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) @ 10^8 spore) 5 ml /lit

T4: Bunch covering with plastic bags.

T5: Spray in chlorpyrifos 20 EC @ 2.5 ml/lit

T6: Untreated control

Table 163. Bioefficacy of entomopathogen against *Nodostoma subcostatum* (Beetles/plant)

Treatments	Pre-treat-ment count	Post treatment count *				Reduc-tion 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:Chlropyrifos 20EC @ 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 (P = 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 different DnMRT

Among the treatments, covering the bunches with the perforated plastic bag was 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 @ 2.5 ml /lit was effective over the neem and entomopathogens in suppressing the beetle population (8.63/plant) with 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 mean fruit damage.

Fig 54. Experimental plot of banana Cavendish (CV-Jahaji)

IV. 14. Papaya

AAU, Anand

IV. 14. 1. Monitoring and record of the incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts

A survey was conducted in randomly selected villages of Anand district to record the infestation of papaya mealybug, *Paracoccus marginatus*. The percentage of plants infested with mealybug was assessed by observing 25 randomly selected plants and the intensity of damage was determined. During the survey, trace incidence (<1%) of papaya mealybug was noticed in three orchards (Table 164). The parasitoid *Acerophagus papayae* was noticed parasitizing mealybug.

Table 164. 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	Atulbhai Ramjibhai Patel Sandeshar Ta- Anand Dist- Anand	-	-	-	-	0
4.	27.11.2020	Rasikbhai Mangalbhai Talpada Bhavanipura Ta- Petlad Dist- Anand	-	-	Deltamethrin	-	0
5.	27.11.2020	Shaileshbhai Vaghjibhai Patel Dhundhakuva Ta- Borsad Dist- Anand	-	-	-	-	0
6.	27.11.2020	Gajendrabhai Bhikhabhai Patel Dhundhakuva Ta- Borsad Dist- Anand	Papaya	-	-	*A. papayae*	< 1% (Trace incidence)
7.	7.1.2021	Harshadbhai Gordhanbhai Patel Bhavanipura Ta- Petlad Dist- Anand	-	-	Azadirachtin 1500 ppm	-	0
8.	7.1.2021	Navgan Bharwad 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	-	-	-	-	-

IV. 15. Mango

AAU, Anand

IV. 15. 1. Large scale demonstration on bio-intensive management of mango hopper

A demonstration on bio-intensive pest management (BIPM) strategies for the management of mango hopper was laid out to create awareness and to train the farmers on BIPM strategies in mango for the management of mango hopper.

T_1	BIPM module	One spray of *Metarhizium anisopliae* NBAIR Ma-4 1% WP (2 × 10^8 CFU/ g) @ 50 g/ 10 litre of water on tree trunk during October Three sprays of *Metarhizium anisopliae* NBAIR Ma-4 1% WP (2 × 10^8 CFU/ 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	-

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 in the flowering period. The BIPM module comprising *Metarhizium anisopliae* was effective in reducing the hopper population. The BIPM module recorded significantly lowest mango hopper population of 3.43/panicle as compared to 7.13/panicle in farmers practice.

Table 165. 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. Sasan Gir	Ganghor, Dist. Navsari	Talala, Dist. Sasan Gir
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 $t_{0.0.5}$

At Talala, Dist. Sasan Gir 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 lowest mango hopper population (2.94/panicle) than farmers' practice (4.67/panicle).

DRYSRHU, Ambajipeta

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

A mango orchard having about 50- 100 trees were selected for taking up the management studies for inflorescence thrips on mango with bio-pesticides in field conditions.

The 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 Gokavaram Mandal 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 166 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 of Thrips (0.80 thrips/tree). In the untreated control block, the maximum population of mango thrips ranged from 4.26 to 15.25.

Table 166. Field evaluation of biopesticide formulations against mango thrips

S. No.	Treatments	Dosage	The average number of thrips / 10 inflorescences / 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 Strain VL15)	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 (P = 0.05)	-	-	0.29	0.23	0.17

*Fig in parenthesis are $\sqrt{x+0.5}$ transformed values.

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

CISH, Lucknow

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 in mango. The treatment schedule was

Treatments : T1: Mango intercropped with maize
T2: Mango intercropped with mustard
T3: Mango intercropped with coriander
T4: Mango as sole.

None of the treatments had an impact on suppressing insect pests. 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 intercrops *viz*., maize, mustard and coriander (Table 167). Thus, enrichment of pollinators and natural enemies rendered prospective ecosystem services in the mango orchard in present experimentation.

Table 167. Habitat manipulation for conservation of bio-agents for management of mango insect pests

Treatments	Occurrence of pollinators, natural enemies and insect pests		
	Pollinators	Natural Enemies	Insect Pests
Mango inter-cropped with maize	Bumble bees, **Chrysopid, *Megachile spp., ** Apis mellifera	**Coccinellids, Syrphids, Spiders, *Praying Mantis, Ants Telenomus spp, Trichogramma spp, *Cotesia sp	Stem borer, Armyworm Chafer beetle, Grasshopper, Ear-wigs, Leaf cutter bee (Megachile anthracina)
Mango inter-cropped with Mustard	***Honey bees (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 brassicae, Bagrada cruciferarum
Mango inter-cropped with Coriander	Apis florea, **Apis mellifera, Trigona sp, Musca domestica Episyrphus balteatus	**Menochilus sexmaculatus, Camponotus sp., Unknown sp, **Chrysoperla zastrowi sillemi	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

CISH-Lucknow

IV. 15. 2. Field evaluation of microbial biocontrol agents for the management of mango thrips

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

A field trial was taken up to assess the of microbial biocontrol agents for the management of mango thrips.

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 168). 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 168. Field evaluation of microbial biocontrol agents for the management of mango thrips

Treatments	No. of thrips / panicle			
	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)	12.7^{c} (4.07)	12.80^{c} (4.08)
LSD (P = 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.

Bioefficacy of entomopathogenic fungi formulations in suppression of mango tortricid borers (CISH-Lucknow).

A field trial was taken up to assess the bioefficacy of entomopathogenic fungi formulations in suppression of mango tortricid borers with the following treatments.

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

Bioefficacy of entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* formulations were tested against mango fruit borer. A significant difference was found between the treatments on 7, 14 and 21 days after the spray. All the entomopathogenic fungi reduced the fruit borer incidence table 169. On bioefficacy of *B.bassiana* 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 169. 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/lit	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 $\sqrt{x+0.5}$; same letters in the column are not significantly different in Tukey's test.

IV. 16. Guava

SKUAST, Jammu

IV. 16. 1. Biological control of guava mealybug using entomopathogens

Treatment details

A field trial to assess the efficacy of entomopathogens on guava mealybug as taken up.

The treatment schedule includes

T1	*Beauveria 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

Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, along with Azadirachtin 10000 ppm were assessed against Guava mealybug. The highest per cent 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.

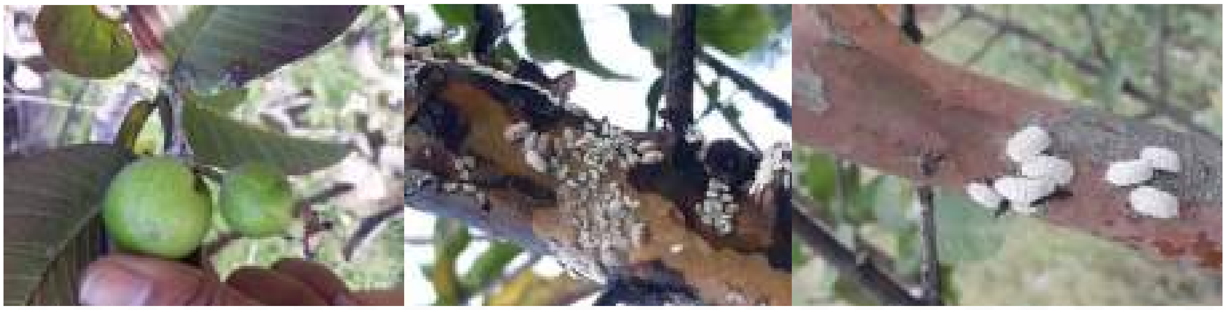


Fig 55. Guava mealy bug

Table 170. Percent reduction in Mealybug nymphs and adults

Treatments	Pre-spray count	Post spray count (mean no. / leaf)		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 (P = 0.05)	N.S.	3.48	3.10	(1.99)	0.174

Figures in parenthesis are arc-sine transformed values

DAS – Days After Spray

CISH, Lucknow

IV. 16. 2. Development of biocontrol based IPM module for the management of guava fruit borer.

A study was taken up to assess the biocontrol based IPM module for the management of guava fruit borer on Allahabad safeda with the following 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-5 g/Lit

T4: Neem oil @ 3ml/Lit

T5: Dimethoate 30% EC 2 ml/Lit (CISH POP)

T6: Untreated control

The experiment was initiated during 2020-21 in institute campus Block II. Three fungal bioagents, an 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 par in reducing the infestation. Chemical pesticide dimethoate caused the highest reduction in fruit damage (Table 171).

Table 171. Bio-efficacy of bioagents for the development of IPM module for guava fruit borer

Treatments	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) @1x108 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/Lit	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 (P = 0.05)	NS	5.209	5.293

UAHS, Shivamogga

IV. 16. 3. Biological control of root-knot nematode in guava

The efficacy of biocontrol agents against root-knot Nematodewas recorded. The bioagents such as *Purpureocillium lilacinum, 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 guava plants at three months interval, the nematode populations and per cent reduction in nematode populations were recorded.

Treatment details

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)

Table 172. 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*	Reduction (%)
T_1: *Purpureocillium lilacinum* (UAHS-15) @ 1 x 10^8 Cfu/ 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 10^8 cfu/ 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 10^8 cfu/ 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 (P = 0.05)	31.46	25.91	29.43	0.35

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 10^8 cfu/ 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 10^8 cfu/ 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.

Evaluation of entompthogenic fungi, *Beauveria bassiana* (ICAR-NBAIR- Bb-5a) against mealy bug in guava ecosystem

UAS, Raichur

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 lecanii* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-8) @ 5.0 g/L
T_3	*Lecanicillium lecanii* @ 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/L
T_7	Buprofeizn 25 SC @ 1 ml/L
T_8	Untreated control

Date of spray : 13-12-2020, 21-12-2020 and 03-01-2021

A field trial was laid to assess the efficacy of entomopathogens against the guava mealy bugs. The infestation of mealy bugs on 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.

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 173).

Table 173. 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 / 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 lecanii* (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 lecanii* (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/L	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/L	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

IV. 17. Apple

Dr YS PUHF, Solan

IV. 17. 1. Management of apple root borer using *Metarhizium anisopliae*

A large scale demonstration on the management of apple root borer, *Dorysthenes hugelii* by using *Metarhizium anisopliae* was laid in apple (cv Royal Delicious) in 13 orchards in Shimla, Sirmaur and Kinnaur districts covering an area of 5ha (Table 174). *Metarhizium anisopliae* (10^8 conidia/g) was applied @ 30 g/ 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 174. 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.

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; 10 ml/gallery), *Steinernemma feltiae*, *Heterorhabditis bacteriophora* (each at 2500 and 5000 IJs/gallery) and azadirachtin (2 ml/L of 1500 ppm; 10 ml/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, 10 ml 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 175) 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* (5000 IJs/gallery) was the most effective resulting in 80 per cent mortality followed by *Steinernemma feltiae* (5000 IJs/gallery) and azadirachtin (2 ml/L of 1500 ppm; 10 ml/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 175. Evaluation of biocontrol agents against leopard moth, *Zeuzera multistrigata* in apple

SN	Treatment	Mortality (%)
1	*Beauveria bassiana* (5 g/L of 10^8 conidia/g; 10 ml/gallery)	33.3 (32.1)
2	*Metarhizium anisopliae* (5 g/L of 10^8 conidia/g; 10 ml/gallery	40 (36.1)
3	*Steinernemma feltiae* (2500 IJs/gallery)	50 (45.0)
4	*Steinernemma feltiae* (5000 IJs/gallery)	66.7 (57.8)
5	*Heterorhabditis bacteriophora* (2500 IJs/gallery)	50 (45.0)
6	*Heterorhabditis bacteriophora* (5000 IJs/gallery)	80 (71.9)
7	Azadirachtin (2 ml/L of 1500 ppm; 10 ml/gallery)	66.7 (57.7)
8	Chlorpyriphos (0.04%; 10 ml/gallery)	100 (90.0)
9	Control (water, 10 ml/Gallery)	0.0 (0.0)
	CD (P = 0.05)	(15.9)

Figures in parentheses are arc sine transformed values

SKUAST, Srinagar

IV. 17. 2. Field evaluation of some bio pesticides against green apple aphid, *Aphis pomi* and mites infesting apple in Kashmir

Bioefficacy of commercial azadirachtin and commercial entomo pathogenic fungus *Lecanicillium lecanii* along with University recommended chemicals were evaluated 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}/L of water and fenazaquin 10 EC @ 0.4ml^{-1}/L 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}/L followed by *Lecanicillium lecanii* (1x10^8 cfu/ml) @ 5.0 ml^{-1}/L and was superior to all the bio pesticides used. 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 tend 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 control was found to be highest in the order of dimethoate 30 EC > T5 > T3 > T2 > T1 (Table 176).

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}/L recorded the lowest cumulative population (4.41) whereas three sprays of Nimbecidine 300 ppm@ 5.0 ml^{-1}/L showed an average of 10.94 mites 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 pre treatment (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 a 80.12 per cent reduction in mite over control (Table 177).

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}/L and maximum in plants treated with Nimbecidine 300 ppm @ 5.0 ml^{-1}/L. Treatments T3 and T5 resulted in containing the population up to 5.25 and 5.92, respectively 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 178). 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}/L (72.79), T5 (69.34), T2 (60.48) and T1 (58.31).

Table 176. 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			
T1 - Nimbicidine 300ppm @ 5.0 ml^{-1}/L	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}
T2 - Azadirachtin 1500 ppm @ 5.0 ml^{-1}/L	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}
T3 - Azadirachtin 10000 ppm @ 2.0 ml^{-1}/L	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}
T4 - *L. lecanii* (1x10^{8} CFU/ml) @ 5ml^{-1}/L	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}
T6 - Dimethoate 30 EC @ 1.0 ml^{-1}/L	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}
T7 - Untreated control	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 √n; similar superscripts in a column indicate values statistically on par

Table 177. 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			
T1 - Nimbi-cidine 300ppm @ 5.0 ml^{-1}/L	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}
T2 - Azadirach-tin 1500 ppm @ 5.0 ml^{-1}/L	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}
T3 - Aza-dirachtin 10000 ppm @ 2.0 ml^{-1}/L	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}

T4 - *L. lecanii* ($1x10^{8}$ CFU/ml) @ 5ml/L	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]
T6 - Fenazaquin 10 EC @ 0.4ml^{-1}	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]
T7 - Untreated control	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 (P = 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 arc sin transformation are √n; similar superscripts in a column indicate values are statistically on par

Table 178. 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			
T1 - Nimbicidine 300ppm @ 5.0 ml^{-1}/L	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]
T2 - Azadirachtin 1500 ppm @ 5.0 ml^{-1}/L	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]
T3 - Azadirachtin 10000 ppm @ 2.0 ml^{-1}/L	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]
T4 - *L. lecanii* ($1x10^{8}$ CFU/ml) @ 5ml^{-1}/L	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]
T6 - Fenazaquin 10 EC @ 0.4ml^{-1}/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]
T7 - Untreated control	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 (P = 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

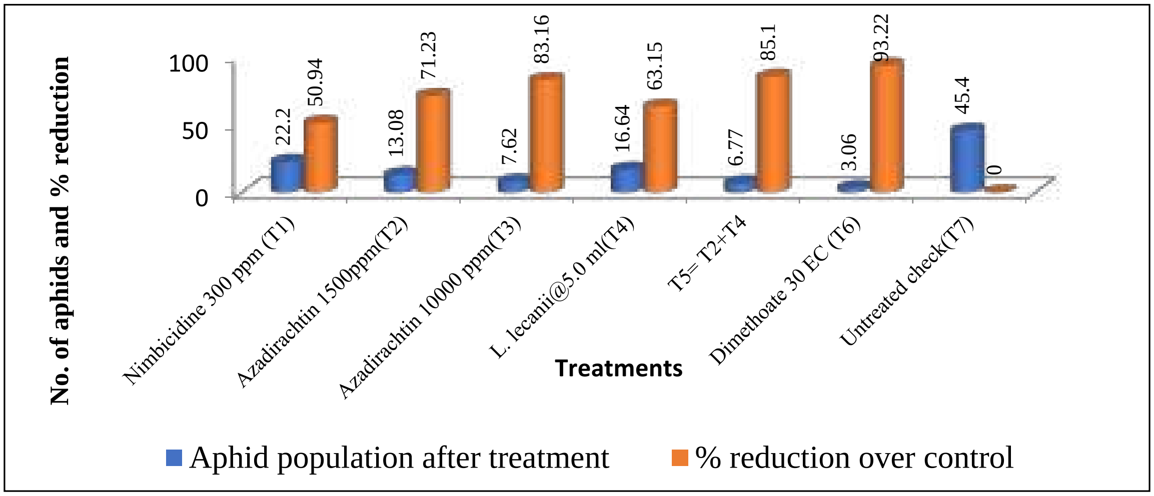


Fig 56. Effect of treaments on Population of Green apple aphid, *Aphis pomi* and % reduction over control on apple during 2020

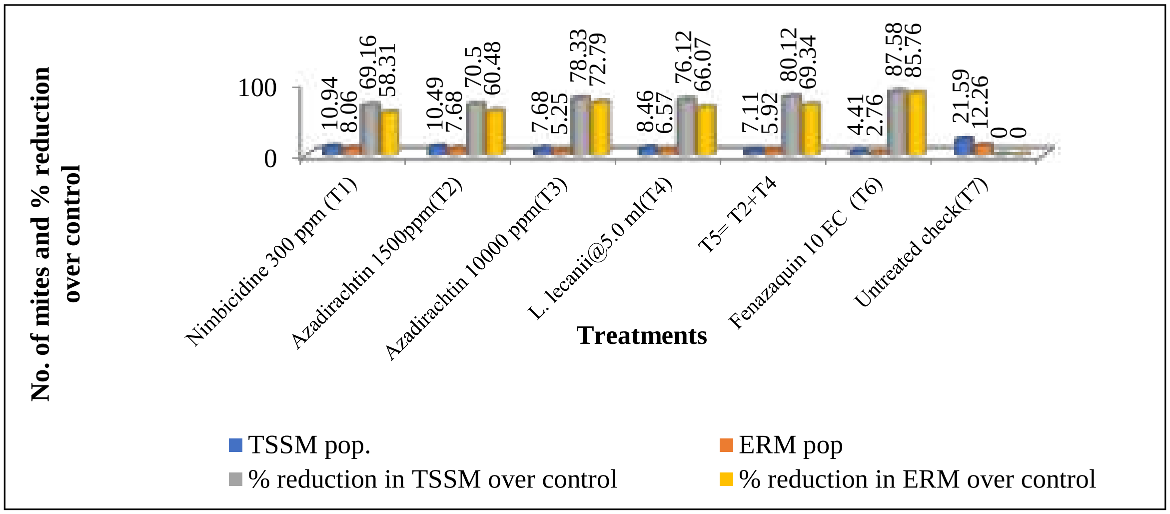


Fig 57. Effect of treatments on mean population and % reduction over control in two spotted spider mite, *Tetranychus urticae* and European red mite, *Panonychus ulmi* on apple during 2020

Organic management of woolly apple aphid, *Eriosoma lanigerum* infesting apple in high density and traditional orchards

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, promted to take up a study on organic management of the pest.

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 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 and observations were made after three days of the treatment. In field, 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 179) and 40.66 to 70.33 in field conditions (Table 180). 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: 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 by *Metarhizium anisopliae* @ 10.0 ml^{-1}/L (94.69) and *Lecanicillium lecanii* @ 10.0 ml^{-1}/L (88.62). The entomofungi at recommended dose i.e. 5.0 ml^{-1}/L of water however exhibited 56.66 and 46.67per cent reduction. Among botanicals, azadirachtin 10000 ppm @ 2.0 ml^{-1}/L of water showed the highest (80.06) per cent reduction. A similar pattern was obtained for per cent reduction over control (Table 179). Although azadirachtin was found a potential repellent aphids were found to recolonize after 6-7 days.

Field observation : In field condition, chlorpyriphos 50 %+ cypermethrin 5% EC @ 1.25 ml^{-1}/L of water caused maximum reduction in aphid density (96.32) followed closely by *M. anisopliae* @ 10.0 ml^{-1}/L of water (94.75) and azadirachtin 10000 ppm @ 2.0 ml^{-1}/L (85.19) in terms of per cent reduction over control. Bio efficacy of *M. anisopliae* was found statistically on par with chlorpyriphos 50% + cypermethrin 5% EC. *L. lecanii* @ 10.0 ml^{-1}also caused 67.30 per cent reduction. However at recommended dose (5.0 ml^{-1} of water) per cent reduction in aphid density was 58.83 and 53.82 for *L. lecanii* and *M. anisopliae* respectively (Table 180) (Figs 56 & 59). Per cent reduction in aphid density in response to treatments was 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).

Table 179. Laboratory evaluation of Biopesticides against woolly apple aphid, *Eriosoma lanigerum* infesting apple in Kashmir, during 2020-21

Biopesticides	Dose-/L of water	Pre treatment count/ colony	Post-treatment count/ colony	reduction over Treat-ment (%)	Reduction over Control (%)
T1 - *L. lecanii*(1x10^8 CFU/ml)	5.0 ml/L	47.00 (6.83)^a	25.00 (4.98)^{cd}	46.67 (43.09)^b	60.05 (50.87)^b
T2 - *L. lecanii*(1x10^8 CFU/ml)	10.0 ml/L	45.33 (6.73)^a	5.00 (2.22)^{ab}	88.62 (70.39)^c	92.01 (73.67)^{bc}
T3 - Azadirachtin 300 ppm	5.0 ml/L	60.66 (7.78)^a	52.66 (7.25)^d	12.93 (20.79)^a	16.08 (22.32)^a
T4 - Azadirachtin 10000 ppm	1.0 ml/L	53.00 (7.28)^a	17.0 (4.12)^c	67.62 (55.33)^{bc}	72.93 (58.68)^b
T5 - Azadirachtin 10000 ppm	2.0 ml/L	48.00 (6.92)^a	9.33 (3.03)^b	80.06 (63.72)^c	85.19 (67.49)^{bc}
T6 - *M. anisopliae*(1x10^8 CFU/ml)	5.0 ml/L.	50.00 (7.07)^a	21.66 (4.64)^c	56.66 (48.84)^b	65.24 (53.98)^b
T7 - *M. anisopliae*(1x10^8 CFU/ml)	10.0 ml/L	62.66 (7.91)^a	3.33 (1.82)^a	94.69 (76.68)^{cd}	94.75 (76.77)^c
T8 - Chlorpyriphos 50 %+ Cypermethrin 5% EC	1.25 ml/L.	51.00 (7.14)^a	2.33 (1.48)^a	95.65 (78.06)^{cd}	96.32 (79.21)^c
T9 - Control	-	61.33 (7.83)^a	65.33 (8.07)^e	--	--
CD (P = 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 180. Field efficacy of Biopesticides against woolly apple aphid, *Eriosoma lanigerum* infesting apple in Kashmir, during 2020-21

Biopesticides	Dose /L of water	Pre-treat-ment count/ colony	Post-treat-ment count/ colony	Reduction over treat-ment (%)	Reduction over control (%)
T1 - *L. lecanii* (1x10[8] CFU/ml)	5.0 ml/L	40.66 (6.36)[a]	31.66 (5.62)[d]	21.84 (27.81)[b]	
T2 - *L. lecanii* (1x10[8]CFU/ml)	10.0 ml/L	48.00 (6.90)[a]	25.66 (5.03)[d]	46.91 (43.22)[c]	67.30 (55.59)[bc]
T3 - Azadirachtin 300 ppm	5.0 ml/L	56.00 (7.48)[a]	49.33 (7.01)[e]	12.09 (18.82)[a]	35.29 (36.24)[a]
T4 - Azadirachtin 10000 ppm (T4)	1.0 ml/L	64.00 (7.99)[a]	37.33 (6.10)[de]	41.58 (40.15)[c]	51.48 (45.84)[b]
T5 - Azadirachtin 10000 ppm	2.0 ml/L	53.00 (7.27)[a]	17.66 (4.16)[c]	67.06 (55.08)[d]	77.35 (61.68)[bc]
T6 - *M. anisopliae* (1x10[8] CFU/ml)	5.0 ml/L	63.66 (7.96)[a]	35.66 (5.96)[c]	43.97 (41.53)[c]	53.82 (47.19)[b]
T7 - *M. anisopliae* (1x10[8] CFU/ml)	10.0 ml/L	55.00 (7.40)[a]	10.33 (3.17)[b]	80.79 (64.38)[e]	86.41 (68.66)[c]
T8 - Cyclone	1.25 ml/L	61.33 (7.82)[a]	5.00 (2.22)[a]	91.75 (73.39)[f]	93.40 (75.21)[c]
T9 - Control	-	70.33 (8.38)[a]	77.00 (8.76)[f]	--	--
CD (P = 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

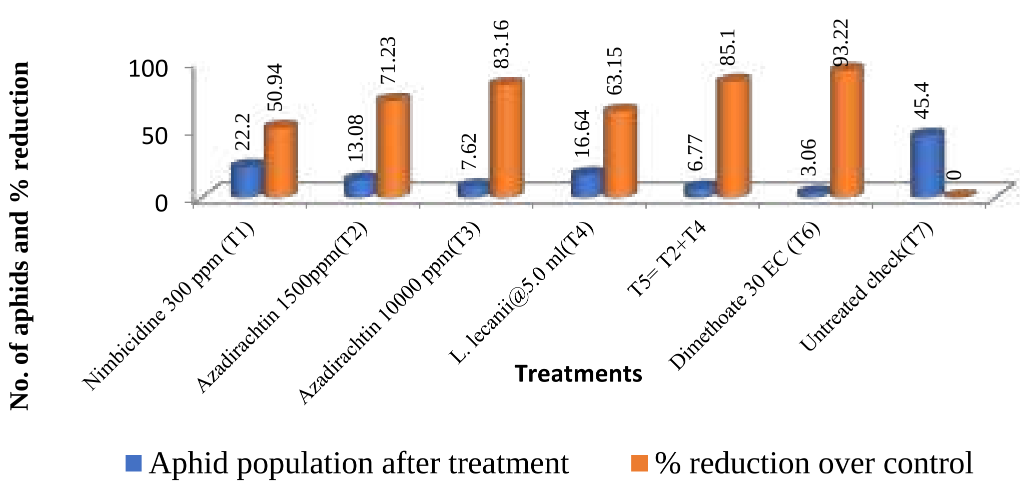


Fig 58. Effect of treatments against Woolly apple aphid, *Eriosoma lanigerum* in high density apple orchard in Shalimar campus, Srinagar during 2020

Fig 59. 1-4 : Woolly apple aphid before and after treatments. 1-2. Woolly apple aphid on High-density apple orchard. 3-4. Reduced attack of WAA after treatments.

IV. 18. Citrus

DRYSRHU

IV. 18. 1. Evaluation of different isolates of entomopathogenic fungi against citrus thrips

A study was taken up to assess the effect of different isolates of entomopathogenic fungi against citrus thrips at Tirupati in an orchard with 6 x 6m spacing.

Treatment details:

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

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 per cent infested fruits were counted. The observed data for per cent thrips infestation on leaf and fruits infestation were analysed statistically and the values will be converted into arc sine transformed values. The yield data were recorded and expressed into tonnes/ha. First spray as given at the peak activity of the pest and the second at 14 days after the first spray for thrips damaging leaf.

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 results in table 181 showed that *Beauveria bassiana* @ 5 g/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 181. Efficacy of entomopathogens against thrips infesting sweet orange

Treatments	Fruits infestation * (%)	No. of fruits/ tree*	Yield (t/ha)
T_1- *Beauveria bassiana* (NBAIR Strain) @ 5 g/L	11.68	244.29	-
T_2- *Metarhizium anisopliae* (NBAIR Strain) @ 5 g/L	16.82	167.37	-
T_3- *Lecanicilium lecanii* (NBAIR Strain) @ 5 g/L	13.10	193.14	-
T_4- Local check (Acephate 75 SP @ 0.1%)	17.34	160.25	-
T5 - Control	24.14	185.36	-
SE (m ±)	-	-	-
CD (P = 0.05)	-	-	-
CV (%)	-	-	-

*Only preliminary raw data collected from fruits on tree, statistical analysed data will be only known at harvest (Probably :Aug-Sept)

Evaluation of different isolates of entomopathogenic fungi against citrus Rust and Green mites

The effect of different isolates of entomopathogenic fungi against citrus Rust and Green mites were taken up at Tirupati in an orchard with trees planted at 6 x 6m spacing

Treatment details:

T_1 : *Beauveria bassiana* (NBAIR Strain) @ 5g/ L
T_2 : *Metarhizium anisopliae* (NBAIR Strain) @ 5g/ L
T_3 : *Lecanicillium lecanii* (NBAIR Strain) @ 5g/ L
T_4 : Local check (Propargite 57EC @ 0.057%)
T_5 : Control

The population counts of mites before and 3, 7 and 14 days after treatment were recorded. In the case of rust mites, observation on infested fruits (%) before harvest were noted and the yield data were recorded and expressed into tonnes/ha. The observed data for population counts on leaf and fruits infestation were analysed statistically.

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 182 showed that *Lecanicillium lecanii* @ 5 g/Lwas found very effective with least infestation by rust mites on fruits (3.32%) followed by *Beauveria bassiana*@ 5 g/L(4.15%) as compared to local check, propargite with 4.59% infestation. Maximum infestation was recorded in control with 16.52 % fruits infested.

Table 182. 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) @ 5 g/Litre	4.15*	192.30*	-

T_2: *Metarhizium anisopliae* (NBAIR Strain) @ 5 g/Litre	8.70	163.89	-
T_3: *L. lecanii* (NBAIR Strain) @ 5 g/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 (P = 0.05)	-	-	-
CV (%)	-	-	-

*Only preliminary raw data collected from fruits on tree, statistical analysed data will be only known at harvest (Probably:Aug-Sept)

IV. 19. Aonla

SKUAST, Jammu

IV. 19. 1. Biological control of aonla mealy bug using entomopathogens

The effect of bioagents on aonla was assessed with following treatments

Treatment details

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

Table 183. Percent reduction in mealy bug nymphs and adults

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

Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, along with Azadirachtin 10000 ppm were assessed against Aonla mealybug. Highest per cent 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 mealybug / 10 cm twig). Untreated control recorded highest mealybug population (8.53 mealy bugs / 10 cm twig).

Fig 60. Aonla mealybug

PLANTATION CROPS

IV. 20. Coconut

UBKV, Pundibari

IV. 20.1. Seasonal incidence of rugose spiraling whitefly (RSW) in Coconut

During 2021-22, seasonal incidence studies of rugose spiraling whitefly in coconut were conducted at the Instructional Farm of UBKV, Pundibari. Study was initiated from August, 2021 to assess the population build-up of RSW in coconut at monthly intervals. Four leaflets collected from two opposite sides of the lower whorl were brought to the lab and counted for number of live spiral colonies. On the other hand, sixteen leaflets (4 leaflets from four sides of each leaf) from each palm were observed to assess the percentage of leaflets infested by RSW per leaf. It was found that the mean number of spirals per leaflet as well as mean percentage of leaflets infested per leaf by RSW population were minimum in the month of August, 2021 (Fig.61) and expressed increasing trend up to January, 2022. But the data in both the parameters showed decreasing values in the month of February, 2022.

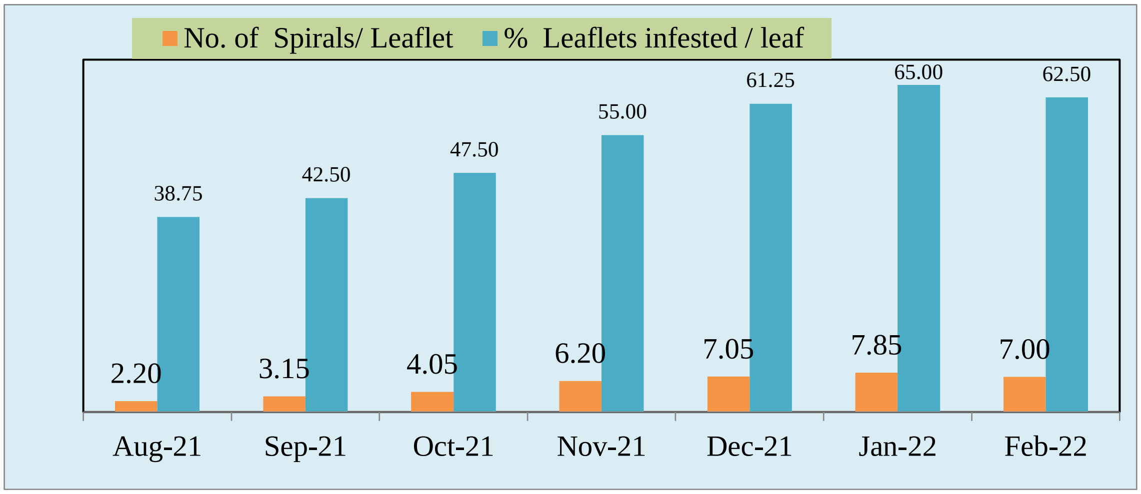


Fig 61. Seasonal incidence of RSW in Coconut at UBKV, Pundibari

KAU, Vellayani: Study on population buildup of RSW in three different locations of Vellayani revealed that all the three locations followed a similar trend in the population pattern, although the mean population recorded from the hot spot area near Vellayani Lake was high. The heavy rainfall received during May and then during September to November almost wiped out the population with a reoccurrence in December which reached the peak during January to March (Table 184). The parasitism level noted varied from 66.08 to 76.94 in Location-I; 61.47 to 71.66 in Location-II and 60.7 to 69.3 in Location-III. Highest parasitism was noted during the month of May 2021 and March 2022. Percentage of RSW infested leaves in a palm was on an average of 71.3 to 88.62 in Location, 71.52 to 75.6 in Location- II and 66.76 to 70.78 (Table 184).

Table 184. Number of colonies infested by RSW and extent of parasitism in KAU Vellayani - Location I (April 2021 – 2022 March)

Palm No.	April, 21		May, 21		June, 21		Dec, 2022		Jan, 2022		Feb, 2022		March, 2022	
	No.of colonies	Parasit-ism (%)	No.of colonies	Parasit-ism (%)	No.of colonies	Parasit-ism (%)	No.of colonies	Parasit-ism (%)	No.of colonies	Parasit-ism (%)	No.of colonies	Parasit-ism (%)	No.of colonies	Parasit-ism (%)
Location-I														
P1	5.5	62.9	6.5	56.4	5.5	55.5	9.5	62.5	10.5	78.5	11.5	68.5	10.5	70.0
P2	5.5	73.9	11.5	62.9	11.5	58.9	13.6	65.0	13.5	68.0	12.5	68.0	13.5	69.5
P3	11.0	68.0	12.5	56.8	12.5	56.9	14.5	62.5	15.5	64.5	16.5	65.0	16.0	65.5
P4	10.5	69.0	8.5	68.0	9.5	72.5	11.5	70.5	12.5	69.5	17.0	70.5	17.5	68.5
P5	17.5	56.8	15.0	76.5	14.5	71.5	16.5	69.9	17.0	61.8	18.5	65.5	18.5	70.5
Mean	10.0	66.1	10.8	76.9	10.7	63.0	13.12	66.0	13.8	68.47	15.2	67.5	15.2	68.8
Severity Index	H		S		S		S		S		S		S	
Location-II														
P1	16.0	55.85	17.0	56.4	15.5	61.5	15.5	62.5	16.5	65.5	16.5	65.0	17.5	66.8
P2	5.5	73.5	5.6	71.5	5.5	70.5	5.0	71.5	6.5	72.5	6.0	70.0	6.5	72.0
P3	4.3	72.5	5.0	70.5	5.0	71.5	5.5	72.5	5.5	72.5	5.5	71.5	6.0	72.5
P4	4.5	60.5	5.5	65.0	3.5	68.5	5.5	70.5	6.0	71.5	6.5	72.5	6.5	74.5
P5	5.5	45.5	5.0	72.5	4.5	71.5	6.0	72.5	5.5	72.5	6.0	73.5	6.5	72.5
Mean	7.0	61.4	7.63	67.1	6.8	68.7	7.5	69.9	8.0	70.9	8.1	70.5	8.6	71.66
Severity Index	M		H		M		H		H		H		H	
Location-III														
P1	10.65	70.0	9.5	71.0	9.0	72.5	12.5	70.5	14.0	71.5	15.0	72.0	16.5	72.5
P2	5.0	60.5	4.5	60.5	4.0	65.5	4.0	68.5	5.5	69.5	6.0	71.5	7.0	72.5
P3	5.5	50.0	5.0	55.5	4.5	60.5	4.5	62.5	5.0	65.5	6.0	68.5	6.5	70.5
P4	4.5	62.5	4.0	62.5	3.5	60.5	3.0	62.5	4.5	65.5	5.5	65.5	6.5	65.5
P5	3.0	60.5	3.5	65.0	3.0	65.0	3.5	66.5	4.5	67.5	5.5	66.5	7.0	65.5
Mean	5.73	60.7	5.3	62.9	4.8	64.8	5.5	66.1	6.7	67.9	7.6	68.8	8.7	69.3
Severity index	M		M		M		M		H		H		H	

No infestation was observed during July to October; Low (3 infested leaflets/frond); M (4to7 infested leaflets/frond);H (>10 infested leaflets/frond); S (>10infested leaflets/frond with sooty mould).

DRYSRHU, Ambajipeta

Rugose spiraling whitefly incidence was observed at monthly interval from three pest infested gardens. Five palms were selected at random in each garden for observation. High incidence of RSW incidence was observed in the month of December (92.33%) and November (87.8%) with grade intensity of 2.6 and 2.5, respectively (Table 185). Mean number of different stages of RSW, Natural enemy population including *Encarsia guadeloupae* parasitisation was also recorded high in these months (Table 185). The incidence of RSW is positively correlated with maximum and minimum temperature and morning relative humidity (Table 186). Similarly, high incidence (90.60%) and intensity (96.3%) of Bonders nesting whitefly (BNW) was observed in the month of April, 2021 Table 187). The incidence of BNW is positively correlated with minimum temperature alone (Table 188). The per cent incidence of RSW was recorded in the alternates hosts banana, cocoa and mango (Table 189). In banana, RSW incidence was high (23.9%) during December 2021, low incidence of 11.9% during April 2021 followed by May 2021, June 2021 and gradually start increasing. Similar trends were observed in cocoa and mango. It was observed that banana was more preferred host than cocoa and mango.

Table 185. Extent of infestation of RSW in coconut and their natural enemies of Ramachandrapuram during 2021

Month	Incidence of RSW (%)	Intensity of RSW (%)	Grade pest intensity	Mean number of RSW stages / four leaflets			Natural enemies / four leaflets		
				Nymph	Pupae	adult	*E. guadeloupae* parasitisation(%)	Predators	
								Spiders	*A. astur*
January 2021	24.61	21.02	0.4 (Low)	0.00	0.00	1.00	6.61	0.21	0.26
February 2021	21.53	19.10	0.3 (Low)	0.10	0.10	0.73	3.52	0.19	0.24
March 2021	20.02	15.14	0.2 (Low)	0.00	0.00	0.51	2.34	0.17	0.23
April 2021	18.48	16. 20	0.4 (Low)	0.12	0.10	0.00	2.02	0.16	0.22
May 2021	16.61	27.48	0.3 (Low)	0.25	0.00	0.50	1.13	0.14	0.20
June 2021	16.39	22.56	0.9 (Low)	0.69	0.00	1.00	3.34	0.18	0.21
July 2021	15.25	25.51	0.7 (low)	1.21	0.82	1.00	7.12	0.15	0.23
August 2021	17.85	39.74	0.5 (low)	2.89	1.48	5.24	6.87	0.29	0.34
September 2021	46.10	59.47	1.8 (Medium)	7.13	3.29	9.53	10.68	0.34	0.56
October 2021	66.43	79.09	2.3 (High)	17.39	10.87	12.68	13.79	0.44	0.69
November 2021	87.80	90.23	2.5 (High)	32.10	22.60	20.42	19.35	0.56	0.75
December 2021	92.33	93.12	2.6 (High)	44.80	36.70	31.90	22.56	0.68	0.83
Mean ± SD	36.958±8.39	42.39±8.63	Medium	8.89±4.31	6.33±3.38	7.04±2.91	8.28±2.06	0.29±0.05	0.39±0.06

Table 186. Correlations of different stages of RSW with weather factors during the year 2021

	Incidence	Intensity	Adult	Nymph	Pupae	*E. guadeloupae (%)*	Predators
T min	0.162*	0.299	0.183	0.174	0.146	0.150	0.480*

T max	0.707*	-0.646*	-0.660*	-0.623*	-0.634*	-0.585*	-0.639*
RH Evening	0.412	-0.361	-0.397	-0.442	-0.467	0.515	0.390**
RH Morning	0.726**	0.803**	0.748**	0.791**	0.785**	0.650**	0.755**
Rain fall	-0.141	0.049	-0.027	0.000	-0.061	-0.195	-0.061

*Significant at 5%, **Significant at 1%

Table 187. Extent of infestation of Bondars nesting whitefly in coconut and their natural enemies of Andhra Pradesh during 2021

Month	Incidence Of BNW (%)	Intensity of BNW (%)	Mean number of BNW stages / four leaflets			Natural enemies
			Nymph	Pupae	Adult	(Spiders + *A. astur*)
January 2021	25.2	26.6	15.2	6.2	4.8	0.47
February 2021	25.8	27.8	24.4	11.3	7.1	0.43
March 2021	26.1	28.9	33.7	16.4	12.9	0.4
April 2021	90.6	96.3	61.33	33.9	32.5	0.38
May 2021	87.3	91.1	59.80	28.6	31.7	0.34
June 2021	83.7	86.8	55.7	26.7	29.2	0.39
July 2021	80.5	83.3	51.2	24.2	28.1	0.38
August 2021	69.1	79.9	49.9	22.1	27.6	0.63
September 2021	61.4	73.4	46.3	21.3	26.4	0.9
October 2021	58.7	71.7	44.7	20.5	25.3	1.11
November 2021	56.7	67. 4	42.6	19.6	24.9	1.28
December 2021	53.8	62.24	41.9	18.8	24.2	1.39
Mean ± SD	56.01± 7.6	59.66±7.8	43.89±3.9	21.13±2.32	22.89±2.69	0.69±0.12

Table 188. Correlations of different stages of BNW with weather factors during the year 2021

	Incidence	Intensity	Nymph	Pupae	Adult	Predators
Minimum temperature	0.595*	0.643*	0.621*	0.568	0.670*	0.175
Maximum temperature	0.397	0.325	0.433	0.489	0.268	-0.686*
Evening relative humidity	-0.034	-0.070	-0.089	-0.094	-0.129	-0.408
Morning relative humidity	-0.030	0.069	-0.019	-0.150	0.150	0.755**
Rainfall	0.499	0.501	0.422	0.333	0.479	-0.074

*Significant at 5%, **Significant at 1%

Table 189. Incidence of rugose spiraling whitefly in alternate hosts during 2021

Months	Incidence (%)		
	Banana	Cocoa	Mango
January 2021	18.2	4.1	12.1
February 2021	17.1	3.9	9.4
March 2021	15.4	3.7	6.8
April 2021	11.9	3.3	4.1
May 2021	12.7	3.6	4.5
June 2021	12.9	3.9	4.9
July 2021	13.3	4.9	5.5
August 2021	14.9	5.2	7.3
September 2021	15.3	6.1	10.1
October 2021	16.4	7.2	13.7
November 2021	18.2	8.6	14.3
December 2021	23.9	9.8	18.6
Mean	15.85± 0.95	5.36 ± 0.53	9.28 ± 1.23

(Mean ± standard error)

KAU, Thrissur

Monitoring of rugose spiraling whitefly population and their natural enemies was carried out at Thrissur and Palakkad districts during 2021-22. Observations were recorded at fortnight intervals. The results on mean rugose spiralling whitefly population as well as mean parasitism are presented in Tables 190 and 191.

The rugose spiraling whitefly infestation broadly followed similar the pattern as observed in previous years. The infestation remained low till November and was positively correlated with temperature. The degree of infestation gradually increased to high or severe towards March 2022. Mean parasitism by *Encarsia guadeloupae* during the study period ranged from 18.23 to 65.50 % at Thrissur and 21.10 to 53.90 % at Palakkad. In Thrissur district, peak level of parasitism was observed in second half of July, 2021. Meanwhile, in Palakkad district, peak level of parasitism was recorded in first half of November as previous years.

In 2017-18, maximum parasitism (92%) was observed as early as in November, while it took longer time in 2018-19 to reach similar levels (first half of February). In 2019-20, the mean parasitism never reached 90% and peaked at around 80 to 85% in second half of November. However, in 2020-21, peak parasitism of 81.53% was reached only during the second half of March. The low mean parasitism could be indicative of a shift in the whitefly species composition infesting palms in the above two locations in favour of the nesting whiteflies (*P. bondari* and *P. minei*).

Pooled analysis (2019-22): Graph was plotted by pooling data on mean parasitism from 2019 to 2022. The observation on mean parasitism in Palakkad district was recorded from October to March (Fig. 62). In 2019-20, the peak level of mean parasitism was observed in November. Meanwhile, in 2020-21 and 2021-22, parasitism was peaked at March. In Thrissur district, the mean parasitism was high in November during 2020-21. Meanwhile, it took long time to reach peak level of parasitism in 2019-20 and 2021-22 (Table 190; Fig.63).

Table 190. Severity of RSW infestation and extent of parasitism in Palakkad District

Palms	11-01-2022		27-01-2022		10-02-2022		25-02-2022		09-03-2022		30-03-2022	
	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Severity	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)
P1	S	27.45	M	40.35	M	34.21	M	40.80	S	55.56	S	44.54
P2	S	33.33	H	30.36	M	50.94	M	52.49	H	28.92	H	50.96
P3	H	49.39	H	59.25	H	49.99	M	20.82	H	35.82	H	25.83
P4	H	55.69	M	34.27	H	43.37	S	23.03	H	39.36	H	18.75
P5	H	33.98	M	51.56	S	30.46	S	18.77	S	16.38	S	23.57
Mean parasitism		39.97		43.16		41.79		31.18		35.21		32.73

Table 191. (Continued)

Palms	18-10-2021		06-11-2021		20-11-2021		04-12-2021		17-12-2021		31-12-2021	
	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)
P1	M	50.00	S	73.33	S	33.03	H	62.50	H	34.09	S	25.00
P2	H	28.94	S	50.00	M	22.50	H	32.50	M	42.72	M	35.41
P3	H	25.00	H	25.00	S	25.00	S	25.00	H	30.00	H	00.00
P4	M	75.00	H	50.00	M	00.00	S	00.00	M	21.87	S	70.08
P5	H	50.00	S	67.16	H	25.00	H	00.00	S	25.00	S	30.95
Mean parasitism		45.78		53.09		21.10		24.00		30.74		32.29

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 192. Severity of RSW infestation and extent of parasitism at KVK campus in Thrissur District

Palms	13-05-2021		25-05-2021		04-06-2021		15-06-2021		01-07-2021		13-07-2021		28-07-2021		11-08-2021		24-08-2021	
	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 (%)
P1	L	75.00	L	25.36	L	21.69	L	30.95	L	17.86	L	00.00	L	81.27	M	58.33	M	25.00
P2	L	36.27	L	50.00	L	50.00	L	50.00	L	00.00	L	50.00	M	47.22	L	00.00	L	00.00

P3	L	66.66	L	74.43	L	7.69	L	50.98	L	09.29	M	12.75	L	78.95	M	56.66	H	75.96
P4	L	49.69	L	70.09	L	70.23	L	28.12	M	60.44	M	39.71	M	67.97	M	35.41	M	16.20
P5	L	62.49	L	75.00	L	00.00	L	07.47	L	03.57	L	61.42	M	52.09	M	94.95	H	66.66
Mean parasitism		58.02		58.97		29.92		33.50		18.23		32.77		65.50		49.07		36.76

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 193. (Continued)

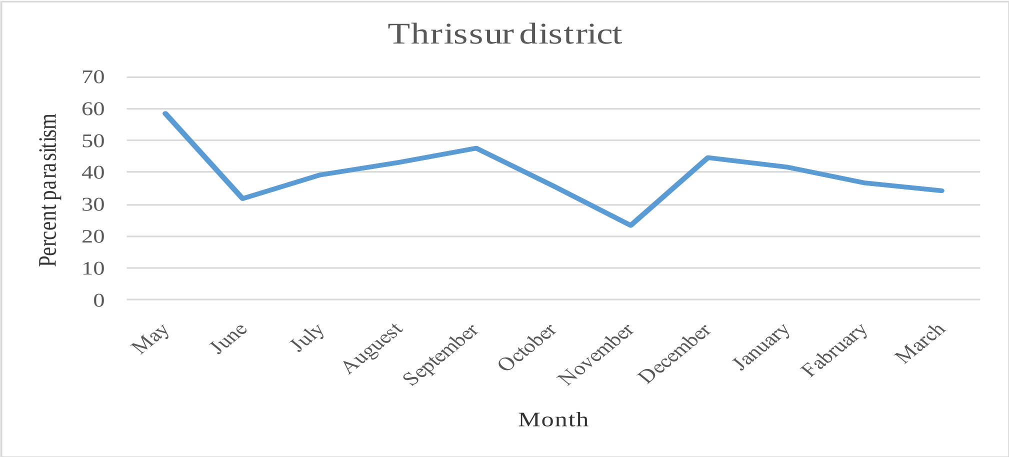
Palms	09-09-2021		22-09-2021		07-10-2021		20-10-2021		05-11-2021		15-11-2021		01-12-2021		15-12-2021		28-12-2021	
	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Severity	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)
P1	M	84.06	H	57.50	M	75.00	H	68.75	H	48.88	H	45.83	S	67.16	M	81.25	H	91.43
P2	M	25.00	M	00.00	H	00.00	H	00.00	H	31.25	M	00.00	H	00.00	M	41.66	S	00.00
P3	M	85.00	M	75.00	M	00.00	M	50.00	M	25.78	H	00.00	H	31.29	H	18.94	M	45.56
P4	H	56.91	L	68.83	H	83.33	H	12.50	H	03.28	M	50.00	M	73.63	S	32.91	H	77.29
P5	H	25.00	L	00.00	H	50.00	H	17.86	H	00.00	M	25.00	M	45.83	S	12.50	S	45.75
Mean parasitism		55.19		40.26		41.66		29.82		21.84		24.16		43.58		37.45		52.00

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 194. (Continued)

Palms	15-01-2022		29-01-2022		09-02-2022		25-02-2022		10-03-2022		30-03-2022	
	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)	Severity	Mean parasitism (%)
P1	S	64.60	S	27.69	S	55.29	S	32.22	S	22.14	S	53.91
P2	M	61.46	M	25.62	H	33.66	S	64.85	S	40.77	S	20.28
P3	H	39.58	H	32.13	H	30.33	H	29.13	H	55.62	H	81.94
P4	M	21.43	H	63.76	S	31.29	H	55.73	H	68.73	S	33.33
P5	S	47.66	S	46.25	S	14.07	S	26.20	S	41.31	S	58.03
Mean parasitism		46.94		39.09		32.93		41.62		45.71		49.49

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)



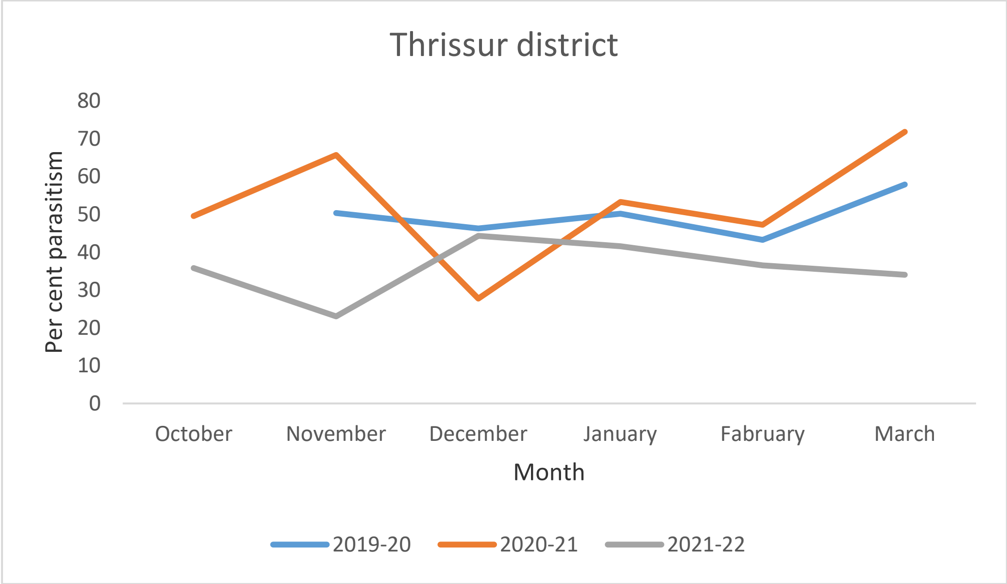
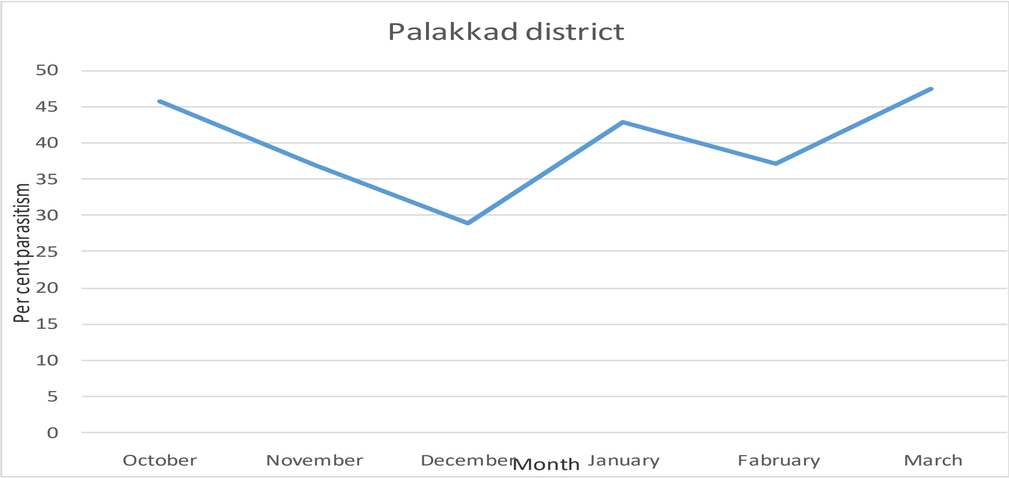


Fig 62. Surveillance of rugose spiraling whitefly in Thrissur district (2021-22) (A) and pooled data (B)



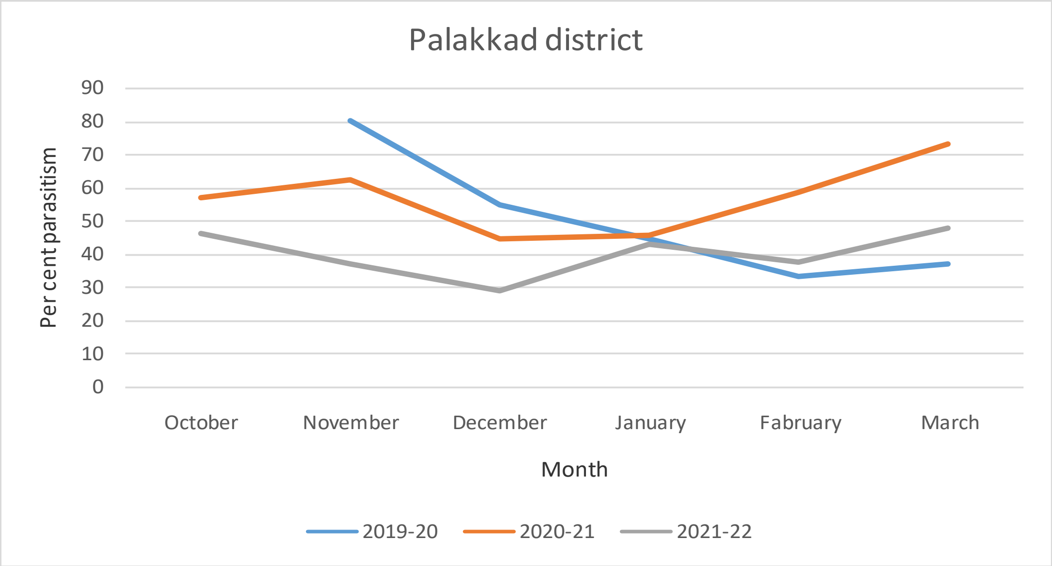


Fig. 63. Surveillance of rugose spiraling whitefly in Palakkad district (2021-22) (A) and pooled analysis (B)

Biological suppression of rugose spiraling whitefly in coconut

ANGRAU, Anakapalle: During 2021-22, after the first spray, per cent reduction in RSW intensity was observed to the extent of 27.36% due to parasitization by *Encarsia guadeloupae* augmented after first spraying of *Isaria fumosorosea* (Pfu-5) at 5 ml/L. Per cent reduction in RSW intensity was enhanced to 56.35%in two spray of *I. fumosorosea* (Pfu-5) at 15 days intervals + augmentation of parasitoid, *E. guadeloupae* after second spray. This was followed by two sprays of *I. fumosorosea* (Pfu-5) + augmentation of predator, *Dichochrysa astur* (51.72%) and it was 24.38 after first spraying of *I. fumosorosea* fungus (Table 195). Reduction in RSW intensity was low in neem formulation 10000 ppm sprays (16.22%) after two sprays than one spray (7.32%).

Table 195. Biological control of RSW using *Isaria fumosorosea* (NBAIR-Pfu-5) during 2021-22

Treat-ment*	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	58.73	40.71	30.67	29.57	10.45	9.54	17.77	5.66	27.36	56.35
T_2	60.14	39.29	39.5	29.71	11.77	11.8	18.97	6.33	24.38	51.72
T_3	57.41	43.04	36.33	39.89	27.88	20.7	36.05	18.67	7.32	16.22

Dichochrysa astur; T3: Neem formulation 10000 ppm

Fig 64. Demonstrations covered was 115 acres in Andhra pradesh during 2021-22

ICAR-CPCRI, Kayamkulam: Under good nutrition management, it was found that palms treated with neem oil (0.5%), water spray and *Isaria fumosorosea* could reduce the RSW population significantly ranging from 0.78 to 1.08 from the initial population of 1.51 to 3.01. Palms maintained under conservation biological control registered highest RSW population (1.51) after two-month of treatment (Table 196). However, highest reduction of RSW population was recorded on neem oil treated palms followed by palms under conservation biological control and water spray. The least reduction was observed on palms exposed to *I. fumosorosea* (42.6%), whereas, neem oil treated palms registered highest pest reduction of 58.8%. Good health management practices are very much important in recouping palm health and thus to reduce the pest impact. After the receipt of monsoon showers all palms became free of pest infestation and BNW is overriding in certain leaflets.

Table 196. Efficacy of biorationals on the bio-suppression of rugose spiraling whitefly in coconut

Treatments	RSWpopulation (No.)					Para-sitism (%)
	Pre-treat-ment	After one month	Reduction (%)	After two months	Reduc-tion (%)	
T1-Conservation biological control	3.01 (1.67)	2.72(1.64)[c]	9.7	1.51(1.17)[b]	49.8	38.5
T2-*Isaria fumosorosea*	1.88 (1.47)	1.61(1.37)[b]	14.4	1.0.8 (1.04)[ab]	42.6	31.9
T3-Neem oil (0.5%)	1.98 (1.41)	1.11(1.08)[a]	43.9	0.83 (0.95)[ab]	58.8	37.9
T4-Water spray	1.51 (1.30)	1.02(1.01)[a]	32.5	0.78 (0.91)[a]	48.3	40.1
CD (P=0.05)	NS	0.227		0.243		

RARS, Kumarakum: Efficacy of *Isaria fumosorosea* (Pfu-5) @ 1x10^8 cfu/ml and neem oil @ 0.5% against Bonder's nesting whitefly was tested under field conditions. Results were compared with the untreated plot where *Encarsia guadeloupae* population is naturally conserved. There were no significant differences between the treatments in terms of number of live colonies of white flies per leaflet at all three intervals of observations after second spray (Table 197).

Table 197. Biological suppression of Bondar's nesting whitefly in coconut

Treatments	Infestation (%)			Intensity (%)		
	10 days after spraying	20 days after spraying	50 days after spraying	10 days after spraying	20 days after spraying	50 days after spraying
T1	84.91 (9.19)*	69.97 (8.40)	74.06 (8.65) [b]	82.88 (9.14) [a]	66.18 (8.18)	65.23 (8.13) [c]
T2	79.92 (8.95)	68.46 (8.31)	86.83 (9.35) [a]	62.88 (8.02) [b]	68.59 (8.33)	70.96 (8.48) [ab]
T3	74.96 (8.71)	69.97 (8.40)	86.00 (9.29) [a]	64.98 (8.11) [b]	66.00 (8.18)	69.23 (8.38) [bc]
T4	75.22 (8.72)	79.19 (8.91)	89.02 (9.45) [a]	64.33 (8.07) [b]	59.38 (7.77)	75.20 (8.72) [a]
CD (P = 0.05)	NS	NS	0.45	0.40	NS	0.32
CV (%)	7.69	8.08	5.43	5.32	5.38	4.28

Table 198.

Treatments	Live colonies/leaflet			Healthy nymphs/leaflet		
	10 days after spraying	20 days after spraying	50 days after spraying	10 days after spraying	20 days after spraying	50 days after spraying
T1	11.20 (3.33)	14.90 (3.78)	20.18 (4.45)	7.25 (2.37) [a]	4.73 (2.87)	7.53 (2.58) [a]
T2	14.80 (3.68)	10.80 (3.12)	22.83 (4.73)	8.53 (2.39) [a]	4.85 (2.63)	6.83 (2.91) [ab]
T3	6.88 (2.58)	6.88 (2.98)	13.83 (3.7)	3.73 (2.47) [a]	5.25 (2.49)	5.20 (2.21) [bc]
T4	6.43 (2.63)	9.08 (2.99)	17.60 (4.2)	3.48 (1.96) [b]	2.95 (2.14)	3.78 (2.30) [c]
CD (P = 0.05)	NS	NS	NS	0.336	NS	0.352
CV (%)	39.12	34.86	27.17	16.11	16.98	15.50

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. Means followed by a common letter in a column are not significantly different. *Values in parentheses are square root transformed values

Significant low mean number of healthy nymphs per leaflet (3.48 and 2.95) was observed on palms sprayed with water at 10 and 50 days after spraying. At 50 days after spraying, neem oil spray could also give significant reduction in healthy nymphs per leaflet. There was no significant difference in the number of healthy nymphs among the other three treatments. Percentage of infestation was found to be identical in all the treatments except 50 DAS where, low infestation was found in untreated palms.

TNAU, Coimbatore: RSW nymphal population was minimum (12.25 Nos.) in the coconut trees sprayed with neem oil 0.5% followed by 13.33 numbers of nymphs in application of *Isaria fumosorosea* (Pfu-5) @ 1x10^8 cfu/ml, water spray (15.25 Nos.) and *E. guadeloupae* (natural conservation) (18.13 Nos.) on 15th day after 2nd spraying. Parasitized nymphs were significantly more in *E. guadeloupae* (37.09%) than in foliar application of *I. fumosorosea* (pfu-5) @ 1x10^8 cfu/ml (26.24%), foliar application of neem oil 0.5% (24.84%) and water spray (30.22%) on 15th day after 2nd spraying (Table 199). There was reduction in nymphal population in *E.guadeloupae* (12.50 Nos.) on 60th day after 2nd spraying, when compared with foliar application of *I.fumosorosea* (pfu-5) @ 1x10^8 cfu/ml, foliar water spray and foliar application of neem oil 0.5%. Parasitized nymphs was maximum in *E. guadeloupae* (natural conservation) (39.16%) followed by and foliar application of neem oil 0.5% (31.70%), *Isaria fumosorosea* (Pfu-5) @ 1x10^8 cfu/ml (33.06%) and foliar water spray (24.5%) on 60th day after 2nd spraying.

Table 199 . Biological suppression of rugose spiraling whitefly in coconut at Coimbatore

Treatment	15 days 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*
Encarsia guadeloupae natural conservation	46.39 (42.93)^{b}	35.45 (36.50)^{b}	4.88 (2.31)^{c}	18.13 (4.26)^{c}	37.09 (37.45)^{a}	37.34 (37.66)^{a}	28.34 (32.15)^{a}	4.38 (2.08)^{a}	12.50 (3.51)^{a}	39.16 (38.72)^{a}
Foliar application of *Isaria fumosorosea* (Pfu-5) @ 1x 10^{8} cfu/ml (2 sprays at 15 days intervals)	32.72 (34.82)^{a}	26.49 (30.93)^{a}	4.13 (2.13)^{bc}	13.13 (3.61)^{ab}	26.24 (30.72)^{b}	43.64 (41.34)^{b}	32.09 (34.48)^{bc}	5.75 (2.39)^{b}	14.63 (3.82)^{ab}	33.06 (35.05)^{b}
Foliar application of neem oil 0.5% (neem oil 5ml + soap powder 10g/L of water) (2 sprays at 15 days intervals)	28.24 (31.99)^{a}	28.69 (32.37)^{a}	3.00 (1.86)^{a}	12.25 (3.48)^{a}	24.84 (29.79)^{b}	41.75 (40.23)^{b}	31.37 (34.04)^{ab}	6.13 (2.46)^{b}	15.75 (3.96)^{b}	31.70 (34.19)^{b}
Foliar water spray (2 sprays at 15 days intervals)	27.74 (31.71)^{a}	27.88 (31.81)^{a}	3.75 (2.05)^{ab}	15.25 (3.89)^{bc}	30.22 (33.16)^{b}	44.27 (41.71)^{b}	35.71 (36.66)^{c}	6.63 (2.56)^{b}	16.38 (4.03)^{b}	26.84 (31.20)^{c}
SEd	1.720	1.087	0.113	0.176	2.012	0.931	1.051	0.110	0.179	1.316
CD (P=0.05)	3.613	2.282	0.238	0.369	4.226	1.956	2.207	0.230	0.375	2.763

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

DRYSRHU, Ambajipeta: There was no significant difference in various stages of RSW in the pre-treatment count. Fifteen days after treatment imposition lowest number of egg spirals were recorded in neemoil spray and *I. fumosorosea* treatment (1.52 and 2.63 egg spirals, respectively). Maximum egg spirals were observed in natural conservation of *E. guadeloupae* treatment (11.23 egg spirals. The number of parasitized nymphs (lives& blackened) & nymphs with parasitoid emergence holes/leaflet were found to be low in all treatments except natural conservation of *E. guadeloupae* treatment. After 15 days after second spray lowest number of egg spirals was recorded in neem oil and *I. fumosorosea* treatments (1.05 and 1.57 egg spirals). The lowest number of RSW infested leaflets /leaf was observed (intensity) in neem oil treatment. A high number of egg spirals (13.56) were observed in natural conservation of *E. guadeloupae* treatment. However, a lownymphal and adult population was observed in neem oil treatment followed by *I. fumosorosea* treatment. A high number (18.92) of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet was recorded in natural conservation of *E. guadeloupae* treatment 30 days after observation.

Table 200. RSW population in various treatments before treatments imposition at Ambajipeta

S. No	Treatments	Leaves infested with RSW/ palm (Incidence %)**	RSW infested leaflets /leaf (from 4 sample leaves/palm (Intensity %) **	Number of live population/ leaflet			No. of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/ leaflet	Aborted nymph/ pupae	Predator *A.astur*	Spiders
				egg	nymph	adult				
T_1	Natural conservation	81.49 (9.52)	79.26 (8.9)	9.03 (3.4)	24.1875 (5.32)	20.76 (4.56)	2.63 (1.92)	1.11 (1.55)	0.19 (0.94)	1.52 (1.23)
T_2	*I. fumosorosea* spray	82.12 (9.9)	78.12 (8.89)	8.92 (2.99)	23.53 (4.93)	19.9 (4.49)	2.03 (1.92)	1.61 (1.28)	0.32 (0.59)	1.21 (1)
T_3	Neem oil spray	79.35 (8.91)	80.23 (8.98)	8.76 (2.98)	22.69 (4.79)	19.87 (4.48)	2.29 (1.59)	1.45 (1.7)	0.28 (0.59)	1.78 (1.72)
T_4	Water spray	82.67 (9.09)	80.41 (8.99)	8.84 (2.99)	22.96 (4.84)	20.23 (4.54)	2.23 (1.53)	0.98 (0.99)	0.21 (0.52)	1.53 (1.64)
	SEm	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CD (P = 0.05)	-	-	-	-	-	-	-	-	-

Table 201. RSW population in various treatments 15 days after first spray imposition at Ambajipeta

S. No	Treatments	Leaves infested with RSW/ palm (Incidence %)**	RSW 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	Predator *A.astur*	spiders
				Egg spirals	nymph	adult				
T_1	Natural conservation of *E.guadeloupae*	83.69 (9.15)	81.54 (9.07)	11.23 (3.39)	23.48 (4.88)	21.21 (4.66)	2.33 (1.53)	2.58 (1.61)	1.89 (1.71)	0.23 (0.49)
T_2	*I. fumosorosea* spray	44.92 (6.70)	41.06 (6.45)	2.63 (1.69)	4.22 (2.55)	2.04 (1.49)	1.03 (1.01)	0.89 (0.94)	1.26 (1.67)	0.68 (0.82)
T_3	Neem oil spray	47.64 (6.90)	37.98 (6.52)	1.52 (1.29)	4.05 (2.42)	1.08 (1.04)	2.78 (1.72)	0.00 (0.00)	1.00 (1.49)	0.23 (0.49)
T_4	Water spray	54.6 (7.39)	46.17 (6.84)	2.99 (1.78)	6.16 (2.53)	5.54 (2.41)	1.52 (1.23)	1.12 (1.06)	1.21 (1.89)	0.99 (0.99)
	SEm	2.44	2.67	0.14	0.25	0.28	0.12	0.08	0.16	0.03
	CD (P = 0.05)	7.36	8.05	0.41	0.76	0.84	0.36	0.24	0.41	0.16

Fig in parenthesis are $\sqrt{x+0.5}$ transformed values

Table 202. RSW population in various treatments 15 days after second spray

S. No	Treatments	Leaves infested with RSW/ palm (Incidence %)**	RSW 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	Predator *A.astur*	spiders
				Egg spirals	nymph	adult				
T_1	Natural conservation	93.38 (9.71)	88.99 (9.48)	13.56 (3.39)	39.45 (6.34)	21.23 (4.35)	18.92 (4.39)	4.21 (2.09)	0.39 (3.69)	0.23 (0.53)
T_2	*I. fumosorosea* spray	39.73 (6.35)	32.46 (5.74)	1.57 (1.28)	2.81 (1.72)	0.54 (0.78)	2.72 (1.69)	1.76 (1.38)	0.02 (1.42)	0.69 (0.87)
T_3	Neem oil spray	39.28 (6.32)	29.12 (5.44)	1.05 (1.12)	1.82 (1.39)	0.04 (0.7)	1.65 (1.32)	0.50 (0.76)	0.11 (1.38)	0.23 (0.53)
T_4	Water spray	41.46 (6.49)	37.64 (6.19)	2.52 (1.33)	3.68 (1.92)	1.02 (0.9)	3.42 (1.89)	3.93 (1.98)	0.42 (1.09)	0.99 (0.99)
	SEm	1.71	3.90	0.13	0.41	0.26	0.31	0.11	0.13	0.09
	CD (P = 0.05)	4.99	7.37	0.40	1.22	0.37	0.93	0.33	0.26	0.21

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

KAU, Thrissur: The mean number of rugose spiraling whitefly infested fronds varied from 8.68 to 12.91/ palm with the lowest value being recorded on palms sprayed with water (Table 203). Palms treated with *I. fumosorosea* and neem oil had 10.91and 12.04 infested fronds, respectively.

Table 203. Number of total fronds and infested fronds per palm

Treatment	Total fronds/palm	Infested fronds/palm
T_1: Natural conservation	23.28	12.91
T_2: *Isaria fumosorosea*	22.11	10.91
T_3: Neem oil (0.5%)	22.37	12.4
T_4: Water spray	22.34	8.68

There was no significant difference between treatments in terms of number of live colonies of RSW except at 30 days after second spray (Table 204) when the lowest number of live colonies were observed in natural conservation (2.28) followed by water spray (3.53), the treatments being on par with each other. Trees sprayed with *I. fumosorosea* and neem oil recorded significantly higher number of 7.64 and 5.93 RSW live colonies, respectively.

Table 204. Effect of *Isaria fumosorosea* on population of RSW at Thrissur

Treatment	Number of RSW live colonies					
	Pre-count	15 DAS1	15 DAS2	30 DAS2	45 DAS2	Cumulative mean
T1: Natural conservation	3.71 (1.91)	3.32 (1.79)	4.43 (2.08)	2.28 (1.44)[c]	4.07 (1.98)	3.52 (1.86)[b]
T2: *Isaria fumosorosea*	5.00 (2.23)	5.82 (2.36)	8.18 (2.79)	7.64 (2.70)[a]	8.07 (2.69)	7.43 (2.67)[a]

T3: Neem oil (0.5%)	4.21 (2.00)	3.53 (1.82)	5.89 (2.39)	5.93 (3.89)[ab]	5.35 (2.24)	5.18 (2.25)[ab]
T4: Water spray	3.07 (1.74)	3.86 (1.91)	5.07 (2.18)	3.53 (1.84)[bc]	3.43 (1.76)	3.97 (1.96)[b]
CD (P = 0.05)	NS	NS	NS	0.59	NS	0.48

*Mean of 28 observations. Values in parenthesis are square root transformed values

A significant difference was observed in the pre-count of number of healthy RSW colonies (Table 205). Hence, ANCOVA was attempted and the results of covariance study indicated that the pre-count did not have influence on observation at 15 days after first spray. Fifteen days after first spray, the lowest number of 3.43 colonies was observed on untreated palms. The same was on par with neem oil (11.57). Palms treated with water spray and *I. fumosorosea* recorded 19.61 and 28.93 number of colonies, being on par with each other as well as with neem oil treated palms.

Fifteen days after second spray, neem oil, water spray and untreated palms had an average of 6.82, 7.28 and 8.50 colonies. The above treatments were comparable to each other and had significantly lower number of live colonies compared to palms treated with *I. fumosorosea* registering 27.43 mean live colonies. There was no significant difference between different treatments with respect to number of parasitized colonies of RSW suggesting that the treatments had very little impact on parasitization.

Table 205. Effect of different treatments on population of RSW and extent of parasitism

Treatment	Number of healthy RSW colonies*					Number of parasitized RSW colonies*				
	Pre-count	15 DAS1	15 DAS2	30 DAS2	45 DAS2	Pre-count	15 DAS1	15 DAS2	30 DAS2	45 DAS2
T1: Natural conservation	15.11 (3.79)[ab]	3.43 (1.73)[c]	8.50 (2.61)[b]	7.82 (2.32)	14.67 (3.66)	10.71 (3.20)	5.53 (2.29)	10.71 (3.18)	4.00 (1.88)	3.96 (1.87)
T2: *I. fumosorosea*	28.28 (5.13)[a]	28.93 (5.19)[a]	27.43 (4.98)[a]	22.21 (4.41)	25.43 (4.77)	14.93 (3.72)	11.32 (3.21)	15.57 (3.59)	7.36 (2.53)	10.85 (3.13)
T3: Neem oil (0.5%)	18.57 (3.91)[ab]	11.57 (3.09)[bc]	6.82 (2.49)[b]	15.82 (3.58)	20.53 (4.09)	10.96 (3.16)	8.28 (2.74)	11.75 (3.31)	10.25 (3.06)	7.14 (2.69)
T4: Water spray	9.36 (2.94)[b]	19.61 (4.13)[ab]	7.28 (2.45)[b]	11.43 (3.32)	13.75 (3.32)	12.32 (3.43)	8.86 (2.75)	7.36 (2.37)	5.07 (2.06)	4.21 (1.81)
CD (P = 0.05)	1.48	1.76	1.43	NS	NS	NS	NS	NS	NS	NS

*Mean of 28 observations. Values in parenthesis are square root transformed values

Pooled analysis (3 years-2019 to 2022): The mean number of RSW infested fronds varied from 9.46 to 11.18/ palm with the lowest value being recorded on palms sprayed with water (Table 206). Palms treated with *I. fumosorosea* and neem oil had 10.27 and 10.75 infested fronds, respectively.

Table 206. Number of total fronds and infested fronds per palm (pooled analysis)

Treatment	Total fronds/palm	Infested fronds/palm
T1: Natural conservation	20.36	11.18
T2: *I. fumosorosea*	20.57	10.27
T3: Neem oil (0.5%)	21.19	10.75
T4: Water spray	21.18	9.46

There was no significant difference between treatments in terms of number of live colonies of RSW except at 15 days after first spray (Table 207). The treatments neem oil and water spray registered the lowest number of 3.32 and 4.23 colonies, respectively, both being on par with each other. The entomopathogen, *I. fumosorosea* recorded significantly higher number of 5.53 live colonies, which was on par with the value of 5.10 on untreated palms. A significant difference in terms of number of healthy rugose whitefly colonies was observed only at fifteen days after second spray. Significantly lower number of healthy colonies were observed in water spray (5.15 no.), followed by neem oil (5.22 no.) and natural conservation (5.76 no.), the three treatments being on par with each other.

Table 207. Effect of *Isaria fumosorosea* on population of RSW on coconut (pooled analysis)

Treatment	Number of RSW live colonies					
	Pre-count	15 DAS1	15 DAS2	30 DAS2	45 DAS2	Cumulative mean
T1: Natural conservation	4.32 (2.09)	5.21 (2.22)[a]	5.16 (2.19)	4.97 (2.13)	5.07 (2.21)	5.10 (2.22)
T2: *I. fumosorosea*	4.09 (2.01)	5.08 (2.17)[a]	5.70 (2.25)	5.84 (2.33)	5.50 (2.23)	5.53 (2.27)
T3: Neem oil (0.5%)	3.77 (1.96)	3.32 (1.71)[b]	4.48 (2.03)	4.50 (2.03)	4.19 (1.97)	4.12 (1.98)
T4: Water spray	3.79 (1.99)	4.23 (1.99)[ab]	4.40 (2.04)	3.75 (1.90)	3.51 (1.81)	3.97 (1.97)
CD (P = 0.05)	NS	0.32	NS	NS	NS	NS

*Mean of 84 observations. Values in parenthesis are square root transformed values

No significant difference was observed between different treatments with regard to number of parasitized RSW colonies except at 45 days after second spray (Table 208). Fourty five days after second spray, the highest number of parasitized colonies were observed in *I. fumosorosea* (12.53 no.), which was on par with untreated palms (10.10 no.). Water spray and neem oil had the lowest number of parasitized colonies at 6.47 and 8.09, respectively.

Table 208. Effect of different treatments on population of RSW and extent of parasitism (pooled analysis)

Treatment	Number of healthy RSW colonies*						Number of parasitized RSW colonies*					
	Pre-count	15 DAS1	15 DAS2	30 DAS2	45 DAS2	Cumulative mean	Pre-count	15 DAS1	15 DAS2	30 DAS2	45 DAS2	Cumulative mean
T1: Natural conservation	9.26 (2.75)	7.37 (2.54)	5.76 (2.31)[b]	7.12 (2.52)	8.54 (2.79)	7.19 (2.66)	11.04 (3.10)	9.27 (2.96)	12.10 (3.33)	11.35 (3.21)	10.10 (2.92)[ab]	10.71 (3.15)
T2: *I. fumosorosea*	13.20 (3.17)	13.43 (3.14)	12.98 (3.08)[a]	14.19 (3.29)	14.26 (3.34)	13.71 (3.37)	10.87 (3.09)	8.66 (2.92)	11.94 (3.12)	13.46 (3.48)	12.53 (3.41)[a]	11.65 (3.33)
T3: Neem oil (0.5%)	8.88 (2.58)	8.09 (2.44)	5.22 (2.06)[b]	9.98 (2.79)	8.62 (2.49)	7.98 (2.61)	10.02 (2.94)	8.18 (2.78)	10.35 (2.91)	9.43 (2.94)	8.09 (2.64)[b]	9.01 (2.89)
T4: Water spray	6.79 (2.44)	10.35 (2.85)	5.15 (2.18)[b]	8.40 (2.74)	6.88 (2.35)	7.69 (2.68)	9.85 (3.05)	9.54 (3.01)	9.01 (2.77)	8.09 (2.77)	6.47 (2.29)[b]	8.28 (2.77)
CD (P = 0.05)	NS	NS	0.73	NS	NS	NS	NS	NS	NS	NS	0.64	(NS)

*Mean of 84 observations. Values in parenthesis are square root transformed values

Area-wide demonstration of biological suppression of black headed caterpillar using *Goniozus nephantidis* and *Bracon brevicornis*

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 (30.6%) was observed in coconut gardens during October 2019 at Mogral Puttur, Kasaragod district. To combat the pest incidence, pruningand destruction of infested frondsat lower whorls as well as timely augmentative release of *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoid/palm was undertaken during November 2019. Pest population was gradually reduced and in August 2021 it was found to be 0.8% with pest reduction exceeding 98% (Fig 65). This validates further the biological control success story in the bio-suppression of the black headed caterpillar using augmentative release of stage-specific parasitoids. 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.

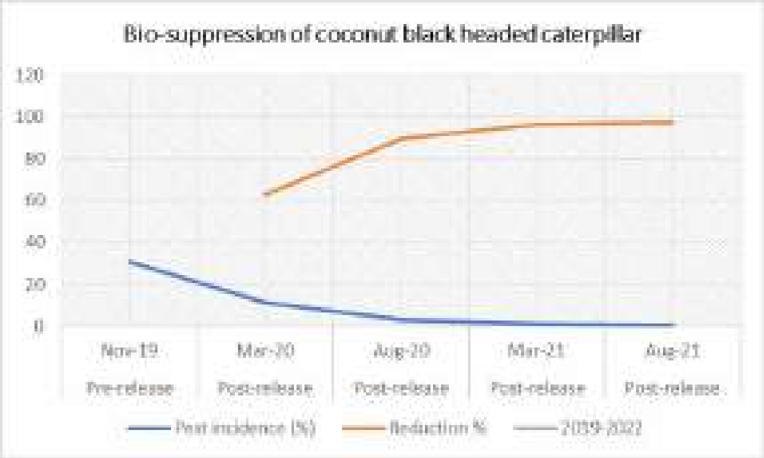


Fig 65. Bio-suppression of coconut black headed caterpillar using augmentative release of stage-specific parasitoids

CPCRI, Kayamkulam

IV. 20. 2. Converging biological suppression approaches for area-wide management of coconut rhinoceros beetle

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. In India, 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 an attempt to detect *Oryctes rhinoceros* nudivirus (OrNV)-resistant haplotype if any in the country, grubs of rhinoceros beetles were collected from the field and inoculated *per os* with OrNV suspension in the laboratory. During 2021, more than 90% grubs exhibited typical symptoms of loss of appetite, absence of dark gut lining and extroversion of gut indicating the absence of OrNV-resistant haplotype (Guam strain).

As part of "Convergence of bio-control technologies for area-wide management of coconut rhinoceros beetle", more than 200 kg of *Metarhizium majus* mass multiplied in semi-cooked rice was distributed to dairy farmers in Vallikunnampanchayat since April, 2021. The application procedure of the entomopathogenic fungus on the breeding sites was demonstrated through sensitization programmes covering all the wards in the village at a regular time period under the co-ordination of the Agricultural Officer/Dairy Society. The farmers were empowered on the technical know-how, famer-participatory technology dissemination as well as sustainable impact of the technology. 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 (Fig 66). The incidence of coconut rhinoceros beetle during 2021 was presented in Table 209.

Table 209. Incidence of coconut rhinoceros beetle in Vallikunnam during 2021

Palms observed (25)	Fronds infested/ palm (%)	Leaf damage (%)	Spear leaf damage (%)
	3.98	19.8	38.6
Per cent reduction over last year	5.28	7.91	5.39

About 4% fronds were attacked by coconut rhinoceros beetle in each palm. The leaf and spear leaf damage were found as 19.8% and 38.6%, with reduction by 7.91% and 5.39%, respectively. It was presently observed that at least three 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 66. Activities performed for localized production of entomopathogen in the area-wide management of coconut rhinoceros beetle

IV. 21. COCOA

DRYSRHU, Ambajipeta

IV. 21.1. Evaluation of entomofungal pathogens against bark eating caterpillar (*Indarbela* spp.)

Evaluation of entomofungal pathogens against bark eating caterpillar (*Indarbela* spp.) in the experiment was carried out at HRS, Amabajipeta farm. Pre treatment data was collected before and after the treatments. The treatments were imposed on 27/1/2022 and subsequently data on frass progression was collected at 1, 3, 7, 10 days after treatment and subjected to RBD analysis.

Table 210. Efficacy of various bio-pesticides against cocoa bark eating caterpillar, *Indarbela* spp as measured by frass ribbon progression during 2022

Treatments	Frass ribbon progression symptom (cm)/tree				
	Pre treat-ment	1 DAT	3 DAT	7 DAT	10 DAT
T_1- Removal of frass + plugging the hole with cotton	**13.20 (3.63)**	**2.35 (1.53)**	**4.06 (2.01)**	**6.59 (2.57)**	**9.10 (3.02)**
T_2- T_1 + *Beauveria bassiana* 5 ml/L plugging the hole with cotton	16.11 (4.01)	2.24 (1.49)	4.75 (2.18)	6.10 (2.47)	8.88 (2.98)
T_3-T_1 +*Metarhizium anisopliae* 5 ml/L + plugging the hole with cotton	10.35 (3.22)	2.23 (1.49)	2.76 (1.66)	3.57 (1.89)	6.92 (2.63)
T_4-T_1 + *Lecanicillium lecanii* 5 ml/L + plugging the hole with cotton	11.78 (3.43)	2.69 (1.64)	3.60 (1.89)	4.35 (2.09)	7.04 (2.65)
T_5-T_1 + Azadirachtin 10000 ppm (1 ml/L) + plugging the hole with cotton	15.69 (3.96)	2.85 (1.69)	4.53 (2.13)	6.99 (2.64)	10.46 (3.23)
T_6-T_1 + Injecting active holes with chlorantraniliprole 18.5 SC (0.4 ml/L) + plugging the holes with cotton	16.97 (4.12)	0.00 (0.5)	0.00 (0.5)	0.00 (0.5)	0.00 (0.5)
T_7- Control	12.39 (3.52)	13.19 (3.63)	15.05 (3.88)	16.49 (4.06)	20.11 (4.48)
*T_8-T_1 +Naphthalene ball pellets	13.89 (3.73)	0.00 (0.5)	0.00 (0.5)	0.00 (0.5)	0.00 (0.5)
SEm	-	0.36	0.09	0.07	0.06
C.D. (P = 0.05)	-	0.9	0.26	0.21	0.16

DAT - Day after treatment; * Additional treatment included

The results revealed that mean frass ribbon length per tree before treatment imposition was ranged between 10.35 cm to 16.97 cm. At 1 DAT, no frass ribbon progression was observed in chlorantraniliprole 18.5 SC and naphthalene ball pellets treated cocoa trees and this continued even up to 10 DAT. In all the treatments consist of biopesticide and control; there was a gradual increase in frass progression indicating treatment inefficacy against bark eating caterpillar (Table 211).

The mean number of active holes/tree increased in all the biopesticidal treatments *viz., Metarhizium anisopliae* (6.25 active holes / tree), *Beauveria bassiana* (5.75 active holes/ tree), *Lecanicillium lecanii* (4.75 active holes/ tree) including azadirachtin (5 active holes/ tree) at 10 DAT. A decrease in the active holeformation was observed only in chlorantraniliprole and naphthalene pellets treated cocoa trees.

Table 211. Status of active holes of bark eating caterpillar *Indarbela* spp. in various treatments during 2022

Treatments	Active holes /tree				
	Pre data	1 DAT	3 DAT	5 DAT	10 DAT
T_1- Removal of frass + plugging the hole with cotton	4.75	4.75	4.75	5.25	6.50
T_2-T_1+ *Beauveria bassiana* 5ml/L plugging the hole with cotton	4.25	4.25	4.25	4.25	5.75
T_3-T_1+*Metarhizium anisopliae* 5ml/L + plugging the hole with cotton	5.25	5.25	5.25	5.25	6.25
T_4-T_1+ *Lecanicillium lecanii* 5ml/L + plugging the hole with cotton	3.50	3.50	3.50	3.50	4.75
T_5- T_1+ Azadirachtin 10000 ppm (1ml/L) + plugging the hole with cotton	4.25	4.25	4.25	4.25	5.00
T_6-T_1+Injecting active holes with chlorantraniliprole 18.5 SC (0.4ml/L) + plugging the holes with cotton	4.25	0.0	0.0	0.0	0.0
T_7- Control	4.25	4.25	4.5	5.25	6.75
T_8- T_1+ Pellets of Naphthalene ball	2.5	0.0	0.0	0.0	0.0

VEGETABLE CROPS

IV. 22. Tomato

PJTSAU, Hyderabad

IV.22.1. Bio-intensive pest management of *Helicoverpa armigera*, *Tuta absoluta* and sucking pests of tomato

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

T1 = BIPM

- Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds.
- Raising marigold as trap crop
- Use of NBAIR pheromone traps @ 1 trap/plot.
- *Trichogramma achaeae* / *Trichogramma pretiosum* @ 50,000 /ha/release (6 releases)
- Azadirachtin 1500 ppm @ 2 ml/L
- *Lecanicillium lecanii* (NBAIR) 1×10^8 spores/ g @ 5g/L for sucking pests

T2 = Chemical control

- Chlorantraniliprole 18.5% SC for *Tuta absoluta* and indoxacarb 14.5 SC for other pests

T3 = Untreated Control

The trial was laid out with RBD design with seven replications, plot size of 4x5 m, U44 as variety during *rabi* 2021-22 at farmers field in Laxmi Thanda, Shamshabad Mandal, Rangareddy district.

In 2021-22, no.of mined leaves was lesser in BIPM and Farmers' package (1.48-1.83/plant), fruit damage was 3.75-5.75% in BIPM and Farmers' practices, while in control plots it was 12.5%. Yield was 738 q/acre in BIPM package, while the farmers practise recorded 840 kg/plot and the control plot recorded 267 kg/plot (Table 212).

Table 212. Impact of BIPM practices on pests, natural enemies and yield in tomato

Treatment	No. of mined leaves/plant	Mirids (No./plant)	Fruit damage (%)	Predators (No./plant)	Parasitoids (No./plant)	Yield (Kg/plot)	B:C Ratio
BIPM package	1.83 (1.32)[a]	2.50 (1.52)	5.75 (2.36)[a]	1.73 (1.27)[b]	1.83 (1.32)[b]	738[b]	1.98
Farmers package	1.48 (1.19)[a]	1.96 (1.31)	3.75 (1.84)[a]	0.57 (0.74)[c]	0.57 (0.74)[c]	840[a]	1.26
Untreated Control	2.71 (1.61)[b]	3.02 (1.67)	12.5 (3.53)[b]	2.36 (1.52)[a]	3.03 (1.74)[a]	267[c]	-
CD (P = 0.05)	0.19	NS	0.91	0.23	1.01	53.0	
CV (%)	13.21	23.81	22.21	14.96	10.91	21.34	

MPUAT – Udaipur

IV. 22. 2. Large scale field trials for the management *Helicoverpa armigera* on tomato

The trial was undertaken with the treatment details mentioned here under

T1 = BIPM

- Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds.
- Azadirachtin 1500 ppm @ 2 ml/L.
- *Beauveria bassiana* @ 1x10^8 conidia /g, @ 5g/L – 2 sprays at 15 days interval.
- Spray of *HearNPV* (1.5 × 10^{12} POBS/ha) twice during the peak flowering and at fruit setting stage at 15 days interval.
- *Bacillus thuringiensis* @ 1kg/ha two times during season 15 days interval

T2 = Chemical control

- Spinosad 45 SC @ 0.25 ml/L

T3 = Untreated Control

The trial was laid out during *rabi* 2021-22 with three replications at farmers field in Pilader and Bovas (Jaisamand). 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 (13.75 t/ha) which was at par with the yield recorded in BIPM package (12.10 t/ha). Significantly, low yield was recorded in untreated control (7.92 t/ha). It could be concluded that BIPM package had promising results in minimizing the pest damage with higher yield.

YSPUHF, Solan

IV. 22.3. 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 Naineti, Narag and Deothi 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 1500 ppm @ 2 ml/L, one spray of *Lecanicillium lecanii* (5 g/L of 10^8 conidia/g). For comparison, the plots were sprayed with chlorantraniliprole 18.5EC and indoxacarb 14.5 EC alternatively at 15 days interval. 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 two sprays each of chlorantraniliprole 18.5EC and indoxacarb 14.5 EC were given. Observations on the number of mines per leaf, number of infested fruits 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. The data were compared by t-test and the results of the experiment are presented in tables 213 and 214.

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 0.24 to 0.26 mines/leaf. Seasonally the mine density remained nearly same in both the plots and varied from 0.24 to 0.41 mines per leaf in BIPM plots and 0.26 to 0.38 mines per leaf in chemical plots (Table 213).

Table 213. *Tuta absoluta* infestation on tomato leaves

Treatment	Mines/leaf on indicated weeks			
	July II	July IV	August II	August IV
BIPM	0.24 ± 0.12[a]	0.41 ± 0.14[b]	0.32 ± 0.13[a]	0.29 ± 0.17[a]
Chemical control	0.26 ± 0.13[a]	0.30 ± 0.11[a]	0.38 ± 0.14[a]	0.33 ± 0.16[a]

Similarly, the fruit infestation in the two plots remained almost same throughout the season and varied from 2.18 to 3.19 per cent in BIPM plots and 1.59 to 3.43 per cent in chemical plots (Table 214). The yield recorded in BIPM plots (33.8t/ha) was also statistically on par with that recorded in chemical treated plots (31.9t/ha).

Table 214. *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	2.71±0.77[a]	2.61±0.58[b]	3.19±0.77[a]	2.89±0.79[a]	2.18±0.52[a]	33.8±7.2[a]
Chemical control	2.63±0.62[a]	1.59±0.31[a]	3.28±0.81[a]	3.43±0.54[a]	2.67±0.45[a]	31.9±8.4[a]

The incidence of *Helicoverpa armigera* remained very low throughout the cropping season. Towards the end of the cropping season, a low incidence of tomato aphid, *Macrosiphum euphorbiae* was also recorded.

IV. 24. Brinjal

AAU - Anand

23.1. Development of biocontrol based IPM module for the management of fruit and shoot borer, *Leucinodes orbonalis* (Guenee) in brinjal

The trial was undertaken with the treatment details mentioned hereunder

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 (2x10^{8}cfu/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 and chlorantraniliprole18.5 SC, (0.006%) 3 ml/10 litre water - Three sprays at fifteen days interval with the initiation of pest.
T_3	Untreatedcontrol	-

The trial was laid out in CRD design with ten replications, plot size of 27x20m, ABH-1 as variety during 2021-22 at Agronomy farm, AAU, Anand. The shoot damage recorded at weekly interval revealed, significantly lowest shoot damage (2.27%) in BIPM module followed by chemical module (3.31%). The highest shoot damage was documented in untreated control treatment (7.89 %). With regard to the data on fruit damage recorded on number and weight basis inferred the same result, i.e.BIPM module recorded less fruit damage than the chemical module. The BIPM module recorded the highest fruit yield of 374.31 q/ha and it was statistically at par with the yield recorded in chemical module (346.78 q/ha) Table 215. 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 215. Efficacy of different modules against shoot and fruit borer damage and yield of brinjal during 2021-22

Modules	Shoot damage (%)	Fruit damage (%)		Yield (q/ha)	B:C Ratio
		Number basis	Weight basis		
BIPM Module	8.47^{a} (2.27)	9.09^{a} (2.50)	10.37^{a} (3.24)	374.31^{a}	7.89
Chemical Module	10.49^{b} (3.31)	11.30^{b} (3.84)	12.67^{b} (4.81)	346.78^{a}	6.93
Untreated Control	16.31^{c} (7.89)	16.15^{c} (7.74)	17.87^{c} (9.42)	85.23^{c}	1.89
S. Em ±	0.50	0.39	0.39	13.11	--
C.D. at 5 %	1.72	1.40	1.13	50.77	--
C. V. (%)	12.08	10.20	9.00	15.42	--

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

The pooled data over the years depicted that BIPM module was statistically significant in reducing the shoot damage (%) as compared to chemical module, whereas, the fruit damage (%) was found non-significant. The fruit yield in both the two components was found statistically at par (Table 216).

Table 216. Effect of different modules against shoot and fruit borer and yield in brinjal (Pooled 2020-21 and 2021-22)

Modules	Shoot damage (%)			Fruit damage (%)						Yield (q/ha)			B:C Ratio
				Number Basis			Weight Basis						
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	
BIPM Module	11.01*a (3.65)	8.47^{a} (2.17)	9.74^{a} (2.86)	12.07^{b} (4.37)	9.09^{a} (2.50)	10.58 (3.37)	14.01^{b} (5.86)	10.37^{a} (3.24)	12.19 (4.46)	499.13^{a}	374.31^{a}	436.72^{a}	9.20
Chemical Module	9.72^{a} (2.85)	10.49^{b} (3.31)	10.11^{a} (3.08)	10.45^{a} (3.29)	11.30^{b} (3.84)	10.87 (3.56)	11.34^{a} (3.87)	12.67^{b} (4.81)	12.00 (4.32)	515.72^{a}	346.78^{a}	431.25^{a}	8.62

Untreated Control	16.83b (8.38)	16.31c (7.89)	16.57b (8.13)	17.67c (9.21)	16.15c (7.74)	16.91 (8.46)	18.39c (9.95)	17.87c (9.42)	18.13 (9.68)	137.00b	85.23c	111.11b	2.47
S. Em ±	0.89	0.50	0.56	0.43	0.39	0.97	0.61	0.39	1.26	9.00	13.11	29.59	--
C.D. (P = 0.05)	2.78	1.72	1.67	1.12	1.40	NS	1.76	1.13	NS	26.75	50.77	180.05	--
C. V. (%)	10.27	12.08	11.36	10.12	10.20	10.17	13.17	9.00	11.42	7.42	15.42	13.33	--
Figures outside the parentheses are arcsine transformed values, those inside are retransformed values; NS = Non-Significant													

IIHR, Bengaluru

23.2. Bio-efficacy of microbial agents against *Myllocerous subfasciatus* on brinjal

The trial was undertaken with the treatment details mentioned hereunder

T1: *Metarhizium anisopliae* (IIHR Strain) oil formulation @1ml/L

T2: *Metarhizium anisopliae* (Biometa, AAU strain) (1x10^{8}spores /g) @ 5g/ L

T3: *Beauveria bassiana* (Biosona, AAU strain) (1x10^{8}spores /g) @ 5g/ L

T4: *Metarhizium anisopliae* (Ma-4) NBAIR strain (1x10^{8}spores /g) @ 5g/ L

T5: *Beauveria bassiana* (Bb-5a) NBAIR strain (1x10^{8}spores /g) @ 5g/ L

T6: *Heterorhabditis indica* @ 2.5 10^{9}IJs/ha

T7: Imidacloprid @ 20 g

The trial was laid out with RBD design with three replications, Arka Anand as the brinjal variety.Three sprays of microbial agents and treated check were done. Observations were recorded on the leaf damage scoring (0-10 scale). The leaf damage scoring was observed both on the older leaves and also the younger leaves. Mean leaf damage/plant was observed before spray and after every spray / treatment. Similarly, number of ash weevil adults were observed on 5 randomly selected plants in each replication.

The results revealed that the mean number of ash weevils per plant were significantly lower in treatments *Heterorhabditis indica* @ 2.5 10^9 IJs/ha and *M. anisopliae* (NBAIR) followed by *B. bassiana* (NBAIR) and *B. bassiana* (AAU). The entomofungal pathogens 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) were showing significantly lower leaf damage scoring compared to other treatments.

Table 217. Bio-efficacy of microbial agents against *Myllocerous subfasciatus* on brinjal

Sl. No.	Treatments	Mean number of ash weevils/plant				
		Before spray	After I spray	After II spray	After III spray	Pooled
T1	*M.anisopliae* IIHR @ 1 ml/L	4.98 (2.34)	1.75 (1.5)	12.33 (3.58)	5.65 (2.47)	6.57 (2.65)
T2	*M. anispoliae* AAU @ 5 g/L	4.66 (2.27)	1.67 (1.47)	12.98 (3.67)	3.66 (2.03)	6.10 (2.56)
T3	*B.bassiana* AAU @ 5 g/L	3.98 (2.11)	1.00 (1.22)	8.66 (3.02)	2.66 (1.77)	4.10 (2.14)
T4	*M. anisopliae* NBAIR @ 5 g/L	6.00 (2.54)	2.02 (1.58)	9.13 (3.10)	3.45 (1.98)	4.86 (2.31)
T5	*B. bassiana* NBAIR @ 5 g/L	6.00 (2.54)	1.25 (1.32)	8.00 (2.91)	2.89 (1.84)	4.04 (2.13)

T6	*Heterorhabditis indica* @ 2.5 10^9 IJs/ha	6.25 (2.59)	2.02 (1.42)	5.66 (2.48)	2.33 (1.68)	3.33 (1.95)
T7	Imidacloprid @ 0.5 ml /L	7.54 (2.83)	1.02 (0.70)	5.06 (2.35)	2.15 (1.62)	2.74 (1.8)
T8	Control	6.66 (2.67)	10.00 (2.91)	9.33 (3.13)	8.66 (3.02)	9.33 (3.13)
	CD (P = 0.05)	NS	1.22	0.88	0.84	1.85

IV. 24. Okra

IIHR, Bengaluru

IV. 24. 1. Management of hoppers, aphids and whitefly on Okra by oil-based formulation of *Metarhizium anisopliae* IIHR and NBAIR Strain

The trial was undertaken with the treatment details mentioned hereunder

T1: *M. anisopliae* (oil-based formulation) @ 0.25 ml/L

T2*: M. anisopliae* (oil-based formulation) @ 0.50 ml/L

T3: *M. anisopliae* (oil-based formulation) @ 1 ml/L

T4: *M. anisopliae* (WP formulation) @ 5 g/L

T5: Standard check – Imidacloprid @0.3 ml/L

T6: Control

The trial was laid out in RBD design with four replications, Arka Anamika as the variety. Observed only the incidence of leaf hoppers and the treatments were imposed. Among the two different formulations tested, T4 (*M. anisopliae* @ 5g/L) recorded the less number of hoppers population (2.13hoppers/plant) whereas with respect to different dosages of *M. anisopliae* (oil-based formulation) tested, T3 (*M. anisopliae* (oil based formulation) @ 1 ml/l) recorded the less number of hoppers population (3.38 hoppers/plant) (Table 218).

Table 218. Effect *Metarhizium anisopliae* formulations (IIHR and NBAIR strain) on hoppers populations

Treatments	Mean no of hoppers/plant		
	Pre count	After 1st spray	After 2nd spray
T1	4.50 (2.12)	4.19 (2.05)	4.25 (2.06)
T2	4.12 (2.03)	3.69 (1.92)	3.63 (1.90)
T3	4.37 (2.09)	3.38 (1.84)	3.38 (1.83)
T4	3.20 (1.80)	2.06 (1.44)	2.13 (1.45)
T5	3.62 (1.90)	1.69 (1.30)	1.75 (1.32)
T6	5.05 (2.25)	5.47 (2.34)	5.63 (2.37)
CD (P = 0.05)	NS	0.21	0.29
CV (%)	NS	4.08	5.63

IIVR, Varanasi

IV. 24. 2. Efficacy of biocontrol agents for management of fruit borer, *Earias vittella* on bhendi

The trial was undertaken with the treatment details mentioned hereunder,

T1: *Metarhizium anisopliae* (NBAIR) 1×10^8 spores/ g @ 5g/L

T2: *Beauveria bassiana* (NBAIR) 1×10^8 spores/ g @ 5 g/L

T3: *Trichogramma chilonis*@ 50,000 parasitoids/ha, 6 releases at weekly interval.

T4: *Bacillus thuringiensis* @ 1 kg/ha

T5: Azadirachtin 1500 ppm @ 2 ml/L

T6: University recommended insecticide (Emamectin benzoate 5 SG)

T7: Untreated control

The trial was laid out with RBD design with four replications, plot size of 8x5 m, Kashi Pragati as variety during *kharif* 2021-22 at ICAR-IIVR, Varanasi. 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 (70.07) 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 45.69 and 39.52 PROC, respectively (Table 219)., over other biopesticides and 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 *Metarhizium anisopliae* (NBAIR)1×10^8 spores/ g @ 5 g/lit.

Table 219. Bio-efficacy of different biocontrol agents against major insect pests of okra

Treatments	Damage fruit (%)		Jassid/leaf			PROC#	Whitefly/ leaf		
	Before spray	After spray	Before spray PROC#	After spray Before spray	PROC# After spray				
T1	12.56	7.43	55.08	4.69	2.46	45.69	2.36	0.51	71.19
T2	13.47	6.78	59.01	5.14	2.89	36.20	2.41	0.55	68.93
T3	11.69	8.29	49.88	4.87	4.12	9.51	2.53	1.69	4.52
T4	12.68	4.95	70.07	5.08	3.55	21.63	2.12	1.15	35.03
T5	13.57	9.81	40.69	4.32	2.74	39.52	2.67	0.46	74.01
T6	11.06	3.87	76.60	4.51	2.31	49.01	2.13	0.78	55.93
T7	12.34	16.54	--	5.06	16.54	--	2.47	1.77	--
SEm (±)	--	0.39	--	--	0.43	--	--	0.18	--
CD (P = 0.05)	--	0.88	--	--	0.97	--	--	0.37	--

#PROC= Per cent reduction over control;

AAU, Jorhat

IV. 24.3. Evaluation of biointensive IPM module against key pests of okra

The trial was undertaken with the treatment details mentioned hereunder,

T1 = BIPM Package

- Yellow sticky traps @20/ha for maintaining sucking pests.
- Rogue out the YVMV affected plant from time to time.

- Application of *Beauveria bassiana* @ 1×10^{8} cfu/ @ 5g/L.
- Applicationof NSKE @ 5%
- Five release of *Trichogramma chilonis* @ 1,00,000 / ha starting from 35 days after sowing at 10 days interval or coinciding with the emergence of *Earis* sp.
- Application of profenofos 50% EC @ 2ml/L. (at 2-3 sprays as need based)

T2 = Chemical control

Alternate spray of Clorantraniliprole 18.5 SC@ 0.4ml/L and lamdacyhalothrin 5% EC @ 1ml/L.

The trial was laid out with RBD design with ten replications, plot size of 60 mx50 m with area cover of 1 ha, Arka Anamika as variety during *kharif* 2021 at farmer'sfield NeulGaon, Jorhat.The results in the Table 220 indicated a significant difference between BIPM package and chemical control plot with regard to the parameters *viz*., mean number of sucking pests /leaf, number of larvae/5 plants and per cent fruit damage after treatment. In chemical control plot, six numbers of alternate spray of insecticides at fortnightly intervals contributed maximum protection from infestation of larvae per five plant and per cent fruit damage of 1.68 and 7.33 %, respectively as against 2.02 and 8.15 % in BIPM plot. However, highest marketable fruit yield of 76.49 q/ha was recorded in BIPM plot, whereas in chemical control plot, the yield was 69.10 q/ha. The per cent parasitisation on *Corcyra* sentinel cards by *Trichogrammatids* species in BIPM plot was 9.4 per cent as against 1.7% in chemical control plot.

Table 220. Biointensive insect management in okra

Treatments	Sucking Pest (No./leaf)		Shootandfruitborer (larvae/ 5 plants)		Fruit Damage (%)	Parasitisa-tion (%) *Tricho-gramma*sp.	Yield (Q/ha)
	Pre treat-ment	Post treat-ment	Pre treat-ment	Post treat-ment			
BIPM Package	3.09	1.73	4.94	2.02	8.15	9.4	76.49
Chemical control	3.55	1.90	4.93	1.68	7.33	1.7	69.10
"t" value	0.36	2.99	0.058	1.97	2.29		7.43
Remarks	NS	S	NS	S	S		S

*Mean of two observations

AAU-Anand

IV. 24.4. Bio-intensive pest management in okra

The trial was undertaken with the treatment details mentioned hereunder,

T_1	BIPM module	• Installation of pheromone traps 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	-

The trial was laid out during *kharif* 2021-22 at Farmers' fields, Umreth, Anand in 10 ha area. Significant lower *E. Vittella* larval population was recorded in BIPM module (1.11/ plant) whereas, the chemical module recorded larval population of 2.89/plant. With regard to *H. armigera*, larval population in BIPM module was (2.63/ plant) and chemical module (4.47/plant) found non-significant. The lowest population of jassid was documented in chemical module (2.26/ leaf) which was statistically at par with the population recorded in BIPM module (3.34/ leaf). In case of whitefly, BIPM module witnessed significantly lowest whitefly population (2.19/leaf) as compared to chemical module (4.21/leaf) (Table 221.). The BIPM module has witnessed significant highest population of coccinellids (2.60/ plant).

The fruit damage was significantly lower in BIPM module (3.50 % - number basis, 3.16 %– weight basis) as compared to chemical module (4.65 % - number basis, 4.02 % – weight basis). The BIPM module recorded higher yield (127.82 q/ha) as compared to chemical module (117.26 q/ha). This result demonstrates the successful bio-intensive module, which helps in reducing the pest incidence in okra with higher yield (Table 222.

Table 221. Effect of different modules against pest complex and natural enemies in okra

Modules	No. of *E. vittella* larvae/plant	No. of *H. armigera* larvae/plant	No. of jassids/ leaf	No. of white-flies/ leaf	No. of cocci-nellids/plan
	Pooled				
BIPM Module	1.27[a] (1.11)	1.77 (2.63)	1.96[a] (3.34)	1.64[a] (2.19)	1.76[a] (2.60)
Chemical Module	1.84[b] (2.89)	2.23 (4.47)	1.66[a] (2.26)	2.17[b] (4.21)	1.10[b] (0.71)
S. Em ± (T)	0.11	0.13	0.10	0.12	0.11
CD. (P = 0.05)	0.42	NS	0.35	0.44	0.43
CV. (%)	12.23	10.66	12.67	11.91	12.33

*Figures are √x + 0.5 transformed values whereas those in parentheses are retransformed values

Table 222. Effect of different modules fruit damage and yield of okra

Modules	Fruit damage (%)		Yield (q/ha)
	No. basis	Weight basis	
BIPM Module	10.78*[a] (3.50)	10.24*[a] (3.16)	127.82[a]
Chemical Module	12.45[b] (4.65)	11.56[b] (4.02)	117.26[b]
S. Em ± (T)	0.40	0.43	3.23
CD. (P = 0.05)	1.19	1.27	9.59
CV. (%)	10.85	12.40	8.33

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

IV. 25. Cabbage

AAU, Anand

IV. 25. 1. Influence of habitat manipulation on incidence and severity of pest damage on cabbage

The trial was undertaken with the treatment details mentioned hereunder,

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

The trial was laid out with RBD design with four replications, plot size of 4.2 x7.2 m, Sutton Express as variety during *rabi* 2020-21at Agronomy farm, AAU, Anand.The pooled over data on no. of aphids/plant in cabbage depicts that the treatment T_1 – cabbage intercropped with mustard and cowpea recorded the lowest aphid population (8.68/ plant) and which was followed by the treatment T_2 – cabbage intercropped with mustard and oats as a border crop (12.46/ plant) and treatment T_3- cabbage intercropped with cowpea and oats as a border crop (14.09/ plant) and these two treatments found statistically at par with each other. The lowest number of aphid population in these two treatments was attributed to the presence of a greater number of coccinellids/plant due to intercrops *viz*., mustard and cowpea and intercrop cowpea acts a trap crop of aphid. The treatment T_1 recorded the coccinellid population of 3.42/ plant, which was followed by the treatment T_2 (3.19 coccinellids/ plant). The highest population of aphids was documented in the treatment T_5-cabbage as a sole crop (23.22/ plant). 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 DBM larval population (1.32/ plant), which was followed by the next best treatment T_1- cabbage intercropped with mustard and cowpea (2.92 / plant). The sole cabbage treatment T_5 recorded the highest DBM larval population of 8.26/ plant.

The influence of intercrops and border crops in reducing the pest incidence was reflected in yield of the crop. The highest yield of 24.98 tonnes/ha was recorded in the treatment T_3- cabbage intercropped with cowpea and oats as border crop, which was followed by the treatment T_1–cabbage intercropped with mustard and cowpea (20.78 tonnes/ha). The pooled over years data also depicted the similar trend as documented during the individual years. The lowest aphid population of 8.44/plant was recorded in the treatment T_1, which was followed by the treatment T_3 (12.17/plant). Similarly, the lowest larval population of DBM was recorded in the treatment T_3 (1.30/plant), which was followed by the treatment T1 (2.42/plant). The highest yield of 25.36 t/ha was documented in the treatment $T_{3,}$ which was statistically at par with the yield recorded in the treatment T_1 (21.76 t/ha). Hence, it is concluded that the intercropping of cabbage with mustard and cowpea helps in reducing aphid infestation and growing cowpea as intercrop with oats as border crop witnesses low DBM incidence with higher yield (Table 223).

Table 223. Influence of habitat manipulation on incidence and severity of pest damage on cabbage (Pooled over Years)

Treat-ments	No. of aphids/plant			No. of larvae of DBM/ plant			No. of coccinellids/ plant			Yield (t/ ha)			B:C Ra-tio
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	
T_1	2.94*[a] (8.14)	3.03[a] (8.68)	2.99[a] (8.44)	1.56*[ab] (1.93)	1.85[b] (2.92)	1.71[b] (2.42)	1.92* (3.19)	1.98 (3.42)	1.95[a] (3.30)	22.75[ab]	20.78[bc]	21.76[ab]	4.23
T_2	3.53[b] (11.96)	3.60[b] (12.46)	3.56[b] (12.17)	1.79[bc] (2.70)	2.06[c] (3.74)	1.92[c] (3.19)	1.84 (2.89)	1.92 (3.19)	1.88[ab] (3.03)	21.00[c]	19.23[cde]	20.11[b]	3.90
T_3	4.25[c] (17.56)	3.82[bc] (14.09)	4.04[c] (15.82)	1.33[a] (1.27)	1.35[a] (1.32)	1.34[a] (1.30)	1.56 (1.93)	1.85 (2.92)	1.71[b] (2.42)	25.75[a]	24.98[a]	25.36[a]	4.92
T_4	4.48[cd] (19.57)	4.77[d] (22.25)	4.62[d] (20.84)	1.86[cd] (2.96)	2.51[d] (5.80)	2.19[d] (4.30)	1.56 (1.93)	1.73 (2.49)	1.65[bc] (2.22)	16.25[cd]	16.45de	17.60[bc]	3.42
T_5	5.10[e] (25.51)	4.87[de] (23.22)	4.98[e] (24.30)	2.35[e] (5.02)	2.96[e] (8.26)	2.65[e] (6.52)	1.31 (1.22)	1.48 (1.69)	1.40[c] (1.46)	15.75[d]	9.45[e]	12.60[d]	2.52

S. Em ±	0.14	0.14	0.10	0.05	0.07	0.13	0.14	0.12	0.09	1.52	1.27	1.63	
CD. (P = 0.05)	0.40	0.40	0.27	0.23	0.20	0.13	NS	NS	0.25	4.68	3.90	6.38	
CV. (%)	15.37	15.71	15.38	13.22	14.91	15.06	16.98	13.70	15.30	14.97	13.08	14.36	

Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values; NS = Non –significant

IV. 25. 2. Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid (*Brevicoryne/Myzus*) and *Plutella xylostella* (DBM) [AAU, Jorhat, MPKV, Pune]

The trial was undertaken with the treatment details mentioned hereunder

T_1= Bb-5a, isolate of *Beauveria bassiana* @ (1x10^8 spores/ml)

T_2= Bb-45, isolate of *Beauveria bassiana* @ (1x10^8 spores/ml)

T_3= Ma-4, isolate of *Metarhizium anisopliae* @ (1x10^8 spores/ml)

T_4= Vi-8, isolate of *Lecanicillium lecanii*

T_5= Alternate spray of malathion 50EC @ 1.5 ml/litre / Emamactin benzoate 5 SG @ 0.5 g/litre- AAU, Jorhat; Cynantraniliprole10.26% OD-MPKV, Pune.

T_6= Untreated control

AAU- Jorhat

The trial was laid out with RBD design with four replications, plot size of 400 m. sq., Asha (F1) as variety during *rabi* 2020-21at Horticultural Orchard, AAU, Jorhat. 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.

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* (3.38/plant) and *P. xylostella* (4.20/plant), with 65.51 and 56.92 per cent reduction over control followed by the next best treatment of *B. bassiana* (Bb-45 isolate) with 65.31 and 50.46 per cent reduction over control of aphid (3.40/plant) and DBM (4.83/plant), respectively. In case of yield, maximum of 215.25 q/ha was obtained in *L. lecanii* (V1-8 isolate) treated plot (Table 224). However, amongst the all treatments, four alternate sprays of chemical insecticides could significantly reduce the mean population of aphid (3.05/plant) and DBM (4.95/plant) in cabbage. It was also observed that, EPF of ICAR- NBAIR strains (Bb-5a, Bb-45, Ma-4 and Vl-8) were very much effective in reducing the insect pests in comparison to untreated control.

Table 224. 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	7.95	3.63^a	62.96	9.25	6.40^b	34.36	177.20
T_2	7.40	3.40^a	65.31	8.53	4.83^a	50.46	190.70

T_3	7.75	4.80[b]	51.02	9.38	6.40 [b]	34.36	179.40
T_4	7.53	3.38 [a]	65.51	9.05	4.20 [a]	56.92	215.25
T_5	7.50	3.05 [a]	68.88	8.60	4.95 [a]	49.23	212.13
T_6	7.55	9.80 [c]		8.95	9.75 [c]		135.65
CV (%)	4.12	10.76		5.22	7.65		2.97
CD (P = 0.05)	NS	0.76		NS	0.70		8.28

MPKV, Pune

The experiment was laid out on Research Farm of Agril. Entomology Section, College of Agriculture, Pune. Cabbage var. Golden Acre during *rabi* 2021-22, having plot size of 2.40 x 4.5 m with spacing 60.00 x 45.00 cm in RBD with six treatments replicated 4 times. Among the entomopathogenic strains, the treatment Vl-8 isolate of *Lecanicillium lecanii* @ 5.00 g per liter of water was found significantly superior with minimum aphid population 21.64 aphids/head and next promising treatment was Ma-4 isolate of *Metarhizium anisopliae* @ 5.00 g per liter of water with 28.03 aphid/head 10 days after last spray.

The two years pooled data after four spray was found statistically significant. Out of biopesticides, the VI-8 isolates of *Lecanicillium lecanii* @ 5.00 g/liter of water was superior in controlling aphid population and it was 28.45 number of aphids/3 leaves/head while Bb-5a isolate of *Beauveria bassiana* @ 5.00 g/liter of water was superior with 0.91 larvae of diamondback moth/head and at par with Bb-45 isolate of *Beauveria bassiana* @ 5.00 g/liter of water with 0.95 larvae of diamond back moth/head. Highest yield (149.98 q/ha) was recorded in the treatment Cynantraniliprol 10.26% OD while 129.59, 129.09 and 125.89 q/ha was recorded in VI-8 isolates of *Lecanicillium lecanii*, Bb-5a isolate of *Beauveria bassiana* @ 5.00 g/liter of water, and Bb-45 isolate of *Beauveria bassiana* @ 5.00 g/liter of water (Table 225).

Table 225. Efficacy of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Brevicoryne* and diamond back moth *Plutella xylostella* L (Two years pooled data)

Tr. No.	Treatment Details	Dose g., ml/l.	Aphid/plant		DBM larvae/Plant		Yield (Q. /ha)	B: C ra-tio
			Pre count	Pooled Mean	Pre count	Pooled Mean		
T1	Bb-5a isolate of *B.bassiana*	5.00	73.71 (8.61)	45.15 (6.76)	1.31 (1.35)	0.91 (1.18)	129.09	1.64
T2	Bb-45 isolate of *B.bassiana*	5.00	73.07 (8.58)	43.35 (6.62)	1.40 (1.38)	0.95 (1.20)	125.89	1.60
T3	Ma-4 isolate of *M. anisopliae*	5.00	71.43 (8.48)	36.69 (6.10)	1.38 (1.37)	1.18 (1.29)	124.90	1.59
T4	Vl-8 isolate of *L. lecanii*	5.00	70.79 (8.44)	28.45 (5.38)	1.40 (1.38)	1.26 (1.32)	129.59	1.65
T5	Cynantraniliprole 10.26% OD	1.50	70.06 (8.40)	18.82 (4.40)	1.44 (1.39)	0.68 (1.08)	149.98	1.75
T6	Untreated Control	Nil	76.98 (8.80)	94.20 (9.73)	1.40 (1.38)	2.10 (1.61)	104.22	1.42
SE ±			0.15	0.09	0.05	0.03	0.60	
CD (P = 0.05)			N.S.	0.27	0.14	0.10	1.81	
CV (%)			3.43	2.72	6.77	5.13	10.64	

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

Table 226. Costs and Economics of bioagent spraying in cabbage

Treatment	Bioagents & Insecticide cost (Rs. L/kg)	Qty/ha (Lt/kg)	Qty. used/ha (3applictn) Kg	Cost (Rs./ha)	Labour charges (Rs. /ha)	Total cost (Rs. / ha)	Cost of Culti-vat-ion/ha	Cost of Spraying Rs	Total cost Rs.	Yield (q/ha)	Rate/ Qt (Rs)	Gross returns (Rs. /ha)	Net return (Rs. /ha)	B: C ratio
T1	350	2.50	10	3500	4488	7988	110000	7988	117988	129.09	1500	193635	75647	1.64
T2	350	2.50	10	3500	4488	7988	110000	7988	117988	125.89	1500	188835	70847	1.60
T3	350	2.50	10	3500	4488	7988	110000	7988	117988	124.90	1500	187350	696362	1.59
T4	350	2.50	10	3500	4488	7988	110000	7988	117988	129.59	1500	194385	76397	1.65
T5	5500	600ml	5500	13750	4488	18238	110000	18238	128238	149.98	1500	224970	96732	1.75
Untreated Control							110000		110000	104.22	1500	156330	46330	1.42

AAU-Anand

IV. 25.3. Bio-intensive pest management in cabbage

The trial was undertaken with the treatment details mentioned hereunder,

T_1	BIPM module	• Installation of pheromone traps 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) (20 ml/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/ Farmer's practice	-

The trial was laid out during *rabi* 2020-21 at Farmers' fields, Navli, Sabarkantha in 10 ha area. Lowest population of diamondback moth larvae was recorded in BIPM module (2.09/plant) as compared to chemical module (3.03/plant). With regard to aphid population BIPM module recorded significantly lowest population (13.64/plant) as compared to chemical module (17.65/plant). With respect to the population of natural enemies, BIPM module witnessed highest coccinellids population (2.53/ plant) which was significantly higher than the population observed in chemical module (0.69/plant). Further, BIPM module recorded the significantly lowest fruit damage (3.09 %) as compared to chemical module (4.41 %). Due to significant low fruit damage in BIPM module, it recorded the highest yield (29.63 t/ha) which was statistically at par with the yield documented in chemical module (23.50 t/ha) (Table 227).

Table 227. Impact of different modules on fruit damage and yield of cabbage

Modules	Fruit damage (%) No. basis	Yield (t/ha)
BIPM Module	10.13*[a] (3.09)	29.63[a]
Chemical Module	12.12[b] (4.41)	23.50[a]
S. Em ±	0.5	2.08
C.D. at 5 %	1.53	5.22
C. V. (%)	14.67	12.15

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

IV. 26. Cucumber

AAU, Jorhat

IV. 26. 1. Evaluation of BIPM against fruit flies *Bactrocera cucurbitae* against cucumber

The trial was undertaken with the treatment details mentioned hereunder

T1: BIPM practices

Good agricultural practices (racking, weeding)

Installation of cuelure @ 15/ha

Destruction of damaged fruits

Sprayof neem - based insecticides (NSKE 5% @ 5ml/L)

Sprayof spinosad 45SC @ 0.3 ml/L

T2: Conventional practices (Chemical Control)

Jaggary 1% + malathi on 50 EC @ 2 ml/L

T3: Untreated control practice

The trial was laid out in RBD design with four replications, plot size of 400m^2, Malainias variety during *kharif* 2021 at Experimental farm, Dept.of Horticulture, Jorhat. The BIPM package revealed minimum per cent damaged fruits (16.18%) which was significantly different from chemical control where the per cent damaged fruit was 28.41% 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 86.46 q/ha yield was recorded in BIPM package as against 58.74 q/ha in conventional package. The maximum damaged fruits (35.20 %) caused by Fruit fly was recorded in untreated control plot with minimum yield of 44.96 q/ha (Table 228).

Table 228. 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	23.54 (11.28)	18.47 (10.00)	16.18 (9.37)	86.46
Conventional practices	25.23 (11.71)	28.69 (12.47)	28.41 (12.40)	58.74
Untreated control	28.82 (12.52)	31.59 (13.10)	35.2 (13.81)	44.96
CV (%)	4.93	6.40	9.22	3.25
CD (P = 0.05)	0.2914	0.3785	0.546	2.4022

*Mean of 10 plants with 3 observations. Data in parenthesis denotes square root transformation.
Means followed by the same letter in a column are not significantly different.

IV. 27. Onion

AAU, Anand

IV. 27. 1. Efficacy of different biocontrol agents against onion thrips (*Thrips tabaci* L.)

Table 229. Treatment to evaluate biocontrol agents against onion thrips

Treatments		Concentration	Quantity required/ 10 litre water
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	-	-

The trial was laid in RBD design with three replications, plot size of 3.0 x 4.8 m, Talaja local as variety during *rabi* 2021-22 at Agronomy farm, AAU, Anand. Among the different bio-pesticides/biocontrol agents evaluated for their bio efficacy against onion thrips, *T. tabaci* the data on thrips population after three sprays depicted that the treatment T_3 – *Metarhizium anisopliae* AAU strain Ma1 recorded the lowest thrips population (3.42 thrips/ plant; 2.29 thrips/plant; 1.52 thrips/plant, first, second and third spray, respectively) which was followed by the next best treatment T_6 – Azadirachtin 10000 ppm (3.83 thrips/plant; 2.42 thrips/plant;1.84 thrips/plant, first, second and third spray, respectively). These two treatments were found statistically at par in reducing the population of *T. tabaci*.

The data on thrips population pooled over periods over sprays depicted that among different biopesticides evaluated, T_3 – *Metarhizium anisopliae* AAU strain Ma1 (3.0 thrips/plant) was the effective treatment with lowest number of thrips/plant followed by T_6 – Azadirachtin 10000 ppm (3.74 thrips/ plant). The untreated control treatment recorded the highest thrips population of 13.56 thrips/ plant (Table 230).

Table 230. Efficacy of different biocontrol agents against onion thrips (Pooled over years)

Treatments	No. of thrips/plant		
	2020-21	2021-22	Pooled
T_1	2.98^{*d} (8.38)	2.90^{d} (7.91)	2.93^{e} (8.08
T_2	2.93^{d} (8.08)	2.43^{c} (5.40)	2.70^{d} (6.79)
T_3	2.05^{b} (3.70)	1.69^{c} (2.36)	1.87^{b} (3.00)
T_4	3.36^{e} (10.79)	3.22^{e} (9.87)	3.29^{g} (10.32)
T_5	3.42^{e} (11.20)	2.90^{d} (7.91)	3.15^{f} (9.42)
T_6	2.34^{c} (4.98)	1.77^{b} (2.63	2.06^{c} (3.74)
T_7	1.14^{a} (0.80)	1.09 (0.69)	1.12^{a} (0.75)

T_8	3.94[f] (15.02)	3.57[f] (12.24)	3.75 (13.56)
S. Em ±	0.05	4.76	0.04
CD. (P = 0.05)	0.15	0.36	0.13
CV (%)	9.83	12.75	10.17

* Figures are √x + 0.5 transformed values whereas those in parentheses are retransformed values

IV. 28. Capsicum

UAS, Raichur

IV. 28. 1. Evaluation of entompthogenic fungi, *Beauveria bassiana* (NBAIR-Bb-5a) and *Lecanicillium lecanii* (NBAIR-VL 15) against sucking insect pests of capsicum in open field condition

The trial was undertaken with the treatment details mentioned hereunder,

T1: *B.bassiana* @ 1×10^8 @ 5 gm/l (NBAIR-Bb-5a) @ 5.0g/L

T2: *L. lecanii* @ 1×10^8 @ 5 gm/l (NBAIR-VL-8) @ 5.0 g/L

T3: *L. lecanii* @ 1×10^8 @ 5 gm/l (NBAIR-VL-15) @ 5.0g/L

T4: *M. anisopliae* @ 1×10^8 @ 5 gm/l (NBAIR-Ma 4) @ 5.0g/L

T5: *Isaria fumosorosea* (NBAIR strain) @ 1×10^8 @ 5.0 g/L

T6: Azadirachtin 1500ppm @ 2 ml/L

T7: Untreated control

The trial was laid in RBD design with three replications, plot size of 54 sq. m, Indra as variety during 2021-22 at Raichur. A day before spray, thrips population ranged from 5.18 to 6.06 per leaf and it was statistically non-significant. Highest per cent reduction of thrips population over control was noticed in *L. lecanii* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l (69.65 %) and followed by *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l (67.50 %). Similarly, mite population ranged from 10.32 to 11.56 per leaf at a day before spray. Among the biocontrol agents, per cent reduction of mite population over control was highest in *L. lecanii* @ 1×10^8 @ 5 gm/l (ICAR-NBAIR-VL-15) @ 5.0 g/l (67.77 %) and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l (64.17%). Highest fruit yield of 25.28 q/ha was noticed in *L. lecanii* @ 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 24.62 q/ha while untreated control recorded lowest fruit yield of 16.04 q/ha (Table 231).

Table 231. Evaluation of *Beauveria bassiana* (NBAIR-Bb-5a) and *Lecanicillium lecanii* (NBAIR-VL 15) against sucking insect pests of capsicum

Sl. No.	No. of thripsleaf				No. of mites/leaf				
	IDBS	7 DAS	10 DAS	ROC (%)	IDBS	7 DAS	10 DAS	ROC (%)	Fruit yield (t/ha)
T_1	5.62 (2.47)	2.78 (1.81)	1.36 (1.36)	64.00 (53.13)	11.28 (3.43)	6.34 (2.62)	4.18 (2.16)	51.43 (45.82)	22.18
T_2	5.46 (2.44)	2.64 (1.77)	1.94 (1.56)	60.17 (50.87)	11.56 (3.47)	5.18 (2.38)	3.74 (2.06)	58.82 (50.08)	23.64
T_3	5.34 (2.42)	2.18 (1.64)	1.14 (1.28)	69.65 (57.34)	10.32 3.29)	4.36 (2.20)	2.62 (1.77)	67.77 (55.41)	25.28

T_4	5.28 (2.40)	3.16 (1.91)	2.78 1.81)	48.35 (44.05)	11.24 3.43)	7.28 (2.79)	5.94 (2.54)	38.97 (38.63)	19.84
T_5	5.18 (2.38)	2.54 (1.74)	1.18 (1.30)	67.65 (55.34)	10.56 3.33)	4.94 (2.33)	2.82 (1.82)	64.17 (53.23)	24.62
T_6	5.24 (2.40)	3.98 (2.12)	3.12 (1.90)	38.26 (38.21)	10.32 3.29)	8.86 (3.06)	5.68 (2.49)	32.87 (34.98)	18.98
T_7	6.06 (2.56)	6.12 (2.57)	5.38 (2.42)	0.00 (0.00)	10.94 3.38)	11.12 (3.41)	10.54 (3.32)	0.00 (0.00)	16.04
S Em $\pm$	0.21	0.04	0.06	-	0.18	0.03	0.05	-	0.65
CD (P = 0.05)	NS	0.12	0.18	-	NS	0.11	0.17	-	1.91

Figures in parentheses are square root transformed values

IV. 29. Amaranthus

KAU, Vellayani

IV. 29. 1. Efficacy of capsule formulations of *Beauveria bassiana* in managing amaranthus leaf webber *Hymenia recurvalis*

The trial was undertaken with the treatment details mentioned hereunder,

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/L

T6- Spore suspension of NBAIR isolate @10^8 spores ml/L

T7- Untreated check

Seven days after second spraying all the treatments were effective in reducing the pest. Spraying *Bb* (KAU) capsules @ 3/ L or its spore suspension 20 ml/L was the best treatment followed by the effect of capsules and spore suspension of *Bb*5 (NBAIR) where the mean population was 0.46 to 0.53 per plan. Talc formulation @ 20 g / L of both the strains were inferior (1.06 to 1.2 caterpillars per plant) to capsules and spore suspensions. The corresponding population in control was 1.4 caterpillars per plant.

IV. 30. Cassava

IV. 30.1. Survey for incidence of *Phenacoccus manihoti*- the recent invasive mealybug on cassava (TNAU, Coimbatore, KAU, Vellayani, ICAR- NBAIR, Bengaluru)

TNAU, Coimbatore

Surveys were conducted to assess the mealybug damage in cassava fields in Erode, Namakkal, Tirupur and Salem Districts. *Phenacoccus manihoti* infestation ranged between 15.00 and 35.00 per cent. Among the predatory species, *Hyperaspis maindroni* was found to be the predominant coccinellid predator of the mealybug. Besides, *Hyperaspis maindroni*, *Mallada* sp., *Cryptolaemus* sp. were seen on the colonies of *P. manihoti.*

KAU, Vellayani

Phenacoccus manihoti was observed only in one or two locations in Kottarakkara block of Kollam district, during Sept.- Oct. 2020 and 20-21. However, its presence could not be located in none of the tapioca fields of Trivandrum district.

ICAR-NBAIR, Bengaluru

The surveillance undertaken in the Tamil Nadu during June-July 2021 indicated the severity of cassava mealybug (CMB), *Phenacoccus manihoti* on cassava with shoot tip damage scale of 3-4 in most of the cassava growing places in Salem, Namakkal, Dharmapuri, Krishnagiri, Tiruppur, Erode, Kallakuruchi, Cuddalore, Karur, Thanjavur, Villupuram, Coimbatore, Tiruvannamalai, Tiruvarur, Tenkasi and Kanyakumari districts. The occurrence and spread of cassava mealybug on cassava was also reported in several places of Thrissur and Thiruvananthapuram districts of Kerala.

Host range of *P. manihoti* across agricultural and horticultural crops:

Other than the host plant (cassava), occurrence of *P.manihoti* in any of the agricultural and horticultural crops were not recorded.

Importation of classical biocontrol agent, *Anagyrus lopezi* from IITA, sub center, Benin

To tackle the CMB outbreak in India, NBAIR has imported the classical biocontrol agent, *Anagyrus lopezi* (Encyrtidae: Hymenoptera) from International Institute of Tropical Agriculture (IITA) with its sub center at Republic of Benin (Permit No. 17/2020-21 dated 29.10.2020) through International cooperation ably facilitated by ICAR.

A total of 192 parasitoids were emerged from the consignment of *A. lopezi* received on 13 August 2021. Its morphological as well as molecular identity was confirmed (GenBank accession No. OK085480). The mandatory quarantine studies on biology, safety and host specificity of the *A. lopezi* was undertaken in the QC2 quarantine facility of NBAIR to ensure its non-target impacts.

ICAR-NBAIR has optimized the mass production and field release protocol of this parasitoid wasp in small as well as large scale setup on cassava mealybug colonies. Further, ICAR-NBAIR has conducted the trainer's training programmes in four batches and trained the staffs of State Agricultural Universities, State Horticulture Departments and Krishi Vigyan Kendras on mass production and field release techniques of *A. lopezi*.

The first field release programme of the parasitoids and its distribution to the cassava farmers have been organized by ICAR-NBAIR in collaboration with Tapioca and Castor Research Station (TNAU), Yethapur, Salem district of Tamil Nadu on 7 March 2022. About 300 tapioca farmers from six districts of Tamil Nadu attended the event.

IV. 31. POLYHOUSE PESTS

KAU, Thrissur

IV. 31. 1. Management of sucking pests on cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition

The experiment was laid out during *rabi* 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 x 2 m^2 Replications: 5

Treatments:

T1: *Blaptostethus pallescens* @ 10 nymphs/m row twice at 10 days interval

T2: *Blaptostethus pallescens* @ 20 nymphs/ m row twice at 10 days interval

T3: Spiromesifen 45 SC @100g.a.i ha^{-1} twice at 10 days interval or recommended insecticide for use in polyhouse

T4: Control

In a thirty days old crop, different stages of *T. truncatus* were released by stapling mulberry leaf discs containing mites onto the under surface of cucumber plants. Plots receiving different treatments were separated from each other by using garden nets to prevent movement of predator from one treatment to another. Treatments were applied after establishment of spider mites on cucumber plants. Mite population was recorded before as well as at 3, 6 and 9 days after application of treatments. Three plants were randomly selected from each replication. Mite counts were taken from one infested leaf each at the top, middle and bottom level of each tagged plant. Number of mites per cm^2 leaf area was recorded *in situ* from three loci/leaf.

Three days after the first release, plots treated spiromesifen at the rate of 100 g.ai/ha recorded the lowest number of 1.24 mites/ cm^2 and was significantly superior to the remaining treatments. This was followed by plots where *B. pallescens* were released at the rate of 20 bugs /m row, with a mite population of 3.57/ cm^2, which was again significantly superior to the remaining treatments. Plots in which *B. pallescens* were released at the rate of 10 bugs/m row had 5.39/ cm^2 and were on par with untreated plots having an average of 6.34 mites/cm^2. A similar trend was observed for second release as well, plots treated with the acaricide recorded less mite infestation and remained significantly superior to the other treatments. This was followed by plots in which bugs were released @ 20/m row. Nine days after second release, all the treatments were on par with each other except control. *B. pallescens* @ 10 m/row (0.08 mites/ cm^2) recorded mite population of 0.078 mites/sq. cm. Both the treatments, *viz*. spiromesifen as well as *B. pallescens* @ 20 m/row recorded zero mite population. Mite population was highest in untreated plot with 0.22 mites/ cm^2.

Difference was also observed in terms of yield per plant. *B. pallescens* released @ 20/ m row recorded a significantly higher mean yield of 2.53 kg per plant, followed by acaricide treated plot (2.23 kg/plant). Untreated control plots and *B. pallescens* @ 10/ m row recorded significantly lower yield of 1.90 and 1.92 kg/ plot respectively and these treatments were on par with each other.

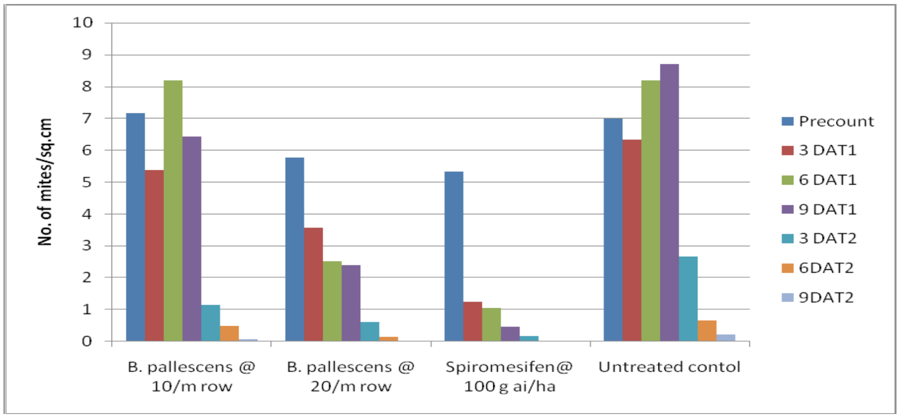


Fig 67.

Field efficacy of *B. pallescens* against *Tetranychus truncatus* on salad cucumber

Pooled analysis (2019-20 and 2021-22)

Results of pooled analysis are presented in Table 232. In the first-year trials, all the plants in the control plots had dried up before the second-round application of treatments due to severe mite infestation. Hence, while pooling the data of two years, data for mite infestation in control plots were not included.

The pooled analysis also mirrors the conclusions of the individual trials. Both acaricide and *B. pallescens* @ 20 m/ row plots were effective in causing a consistent reduction in the mite population throughout the study period, thereby indicating the potential of the predator to be a safer alternative to synthetic acaricides in managing spider mites in cucumber under polyhouse conditions. *B. pallescens* has been reported as a type II predator with increasing prey at higher densities. Difference was also observed in terms of yield per plant. *B. pallescens* released @ 20 /m row recorded the highest mean yield of 2.73 kg per plant, followed by acaricide treated plot at 2.70 kg/plant, both being on par with each other. *B. pallescens* @ 10/ m row recorded a mean yield of 2.17 kg per plant. Untreated control plots recorded significantly lower yield of 1.72 kg/plot. All the treatments were significantly superior to control plots (Table 232).

The above trial has indicated that two releases of the predatory anthocorid @ 20/m row can be effective in controlling spider mites in polyhouses with superior yield and confirms the potential of *B. pallescens* as a biocontrol agent under protected situations.

Table 232. Pooled analysis of field efficacy of *Blaptostethus pallescens* against *Tetranychus truncatus* on cucumber

Treatment	Number of mites/cm^2 after							
	first release				second release			
	Precount	3 DAT$_1$*	6 DAT$_1$	9 DAT$_1$	3 DAT$_2$	6 DAT$_2$	9 DAT$_2$	
B. pallescens @ 10/m row	5.53 (2.28)	4.54 (2.09)^{a}	5.96 (2.35)^{a}	4.96 (2.14)^{a}	1.80 (1.47)^{a}	1.16 (1.24)^{a}	0.74 (1.05)^{a}	2.17^{b}
B. pallescens @ 20/m row	4.84 (2.16)	3.26 (1.79)^{a}	2.56 (1.57)^{b}	2.41 (1.52)^{b}	1.19 (1.26)^{a}	0.80 (1.08)^{a}	0.32 (0.88)^{ab}	2.73^{a}
Spiromesifen @ 100g.ai ha^{-1}	4.66 (2.13)	1.38 (1.14)^{b}	1.14 (0.99)^{c}	0.76 (0.82)^{c}	0.15 (0.80)^{b}	0.03 (0.73)^{b}	0.04 (0.73)^{b}	2.70^{a}
Control								1.72^{c}
CD (P = 0.05)	NS	0.306	0.445	0.398	0.268	0.279	0.222	0.365

Values in parentheses are square root transformed values. *DAT – Days after treatment

IV. 31. 2. Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse (ICAR-IIHR, Bengaluru)

The trial was undertaken with the treatment details mentioned hereunder,

T1: *Metarhizium anisopliae* (NBAIR) 1x10^8 spore/ g @ 5 g/L

T2: *Metarhizium anisopliae* (IIHR) oil based formulation @1 ml/L for only IIHR

T3: *Lecanicillium lecanii* (NBAIR) 1x10^8 spore/ g @ 5 g/L

T4: *Beauveria bassiana* (NBAIR) 1x10^8 spore/ g @ 5 g/L

T5: *Chrysoperla zastrowi sillemi* @ 4 larvae / plant, 2-3 releases (weekly) to be made.

T6: Five (weekly) releases of *Blaptostethus pallescens* @ 30 nymphs/ m row length

T7: Azadirachtin @ 2 ml/L of 1500ppm

T8: Fipronil @1 ml/L

T9: Control

The expereimet was laid out in RBD design with plot size of 2x2 mo, Arka Mohini as the variety. The results revealed that, there was significant reduction in the thrips population in chemical control. All the entomopathogenic treatments are not statistically significant with each other. There was no significant difference observed among the treatments except chemical control. Among the entomopathogens treatment, *Beauveria bassiana* (NBAIR Bb5a) @ 5 g/L followed by *Lecanicilium lecanii* (NBAIR Vl8) @ 5 g/L was significant against thrips on capsicum under polyhouse conditions. But not significant reduction of thrips was observed.

IV. 31. 3. Management of phytophagous mites on cucumber using *Blaptostethus pallescens* and *Neoseiulus longispinosus* under polyhouse condition (YSPUHF, Solan)

Experiment on the management of phytophagous mite, *Tetranychus urticaes* on cucumber by using *Blaptostethus pallescens* and *Neoseiulus longispinosus* was carried out at the experimental farm, Department of Entomology, YSPUHF, Solan under polyhouse conditions in an RBD with 5 replications. *Blaptostethus pallescens* was released at the rate of 10 and 20 nymphs per metre 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 of the experiment revealed, mite population before treatment varied from 2.9 to 3.4 mite/cm^2 with no significant differences. The mite population in treated plots decreased gradually and was 1.9, 1.6, 1.4, 1.1 and 0.9 mites/cm^2in plants treated with *B. pallescens* (10 nymphs/m row), *B. pallescens* (20 nymphs/m row), *N. longispinosus* (1:30), *N. longispinosus* (1:20) and spiromesifen (100 g a.i./ha), respectively, after 14 days of the second treatment. In control plants, the mite population increased from 3.4 mites/ cm^2 in the beginning to 19.2 mites/ cm^2 in the end of the experiment. After 14 days of the second treatment, the mite population was the lowest in spiromesifen (100 g a.i./ha) treated plants, however, the mite population was on par in plants where *N. longispinosus* (1:20), *N. longispinosus* (1:30) or *B. pallescens* (20 nymphs/m row) was released. The yield was significantly higher in all the treatments when compared with untreated control. The highest yield (6.8 kg/plant) was recorded in plants treated with spiromesifen (100 g a.i./ha) followed by *N. longispinosus* (1:20) (5.5 kg/plant), *N. longispinosus* (1:30) (4.6 Kg/plant), *B. pallescens* (20 nymphs/m row) (3.9 Kg/plant) and *B. pallescens* (10 nymphs/m row) (3.4Kg/plant). In untreated control plants the yield was 2.0 Kg/plant Table 233.

Table 233. Evaluation of *Blaptostethus pallescens* and *Neoseiulus longispinosus* against *T. Urticae* in cucumber

SN	Treatment	Mite count/cm^2 @ days after treatment					Yield (kg/ plant)
		Pre-count	I- treatment		II- treatment		
			7	14	7	14	
1	*B. pallescens* @ 10 nymphs/m row twice at 15 days interval	3.3	3.1[c]	2.9[c]	2.4[c]	1.9[b]	3.4[c]
2	*B. pallescens* @ 20 nymphs/ m row twice at 15 days interval	3.1	2.7[c]	2.3[b]	2.1[c]	1.6[ab]	3.9[c]
3	*N. longispinosus* @ 1:30 (predator: prey) twice at 15 days interval	2.9	2.7[c]	2.1[b]	1.9[bc]	1.4[ab]	4.6[b]
4	*N. longispinosus* @ 1:20 (predator: prey) twice 72 at 15 days interval	3.2	1.9[b]	1.8[ab]	1.6[b]	1.1[ab]	5.5[ab]
5	Spiromesifen 45SC (100g.a.i ha^{-1}) twice at 15 days interval	3.3	0.8[a]	1.4[a]	0.6[a]	0.9[a]	6.8[a]
6	Control	3.4	4.8[d]	8.6[d]	12.9[d]	19.2[c]	2.0[d]
	CD (P = 0.05)	NS	0.7	0.6	0.4	0.8	1.3

V. 32. TRIBAL SUB PLAN

Table 234.

State	District, Sub district and Taluk	Name of the tribal villages	Description of the activities/ Achievements	Number of beneficiaries	Amount spent (in Lakhs)
Assam	Jorhat, Golaghat, Nagaon, Majuli	Baghmora, Charighoria, Kareng Chapori, Sadiyal, Na-chelauria - Jorhat. SDAO, Bokakhat, Bankuwal, Mohuramukh, Bokakhat – Golaghat. Barkachari gaon, Barkachari gaon – Nagaon. Kamalbari - Majuli.	Training and material distribution	350	9.5
Gujarat	Narmada, Dediapada, Dahod.	Soliya, Mohabhi, Kham, Almavadi, Nigat, Barsan, Guldacham, idiyapada, Vedchha, Taval, Nani bedva, Navagam,Gajar gota, Aajnai, Timba pada, Nana, Suka amba, Khokharaumer, Sorapada, Aalamavadi, Gurnumbar, Khodaaamba, Chikda, Khokharaumar, Navagam, Saburi, Dabaka, Jaragam - Narmada, Dediapada. Aabhalod, Singapur, Sanjeli, Motihandi - Dahod.	Khedutshibir and training programme (input distribution) was organized to train the farmers on use of biocontrol inputs and strategies to tackle key pests and diseases to achieve sustainable crop production.	75	2.43

Andhra Pradesh	Visakhapatnam district Arakuvalley division	15 hamlet villages Sovva , Killoguda, Kothavalasa panchayathi's, Dumbriguda mandal, Arakuvalley division, Visakhapatnam district	1. Awareness programme on Biological control in plant protection of rice, ginger, turmeric and vegetables on 27.08.2021 and 21.12.21 for 130 tribal farmers . 2.Exposure visit for creating awareness on Biological control agents and Biopesticides for 40 tribal farmers 3. Demonstration on Biointensive pest mangement in rice, ginger, turmeric and vegetables in 179 acres by 125 farmers. 4. Establishment of Biopesticides production unit for farmers level production of Biocontrol agents *Trichogramma*) and Biopesticides (*Beauveria, Metarhizium, Trichoderma, Pseudomonas*) with training the field functionaries of Dhimsa Natural farming Farmers Producer Organisation (FPO) working under Sanjeevini NGO for promoting organic cultivation by tribal farmers with Rs.3.0 lakhs is in progress.	130	6.16
West Bengal	Alipurduar II, Coochbehar-II.	Baniagaon, Nurpur, Shamuktala - Alipurduar II. Singimari - Coochbehar-II.	i) Training on cultivation practice of mustard with special reference to biological control. ii) Distribution of mustard seed, *Trichoderma viridae* and neem oil. iii) Training on cultivation practice for litchi with special reference to biological control iv)Distribution of litchi saplings v)Awareness about use of biocontrol agents for management of crop, pests and diseases. vi) Training on biological control of insect pests and input distribution	208	0.80178
Kashmir	Rafiabad	----	Collection of base line data regarding holding capacity of each farmer and extent of apple damage	100	----
Himachal Pradesh	Keylong, Udaipur, Kalpa.	Tandi – Keylong. Udaipur – Udaipur. Poorbani, Roghi - Kalpa.	Trainings and input distribution	160	1.70

Chhattisgarh	Rajnandgaon, Kondagaon, Bastar	Arajkund, Ambagarh, Chowki - Rajnandgaon. Bangoli, Bangaon, Kongud, Bhumka, Bhupgaon, Bokrabeda, Bhandarshivni, Paharasgaon, Pasangi and Bade Donger - Kondagaon. Lendra and Sedva – Bastar.	Demonstrated the various bioagents. Distributed the items of Wota T traps, plastic drums and sprayers	253	
Uttarakhand	Udham Singh Nagar, Bajpur block.	Vijayrmpura and Sheetpuri - Udham Singh Nagar.	20q Biocontrol agent PBAT-3 (*Trichoderma harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) was distributed to the farmers for soil, seed, root dip treatment and foliar spray through biocontrol agents to counter soil borne diseases. Distributed quality seed of paddy (5q), a vegetable seed kit containing seeds pea (1kg), coriander (250g), fenugreek (100g) and spinach(100g). Demonstrated Soil Solarization technology to farmers for the application of polysheet (2x10m) on nursery beds of paddy. Placed Pheromone trap (nos.2000) with lure control rice stem borer. Placed Yellow sticky trap for control of sucking pest. 02 field day conducted. 08 training conducted.	232	5
Karnataka	Raichur	Buddinni, Sirwar -Raichur.	Distribution of inputs cum training programme on integrated crop management. Training programme on integrated pest management in chickpea. The various inputs including seeds and bio-inputs were distributed to farmers and they were trained about integrated crop management in rabi crops on 21st October 2021	72	
Odisha	Dhenkanal	Dolopasi, Batagaon and Haladikundi village of Kankadahada block.	Training and material distribution (Booklets and Trichocards)	100	0.67035

Fig 68. Glimpses of TSP activities by AICRP-BC , AAU, Jorhat centre

Training and material distribution at Baghmora, Allengmora, Jorhat, on 26.04.2021

Training and material distribution at Charighoria, Allengmora, Jorhat, on 27.04.2021

Training and material distribution at Kareng Chapori, Allengmora, Jorhat, on 28.04.2021

Training and material distribution at SDAO office, Bokakhat, Golaghat, on 23.11.2021

Fig 69. NBAIR scientists, Dr.G.Sivakumar, AICRP cell incharge and Dr.Venkatesan, Principal Scientist (Entomology interacted with tribal farmers about the advantages of Biological control. Hon'ble board member Sri. Demudulugaru attended the meeting, distributed biocontrol agents, Biopesticides, biofertilizers to tribal farmers. A total of 70 tribal farmers, VAA's benefitted with the programme, at RARS, Anakapalle.

Fig 70. Dr. G.Sivakumar and Dr.T.Venkatesan, NBAIR scientists visit on 26.7.21

Fig 71. Dr.M.Nagesh, Director and Project Coordinator (AICRP BC), NBAIR, Bangalore visit on 25.2.22

Fig 72. Farmers'participation in training programmes at Solan

Fig 73. Training under TSP on AICRP on Biocontrol, at Village- Arajkund, Ambagarh Chowki Rajnandga-onand Bade Dongar, Kondagaon - Raipur

Fig 74. Activities at farmer's field of tribal area in District Udham Singh Nagar (Pantnagar)

Fig 75. View of Training Programme on IPM at Buddinni Village (Raichur)

VI. 33. GENERAL INFORMATION

VI. 33. 1. Functioning of the co – ordinated project

33.1.1 Scientific staff position

Table 235.

Centres	Name of the Scientist/s	Phone number	E-mail ID
Regular Centres			
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ANGRAU, Anakapalle	Dr. M.Visalakshi	09618061963	visalamahanthi@yahoo.co.in
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VI. 33. 2. BUDGET of AICRP for 2021-2022

Table 236.

Details of Expenditure	Sanctioned and allotted grants (Rs. in lakh)	Grants released during 2021-22 from ICAR (Rs. in lakh)	Total expenditure (Rs.)
Pay and allowances	**217.08**	**217.08**	**217.08**
Capital	**6.10**	**6.10**	**6.10**
Recurring Contingencies	**429.67**	**429.67**	**429.67**
T.A	**25.33**	**25.33**	**25.33**
Toatal	**678.18**	**678.18**	**678.18**

VI. 33.3. PROBLEMS ENCOUNTERED DURING THE YEAR (2021-2022)

AAU, Jorhat

Survey and collection of natural enemies from different Agro-ecological zone, demonstration and field trials on farmer's fields were partially affected by corona pandemic and assembly election of the state.

TNAU

Mealybug (*Phenacoccus manihoti*) damage in cassava was observed in Coimbatore, Salem, Tiruppur and Namakkal Districts.

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. *Apertochrysa* sp eggs are being supplied to farmers for the management of this invasive pest.

In the maize growing areas in Tamil Nadu, fall army worm damage was observed and IPM measures were recommended to the farmers.

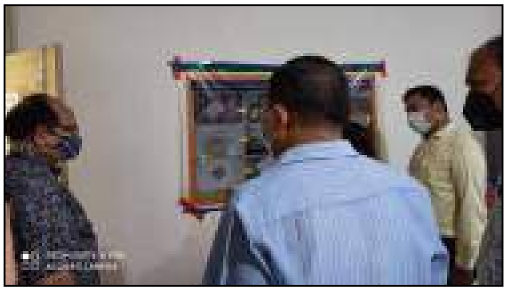
PAU, Ludhiana

Deficit funds under Salary head.

VI. 33. 4. VISITORS

AAU, Jorhat

- Nilam Dutta, Director, Pabhoi organic visited the biocontrol laboratory on 30th August, 2021.
- Dr. Jitender Kumar, Director, IPFT, New Delhi visited biocontrol laboratory on 7th September, 2021.
- A group of farmers lead by Mr. Dimbeswar Panging of Lakhimpur visited biocontrol laboratory on 10th December, 2021.
- Mr. Keerti Bordoloi from All India Radio, Jorhat visited biocontrol laboratory on 13th December, 2021.
- Dr. Meghali Chaliha, HoD, Forensic Science, Jorhat Medical College, Jorhat, Assam visited the biocontrol laboratory on 10th February, 2022.
- Practical on "Mass production of Bioagents" to the trainees of NAHEP sponsored short training on 'Skill in handling and management of agrochemicals and their impact on health and environment after 75 years of Independence" on 12.02.2022 held from 8th to 19th February, 2022 in the Department of Entomology, AAU, Jorhat campus.



Visit of Dr. Jitender Kumar, Director, IPFT, New Delhi on 7th September,2021

Visit of Dr. Meghali Chaliha,HoD, Forensic Science, Jorhat Medical College, Jorhat, Assam on 10th February,2022

Visit of farmers to biocontrol laboratory on 10th December,2021

Practical on "Mass production of Bioagents" to the trainees of NAHEP sponsored short training on 12.02.2022

Fig 76.

ANGRAU at RARS, Anakapalle

AICRP biological control Project coordinator cell Chairman, Dr. G. Sivakumar, Principal scientist (Microbiology) and Dr. T. Venkatesan, Principal scientist (Entomology) visited RARS, Anakapalle, monitored AICRP BC scheme laboratory activitites and field experiments on 26.08.2021. NBAIR, Bangalore scientists participated in awareness programme on biological control at Killoguda panchayat, Dumbrigudamandal interacted with tribal farmers on 27.08.2021. NBAIR, Bangalore scientists visited previously operated TSP villages, Pedalabudu, kothavalasa, observed apiary unit, discussed with farmers on 28.08.2021.

ANGRAU Board members visited biocontrol laboratory during july, 2021and interacted on scope for up scaling biocontrol agents production.

AICRP on sugarcane Monitoring team of scientists visited AICRP Biocontrol lab and interacted on research activities of AICRP biological control on 07.12.2021

Dr. M. Nagesh, Director and Project Coordinator (AICRP BC), NBAIR, Bangalore along with Dr. C. V. Narayanan, Principal scientist, IIHR, Bangalore and two NBAIR scientists visited AICRP BC, observed the Biocontrol laboratories activities, interacted on mass production of bioagents and gave valuable suggestions in research activities of AICRP biocontrol on 25.2.2022.

Fig 77. Dr. G. Sivakumar and Dr. T. Venkatesan, NBAIR scientists visit on 26.7.21and
Dr. M. Nagesh, Director and Project Coordinator (AICRP BC), NBAIR, Bangalore visit on 25.2.22.

Fig 78. AICRP on Sugarcane monitoring Team visited AICRP Biocontrol labs on 22.12.21

Fig 79. Agricultural college students learning on Biocontrol agents production technology

Fig 80. Awareness on biocontrol agents to Pesticide dealers

PJTSAU, Hyderabad

Dr. Ch.Damodar Raju, Associate Director of Research Regional Agricultural Research Station, Palem, Nagarkurnool dt. for an office inspection on 11 November, 2021

Dr. V.Anitha, Dean – P.G.Studies, PJTSAU, for discussions on Black Soldier Fly project for submission to NAHEP Wealth to Waste on 9 January, 2021.

Dr. V.Anitha, Dean – P.G.Studies, PJTSAU, for discussions on Black Soldier Fly project for submission to NAHEP 12 February, 2021

TNAU

Table 237.

Sl. No.	DATE	VISITORS	PURPOSE
1.	27.09.21	Dr.P.Kolandaivel, Ex Vice Chacellor of Periyar Univesity	To know about the mass production of Bio-control agents
2.	06.10.21	Mr.M.V.S.NagiReddy, Vice Chairman, AP State Agriculture Mission	To know about status of Coconut RSW and its management.
3.	27.12.21	Dr.G.Sivakumar, Principal Scientist, NBAIR, Begaluru	To review the activities of AICRP-BC

VI. 33. 5. Awards/Honours/Recognition

AAU, Anand

The center is awarded with 'Certificate of Excellence' by Plant Protection of Association of Gujarat (PPAG), Gujarat on 30th December 2021 in recognition of center's continuing excellence in research and extension activities on biological control of crop pests and diseases

ICAR - CPCRI

- Dr. Chandrika Mohan, Principal Scientist (Agricultural Entomology), ICAR-CPCRI, Regional Station, Kayamkulam was awarded the first Dr K. K. Nirula Memorial Prize-2021 in recognition of her outstanding contributions in Biocontrol of Coconut Pests. She also delivered the first Dr. K. K. Nirula Memorial lecture-2021 during the "*National Seminar on Advances in Biological Suppression of Pests*" held at ICAR-CPCRI, Regional Station, Kayamkulam on 22-09-2021.

- The research paper (OP03) entitled "Antagonistic interaction of bacterial symbionts of entomopathogenic nematodes against fungal pathogen associated with coconut leaf rot disease" presented by Arsha G. Madhu, Anes K.M., Merin Babu, Indhuja S., Vidya J. and Josephrajkumar A. was conferred the third best oral presentation award during the "*National Seminar on Advances in Biological Suppression of Pests*" held at ICAR-CPCRI, Regional Station, Kayamkulam on 22-09-2021.

DRYSRHU, Ambajipeta (HRS)

- Dr. N.B.V.Chalapathi Rao, Principal Scientist (Ent.) was awarded "Dr. B.S.Bhumannavar Team Research Award" in the Sixth National Conference on Biological Control held from 3rd to 5th March 2021 from ICAR-National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru.

- Dr. N.B.V.Chalapathi Rao, Principal Scientist (Ent.) received "Best Research Paper Award" from ICAR-National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru for the paper "Effect of Bio Pesticides on Mango Hopper *Idioscopus* spp under field conditions in Andhra Pradesh".

- Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ent.) received Best Scientist Award for his contribution in coconut pest management from Dr .B.V. David foundation 3rd National conference- Recent advance in crop protection including IPM and Environmental Sciences from GLP perspective held on October 17th, 2021 in Chennai, Tamilnadu.

- Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ent.) received Rythu Nestam Puraskaram 2021 Award on 30.10.2021 by the Sri M. Venkaiah Naidu, Honble Vice-President of India organized by Muppavarapu Foundation, Andhra Pradesh

SKUAST-K

- Dr. Jamal Ahmad: Best oral presentation award on Field efficacy of entomopathogenic nematodes against two lepidopteran pests infesting kale, *Brassica oleracea* L. var. Khanyari in Kashmir valley in 6th National conference on Biological Control at Bengaluru, 3-5 March, 2021.

- Dr. Malik Mukhtar: University award for the grant of patent on 'Estimation of mineral oil residue in apple and soil by Gas Chromatograph with Flame Ionization Detector.

PAU, Ludhiana

- PAU Centre got best All India Coordinated Research Project (AICRP) on Biological Control of Crop Pests Centre Award for year 2020-21.

GBPUA&T, Pantnagar

- Best Oral Presentation Award for the paper on Bio-intensive management of major diseases in vegetable cultivation in Uttarakhand at 6th National conference on Biological Control held at Bengaluru organized by ICAR and NBAIR, from 3-5 March, 2021. Bhupesh Kabdbwal, Roopali Sharma and J Kumar.

- Faculty Excellence Award 2021 for significant and exemplary contribution of Dr. Roopali Sharma. GBPUA & T, Pantnagar.

ANGRAU

- Dr. M.Visalakshi, Principal Scientist (Entomology) received Best sugarcane scientist for significant contribution in sugarcane organic farming sponsored by Sri. Durgamamba charitable trust, KCP sugars during ANGRAU annual convocation held at Tirupati in Oct, 21.

VI. 33. 6 Education &Training

AAU, Jorhat

- 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.
- Dr. D. K. Saikia, Principal Scientist was appointed as external question setter for Umroi, Umiam Meghalya for comprehensive examination.
- Dr. D. K. Saikia, Principal Scientist was appointed as examiner for thesis evaluation of M. Sc. (Ag.) of Nagaland University.
- 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)
- Seven Ph.D. students are being carried out P.G. research work under the guidance of Dr. D.K.Saikia,
- 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
- Dr. D.K.Saikia, Principal Scientist impart coaching to UG students for JRF examination
- Dr. D.K.Saikia act as a Co- investigator in the Biopesticides programme under DBT –AAU, Centre
- R. N. Borakakati, Jr. Scientist acted as a course leader of UG course viz., PP (Ento)-213 & PP(Ento)-312 . Besides this he also acts as course instructor of PG courses Biological Control (ENT 507) and Integrated Pest Management (ENT-510)
- 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:

- R. N. Borkakati acted as resource person in a training programme entitled "Production of vermiworm and other beneficial animals" on 22.12.2021, where target group is Progressive farmers
- R. N. Borkakati acted as resource person in a training programme organized by AAU, Jorhat in collaboration with NAHEP on 12.02.2022, where target group is Scientist, Assistant professor, Extension functioneries and Students

Training programme to extension functionaries

Fig 81.

Normal training

Three numbers of training were conducted on 19th, 20th, 22nd and 23rd April, 2021 at different villages viz., Kareng Chapori Gaon, Nagabaat, Sologuri, 2 no. Tiruwal area of Jorhat and Golaghat. A total of 100 numbers of farmers participated in this training programme. The main subjects covered in the training were BIPM package of Field &Vegetable crops and eco-friendly pest management strategy etc. The farmers were asked about different agricultural problems regarding rice and vegetable pests and their biological control approach. They were satisfied with the practical of training.

Four numbers of training were conducted on 4th, 5th, 6th and 23rd October, 2021 at different villages viz., Na cheleria (Jorhat district), Tiruwal (Goaghat district), Rajabahar ((Jorhat district) and Simaluguri (Nagaon district). A total of 105 numbers of farmers participated in this training programme. The main subjects covered in the training were BIPM package of Field &Vegetable crops and eco-friendly pest management strategy etc. The farmers were asked about different agricultural problems regarding rice and vegetable pests and their biological control approach. They were satisfied with the practical of training.

Four numbers of training were conducted on 23.12. 2021, 24.12. 2021, 14.02. 2022 and 15.02. 2022 at different villages viz., Baghmora (Jorhat district), Charighoria (Jorhat district), Bankuwal, Mahuramukh (Goaghat district) and SDAO, Bokakhat (Golaghat district). A total of 100 numbers of farmers participated in this training programme. The main subjects covered in the training were BIPM package of Field &Vegetable crops and eco-friendly pest management strategy etc. The farmers were asked about different agricultural problems regarding rice and vegetable pests and their biological control approach. They were satisfied with the practical of training.

A training pragramme was conducted on 07.03. 2022 at Senchowa village of Nagaon district. A total of 35 numbers of farmers participated in this training programme. The main subjects covered in the training were BIPM package of Field &Vegetable crops and eco-friendly pest management strategy etc. The farmers were asked about different agricultural problems regarding rice and vegetable pests and their biological control approach. They were satisfied with the practical of training.

Glimpses of the Training programme

Training and material distribution Kareng Chapori Gaon, Jorhat on 19.04.2021

Training and material distribution Nagabaat, Jorhat on 20.04.2021

Training and material distribution Sologuri, Jorhat on 22.04.2021

Training and material distribution 2 No. Tiruwal, Golaghat on 23.04.2021

Fig 82.

Training and material distribution at Na-cheleria, Jorhat on 4.10.2021

Training and material distribution at Tiruwal, Golaghat on 5.10.2021


Training and material distribution at Rajabahar, Jorhat on 6.10.2021


Fig 83. Training and material distribution at Simaluguri, Nagaon on 23.10.2021

AAU, Anand

- Training/webinar on 'Importance of biocontrol agents in organic farming'on 31.08.2021
- State level training on 'Production and use of biocontrol agents was organized jointly by Anand Agricultural University (AAU), Anand and Gujarat Organic Agricultural University (GOAU), Anand on 07.10. 021

Extension activities

- Conducted one-day training programme on 'Bioagents Awareness Day' to commemorate Azadi ka Amrit Mahotsav on 28.09.2021
- Farmers meet/Khedutshibir and input distribution/training programme under TSP in association with KVK, Dediapada (Navsari Agricultural University, Navsari) on 28.10.2021
- Farmers meet/Khedutshibir and input distribution/training programme under TSP in association with KVK, Dediapada (Navsari Agricultural University, Navsari)on 22.02.2022
- Farmers meet/Khedutshibir and input distribution/training programme under TSP in association with KVK, Dahod (Anand Agricultural University, Anand) on 15.03.2022
- Participated and exhibited the stall of Biological Control Research Laboratory in Pre-Vibrant (Agriculture) Gujarat summit 2021 during 14th to 16th Dec 2021.
- In the year 2021-22 the center has taken an initiative to conduct 'Bio-agents awareness week' in farmers' fields in every month. Different bio-agents were released in various farmers' fields. On-farm awareness trainings on utilization of bio-agents and on-farm production/enrichment of microbial bio-pesticides were given to the farmers. An approximate area of 100 ha has been covered under this programme

ANGRAU at RARS, Anakapalle

- Dr. M. Visalakshi, Principal Scientist (Entomology) gave lecture on "Role of Biopesticides and Biocontrol agents in Organic farming" on organised by Open and Distance learning Centre, ANGRAU through online for participants of organic farming certificate course.

- Dr. M. Visalakshi, Principal Scientist (Entomology) organised awareness programme on Biological control for 100 farmers of Srikakulam, Vizianagaram, Visakhapatnam districts and felicitated six best farmers for adopting biological control in rice, maize and one agricultural officer and one extension personnel for promoting biological control in plain and tribal areas of Srikakulam, Vizianagaram and Visakhapatnbam districts at RARS, Anakapalle during 63rd Kisan mela on 29.11.2021.

- Dr. M. Visalakshi PS (Ento) conducted awareness programme on Biointensive pest management practices in vegetables, turmeric, ginger and rice for 60 tribal farmers of Demudulavalasa village, Dumbriguda mandal, Araku valley division, Visakhapatnam district on 21.12.2021.

- Dr. M. Visalakshi PS (Ento) conducted training programme on management of maize fall army worm to 50 maize farmers at Thatithuru village, Bheemili mandal Visakhapatnam districts on 31.01.2022.

- Dr. M. Visalakshi, PS (Ento) organised awareness programme on Biological control in coconut to 100 coconut farmers at Govindapauram, Pusapatirega mandal, Vizianagaram district on 19.02.2022 and conduted demonstration on management of coconut rugose spirallying whitefly in 50 acres .

Fig 84.

Resource person for Short Course on Organic farming in Practice

- Dr. M. Visalakshi, Principal Scientist (Entomology) participated as resource person in Short course on Organic farming in Practice organised by Regional Agricultural Research Station, Chinthapalli, ANGRAU during 21.10.21 to 1.11.2021 and gave lecture on Integrated pest management in organic cultivation on 28.10.21

Kisan mela

- Dr. M. Visalakshi PS (Ento) arranged exhibition on Biological control during Kisan Mela at RARS, Anakapalle on 29.11.2021 and created awareness to farmers in biological control in agricultural and horticultural crops.

- Dr. M. Visalakshi PS (Ento) conducted awareness programme on Biological control for 100 farmers of Srikakulam, Vizianagaram, Visakhapatnam districts and felicitated six best farmers for adopting biological control in rice, maize and one agricultural officer and one extension personnel for promoting biological control in plain and tribal areas of Srikakulam, Vizianagaram and Visakhapatnbam districts at RARS, Anakapalle during 63rd Kisan mela on 29.11.21.

MPUAT, UDAIPUR

Table 238. Farmers Training:

S. No.	Area	Crop	No. of farmers
1.	Madar, Lakhawali and Sare (Badgaon)	Maize	88
2.	Piladar (Jaisamand)	Tomato	13
3.	Falichadakhedi (Mavali)	Gram	12
	Total		113

Two farmer's trainings were conducted at farmer's 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 2021-22.

Table 239.

S. No.	Locations	Date of training	No. of Participants
a.	**TSP area**		
1.	Hayla, Block Sayara	29.07.2021	44
2.	KVK, Vallabhnagar	06.08.2021	70
3.	Sagatari (Kurabar) 30.12.2021		103
4.	Khokhrafalan (Debari)	11.01.2022	67
	Total		284
b.	**Non-TSP area**		
5.	On-Campus Training: Department of Entomology, RCA, Udaipur	18.09.2021	28
6.	On-Campus Women's Training: Department of Entomology, RCA, Udaipur	13.01.2022	35
	Total		63
	Grand Total		347

Fig 85. Farmer's training at different villages of Udaipur district

PJTSAU, Hyderabad

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.

Farmer level preparation and use of biological control methods for the management of Fall armyworm on 22 December, 2021 as part of the National Interactive Workshop on Fall armyworm organized by NIPHM, Rajendranagar on 21-22 December, 2021.

EXTENSION ACTIVITIES

VILLAGE ADOPTION PROGRAMME

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* 2022

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.

Integrated Pest Management of shoot and fruit borer in brinjal in rabi 2022

Regular monitoring of various crops to know pest situation in the village

Conducted an interactive session cum awareness programme on "Use of bioagents and biopesticides in pest management" on 5 February, 2022 in the village

Distribution of pheromone traps to rice farmers for the Rice IPM field demonstration at Sheriguda Bhadraipally Village, Kothur mandal, RR dt.

Fig 86. Demonstrating the erection of pheromone traps to IPM farmers and Exhibiting biological pesticides and bioagents in Fifth International Agronomy Congress in "Agri Inputs to Combat Food and Nutrition Challenges" held during 23-27, 2021 at PJTSAU.

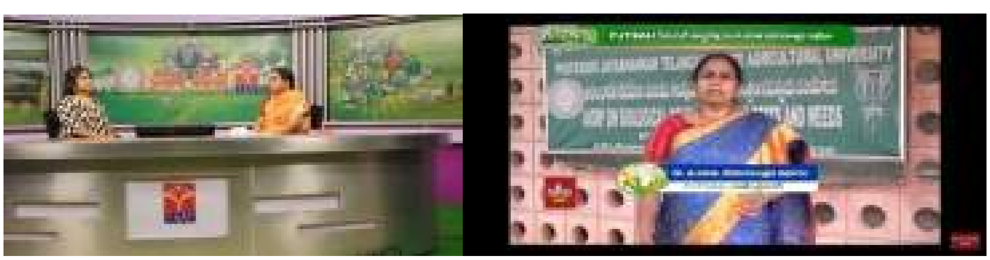


Fig 87. PHONE-IN LIVE PROGRAMME to answer farmers querries in the use of bioagents and biopesticides in Telangana State Govt channel, TSAT on 25 November, 2021 and Participated in a 30 minute awareness programme on biopesticides and their field use in HMTV AGRI channel broadcasted in March 2022

CPCRI

(i) National Seminar organized

As part of *Bharat kiAzadi ka Amrit Mahotsav*, ICAR-CPCRI, Regional Station, Kayamkulam organized a one-day National Seminar on "*Advances in Biological Suppression of Pests*" on 22-09-2021 in virtual mode to stock take on bio-control in crop pest management in general and biological pest suppression in coconut, in particular. Dr. S. Kalavathi, Head, ICAR-CPCRI, RS, Kayamkulam welcomed the gathering and introduced all dignitaries and the theme of the seminar. Dr Anitha Karun, Director, ICAR-CPCRI, Kasaragod delivered the presidential address. The National Seminar was inaugurated by Dr. Chandish R. Ballal, Former Director, ICAR-NBAIR, Bengaluru. She also delivered the key note address on the topic 'Classical Biological Control – India as a Beneficiary and Benefactor. Dr. Chandrika Mohan, Principal Scientist delivered the first 'Dr. K. K. Nirula Memorial lecture (2021)' on 'Advances in Bio-Suppression of Coconut Pests'.

Fig 88. The special guests Dr. Madhu Subramanian, Director of Research, KAU and Dr. M. Nagesh, Director, ICAR-NBAIR, Bengaluru offered felicitation address. Two publications *viz*., Entomology Luminaries @ Kayamkulam and Proceedings of the National Seminar on Advances in Biological Suppression of Pests with abstracts from PG scholars as well as a short video on "Ecological engineering for Pest Regression" was released. A panel discussion moderated by Dr. C. P. R. Nair, Former, Head, ICAR-CPCRI, RS, Kayamkulam and attended by esteemed dignitaries, Dr. Santhosh J Eapen, Head, Crop Protection, ICAR-IISR, Kozhikode, Dr. C. A. Jayaprakas, Head Division of Crop Protection, ICAR-CTCRI, Thiruvananthapuram, and Dr. G Suja, Head, ORARS, Kayamkulam. Dr. R. Chandramohanan, Former Head, Division of Crop Protection, ICAR-CPCRI, Kasaragod chaired the Technical session on "*Bio-control of pests, nematodes and diseases of crops*" Dr. Rohini Iyer, Former Head, Division of Crop Protection, ICAR-CPCRI, Kasaragod and Dr. K. Subaharan, Principal Scientist, ICAR-NBAIR, Bengaluru served as co-chairs of the session. About 30 students were participated in the technical session and made their oral and poster presentations. Dr. Vinayaka Hegde, Head, Division of Crop Protection, chaired the valedictory function and farewell felicitation meeting for Dr. Chandrika Mohan, P S. Dr. K. Subaharan, PS presented the seminar recommendations and announced the best oral presentation awards for successful three scholars. Dr. A. Joseph Rajkumar, PS outlined the Entomology Luminaries at Kayamkulam from Dr. Nirula to Dr. Chandrika Mohan briefly.

- Recommendations of National Seminar on Advances in Biological Suppression of Pests
- Virulence validation, smart packaging of entomophaga and quality assessment of entomopathogen formulations used in palm system
- Ecological intensification through crop pluralism induced conservation biological control for tackling pest outbreaks and conserving pollinators and defenders.
- Promoting one-health approach encouraging animal, plant, human and environmental health for sustainable food production system

- Ecosystem services of pollinators in plantation crops
- Deciphering the Functional genomics and evolutionary approaches to unravel the questions to betterment for development of strategies
- Imaging techniques for non-invasive diagnosis of pest and diseases.
- Impact of climate change in palm pest and disease dynamics and their mitigation measures

(ii) Organized Coconut Advisory Series from 16thJuly to 1stSeptember 2021 on virtual platform

As part of '*Bharat ki Azadi Ka Amruth Mahotsav*' ICAR-CPCRI, Regional Station Kayamkulam organized 'Coconut Advisory Series-2021' entitled 'Coconut Based Sustainable Agriculture' on every Monday, Wednesday and Friday from 16th July to 1st September, 2021. The series started with ICAR Foundation Day lecture by Dr. S. Kalavathi, Acting Head of the Regional Station on the topic 'How to make coconut cultivation sustainable in the changing climate'. There were a total of twenty lectures in the series wherein the farmers were empowered in a comprehensive manner on every aspects of coconut cultivation including information on coconut varieties, mother palm selection, nursery management, planting and aftercare, nutrition management, irrigation, intercropping, pest and disease management in coconut and intercrops, incursion management of invasive pests, organic recycling, use of microbes, value addition and entrepreneurial opportunities in coconut sector. Farmers from all over the Kerala have registered and attended the advisory series which was conducted online in Zoom platform and simultaneously as YouTube live. More than 11000 views have been registered averaging more than 500 views per session in YouTube, which is visible evidence on the success of the programme.

Fig 89.

KAU, Thrissur

Table 240.

Sl. No	Date of training/ class/ interface	Topic	Venue	Beneficiaries	Organised by
1	17, 20 & 29-05-21	MTA programme	Online	Farmers	KVK, Thrissur
2	17-09-21	Training programme - production of cost effective biopesticides	AICRP on BCCP	Kudumbasree members	Krishi bhavan, Alathur
3	19-11-21	Biological control in rice	Variyam kole padavu, Arimbur	Farmers	AICRP on BCCP, Vellanikkara
4	18-11-21	Biological control in rice	Manali Padasekharam Thekkinkara	Farmers	AICRP on BCCP, Vellanikkara
5	03-02-22	Biocontrol agents – on farm production	Online	Agriculture Assistants	RATTC, Vytilla
6	26-02-22	Biological control	AICRP on BCCP	Farmers	KVK, Tavanur
7	05-03-22	Biocontrol agents	AICRP on BCCP	Farmers	KVK, Thrissur
8	26-03-22	Biocontrol agents	AICRP on BCCP	Farmers	KVK, Thrissur

Fig 90. Training programme at Manali Padasekharam, Thekkinkara, Thrissur
Training programme to empower Kudumbasree members
Training programme and demonstration at Variyam kole padavu, Thrissur

DRYSRHU, Ambajipeta (HRS)

On 04.08.2021, Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ent.) Ambajipeta conducted one day Training Programme on "Predator Rearing Technique (*Apterochrysa astur*)" to AICRP on palms Centres Entomologists through virtual mode in collaboration with AICRP on Palms, ICAR-CPCRI Kasaragod, Kerala.

SKUAST, Jammu

Training programme for farmers

- Organized One day training programme entitled "Bio intensive pest management of fall armyworm (*Spodoptera frugiperda*) and stem borer (*Chilo partellus*) in maize under AICRP Bio-control on 29th July, 2021 at village Madana.

- Organized one day training programme on First release of *Trichogramma chilonis* for the management of Fall armyworm in maize at village Khara Madana 9th August 2021.

- Organized one day training programme for farmers entitled, "Second Field Release of *Trichogramma chilonis* and neem (commercial product) for the management of fall armyworm in maize. At village Khara and Madana, Distt, Samba byAll India Coordinated Research project on Bio-control in collaboration with AICRP for Dryland Agriculture, ACRA, Rakh Dhiansar under the aegis of SKUAST-Jammu on 12thAugust 2021.

Training/conference/ kisanmela attended

- Five days online training on "Pest Surveillance" organized by National Institute of Plant Health Management, Hyderabad from 23rd to 27th August, 2021.

- As an expert in the village and Revisit programme on 6-11-2021 at ChanniManhasaVijaypur organizes by Directorate of Extension SKUAST-Jammu.

- As an expert in the village and Revisit programme on 04-02-2022 at Suba Chak Kathua organizes by Directorate of Extension SKUAST-Jammu

- As an expert in the village and Revisit programme on 11-02-2022 at ChanniManhasaVijaypur organizes by Directorate of Extension SKUAST-Jammu.

- Attended one day online Webinar on "Mass Production of fungal and bacterial agents A, scope for budding start up organized by College of Horticulture and Forestry, Central Agricultural University (Imphal), Pasighat, Arunachal Pradesh, under Institutional Development Plan of National Agricultural Higher Education project held on 2nd and 03rd November, 2021.

- Prepared and Displayed exhibits pertaining to available IPM techniques for Kisan Mela organized by SKUAST-Jammu w.e.f. 7th to 11th October, 2021.

- Prepared and Displayed exhibits pertaining to available IPM techniques during five days


फाल आर्मी वर्म से निपटेंगे ट्राइकोग्रामा चिलोनिस के अंडे

Fig 91. Kisan Mela organized by SKUAST-Jammu w.e.f. 21st to25th March, 2022.

Training programme for farmers

- Organized One day training programme entitled "Bio intensive pest management of fall army worm (*Spodoptera fungiperda*) and stem borer (*Chilo partellus*) in maize under AICRP Bio-control on 29th July, 2021 at village Madana.

- Organized one day training programme on First release of *Trichogramma chilonis* for the management of Fall armyworm in maize at village Khara Madana 9th August 2021.

- Organized one day training programme for farmers entitled, "Second Field Release of *Trichogramma chilonis* and neem (commercial product) for the management of fall armyworm in maize. At village Khara and Madana, Distt, Samba byAll India Coordinated Research project on Bio-control in collaboration with AICRP for Dryland Agriculture, ACRA, Rakh Dhiansar under the aegis of SKUAST-Jammu on 12thAugust 2021.

Table 241. Lectures delivered

Name of the programme & the place	Date (s)	No. of Lectures	No. of participants (Approx.)
Lecture delivered on '*Integrated pest management in Rabi crops*' in a training programme entitled "Farmers awareness programme cum Input distribution" organized by AICRPAM under SC-SP, Division of Agro-meteorology, at Village Ranjadi, Tehshil – Vijaypur, Samba	09.02.2022	One	150 (Farmers)
Delivered a lecture on *Bio-intensive Integrated Pest Management for Soil Health*. In training on "Climate Smart Agriculture: Soil Health and Carbon Farming" organized by SAMETI and Advanced Centre for Horticulture Research, Udheywalla, SKUAST-Jammu w.e.f. 01st to 03rd November, 2021	02.11.2021	One	30 (Department of Agriculture officials)
Delivered a lecture on *Biological Tools for Biotic Stress (Insect pest) Management in Crop Plants* In training on "Mitigation Strategies of Abiotic and Biotic Stress in Agriculture / Horticulture Crops" organized by SAMETI and Advanced Centre for Horticulture Research, Udheywalla, SKUAST-Jammu w.e.f. 10thto11th November, 2021	10.02.2021	One	30 (Department of Agriculture officials)
Delivered two lectures on "Insect Pest Management; Identification (harmful& beneficial insect pests), symptoms" and "Classification of new generation pesticides, compatibility of agrochemicals, storage pests and Management"In DAESI Programme organized by SAMETI, SKUAST-Jammu	01.12.2021 02.12.2021	Two	35 (Agri- Input dealers)



Fig 92. Pictures of training programme and kissanmela

KAU, Kumarakom

- Faculty induction training programme of Kannur University, January 2022 attended by Mrs. Pallavi Nair (Co-PI)
- Data analysis and hands on training in statistical methods, February 2022 attended by Mrs. Pallavi Nair (Co-PI)
- Identification of phytophagous mites with special reference to Tetranychidae, March 2022 attended by Mrs. Pallavi Nair (Co-PI)

PAU, Ludhiana

- Dr. P.S. Shera delivered lecture on ‘Use of tricho-cards in major *kharif* crops’ during Webinar for PAU *kisan* club members organized by Directorate of Extension Education, PAU, Ludhiana on May 6, 2021.
- Dr. Sudhendu Sharma delivered lecture on ‘Integrated pest management of wheat insect pests’ training on ‘Good Agricultural Practices in Wheat’ organized by School of Organic Farming, PAU, Ludhiana on September 15, 2021
- Dr. P.S. Shera delivered lecture on ‘Biocontrol of insect pests’ to the students of Diploma in Agricultural Extension Services Candidates for Inputs Dealers organized by Agricultural Technology management Agency (ATMA) Faridkot and PAMETI Ludhiana on October 1, 2021
- Dr. Rabinder Kaur delivered lecture on “Biocontrol of insect pests” to the students of Diploma in Agricultural Extension Services for Inputs Dealers organized by ATMA Sri Muktsar Sahib and PAMETI Ludhiana on November 26, 2021
- Dr. Rabinder Kaur delivered lecture on “Biocontrol of insect pests” in one day training programme on ‘Training and Capacity Building through Online/ Virtual mode under the scheme – Strengthening and Development of Higher Agricultural Education in India, ICAR-1”organized by Department of Entomology, PAU Ludhiana on November 30, 2021.

- Dr. P.S. Shera delivered lecture on ‘Biocontrol of insect pests’ to the students of Diploma in Agricultural Extension Services Candidates for Inputs Dealers organized by A gricultural Technology management Agency (ATMA) Ferozepur and PAMETI Ludhiana on March 4, 2022.

Guest Lectures organized

- Organized guest lecture on ‘Biocontrol for sustainable agriculture’ for students and faculty members of Entomology Department – Speaker Dr Chandish Ballal (Ex Director ICAR-NBAIR)
- Organized guest lecture on ‘Registration requirements and regulatory approaches for commercialization of biopesticides’ for students and faculty members of Entomology Department – Speaker Dr SJ Rehman (University Head – Entomology, PJTSAU, Hyderabad)

DRYSPUHF, Solan

- Organised one day farmers training on Eco-friendly management of insect-pests of crops on 23-07-2021 at Tandi, district Lauhal&Spiti; 30 farmers participated.
- Organised one day farmers training on Eco-friendly management of insect-pests of crops on 24-07-2021 at Udaipur, district Lauhal&Spiti; 30 farmers participated.
- Organised one day farmers training on Eco-friendly management of insect-pests of crops on 23-11-2021 at Poorbani, district Kinnaur; 50 farmers participated.
- Organised one day farmers training on Eco-friendly management of insect-pests of crops on 24-11-2021 at Roghi (Kalpa), district Kinnaur; 50 farmers participated.
- Organised one day farmers training on role of bioagents under Subhash Palekar Natural Farming system on 15-12-2021 at Gadog (Ochhghat), district Solan.
- Organised one day farmers training on role of bioagents under Subhash Palekar Natural Farming system on 16-12-2021 at Kurgal, district Sirmaur.

UBKV

- Conducted 1 farmers training-cum-input distribution among tribal farmers under AICRP-Biological control on 31.07.2021 at Samuktala, Alipurduar.
- Conducted 2 farmers training in connection with TSP programme of AICRP Bio-control on 30.11.2021 (Nurpur, Alipurduar) and 30.12.2021 (Chhatsingimari, Coochbehar).
- Conducted 1 farmers training-cum-input distribution in connection with TSP programme of AICRP Bio-control on 17.03.2022 (Baniagaon, Alipurduar) and another event on same topic shall be organised on 24.03.2022 (Singimari, Coochbehar).

Table 242.

Date	Topic of the Programme	Venue (Mode)	No. of Participants
07.09.2021	Training on “Use of bio-control agent (*Trichogramma chilonis*) for management of insect-pests”	Malda KVK, West Bengal (Virtual)	30 (SHG members)
15.09.2021	Lecture on “Organic pest management in Medicinal plants”	Basundhara (NGO), Coochbehar (Physical)	30 (SHG members)

02.11.2021	Lecture on "Awareness about the biological control of insect pests"	Baguihati High School, Kolkata (Physical)	50 (Students and staffs)
11.02.2022	Lecture on "Use of bio-control agents for eco-friendly pests management"	KVK, Uttar Dinajpur (UBKV) (Physical)	20 (Kisan Kart trainees)
22.02.2022	Lecture on "Bioagents and bio-pesticides for management of insect-pests in different crops"	ATC, Coochbehar (Physical)	30 (Tribal farmers)
01.03.2022	Lecture on "Bioagents and bio-pesticides for management of insect-pests in different crops"	ATC, Coochbehar (Physical)	30 (Tribal farmers)

TNAU

Table 243. Training imparted / lectures delivered during the year

Sl.No.	Title of the training / lecture	Beneficiary / participants	Date	Sponsor
1.	Technology capsule for the management of RSW	Virtual brain storming session Scientists - 43Nos.	16.07.21	ICAR - Indian Institute of Oil Palm Research, Pedavegi
2.	Mass Production of bio-control agents	JAO's, TNAU 22Male +2Female	4.12.21	TNAU
3.	Mass Production of bio-control agents	Entrepreneurs - 29Male +9Female	8.12.21	ICAR MYRADA KVK, Gopi
4.	Mass Production of bio-control agents	Teachers- 2M+1F	23.12.21	Sakthi Institute of Engineering and Technology, Chinniyampalaym
5.	Management of Rugose Spiralling Whitefly	Kundadam , Coimbatore District – 29 Farmers	21.1.22	Coconut Development Board
6.	Management of Rugose Spiralling Whitefly	Kannakurichi, Salem District – 25Farmers	25.1.22	Coconut Development Board
7.	Mass Production of bio-control agents	Entrepreneurs – Paid training -15Nos. 13M + 2F	18.02.22	Venture Capital Scheme, TNAU
8.	Management of Rugose Spiralling Whitefly	Palakkarai, Erode Dt. - 40Nos. - 35M + 5F	09.03.22	Coconut Development Board
9.	Management of Rugose Spiralling Whitefly	Uchipuli , Ramanathapralm Dt- 105Nos. - 81M +24 F	11.03.22	Coconut Development Board Department of Agriculture, GoTN
10.	Management of Rugose Spiralling Whitefly	Thondamuthur , Coimbatore Dt. 43Nos. - 36M + 7F	15.03.21	Coconut Development Board

SKUAST-K

- 21 days training on Plant Protection Techniques for Plant Health Management" w.e. f. 03-23rd December 2021 at National Institute of Plant Health Management (NIPHM) Hyderabad.
- Recognition Dr. Jamal Ahmad
- Acting as major guide of Ph.D. student Ms. JasraBano, Division of Entomology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as major guide of Ph.D. student Ms. Quratul Ain, Division of Entomology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as major guide of M. Sc. student Ms. Kaneez Fatima, Division of Entomology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acted as co guide of Ifrahim Zehra, Division of Entomology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acted as Dean, PG Nominee of Aijazul Mumtaz Khatana, College of Engineering, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acted as Dean, PG Nominee of Ms. Arifa Gulzar, Division of Plant Pathology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as Dean, PG Nominee of Ms. Insha Javeed, Division of vegetable Science, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as Dean, PG Nominee of Ms. Bisma Basheer, Division of vegetable Science, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as Dean, PG Nominee of Ms. Bisma Basheer, Division of vegetable Science, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as Dean, PG Nominee of Sharanabasava, Division of vegetable Science, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as Dean, PG Nominee of Samiksha Heer, Division of Food & Technology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as Dean, PG Nominee of Javeid Ahmad Dar, Division of Plant Pathology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acted as Superintendent of examination for PG. competitive test of SKUAST-K

Dr. Malik Mukhtar

- Advisory committee member of M.Sc. student of the Division of Entomology, Faculty of Horticulture SKUAST Kashmir Shalimar
- Advisory committee member of Ph.D. student of the Division of Plant Pathology, Faculty of Horticulture SKUAST Kashmir Shalimar
- Dean P.G. nominee of Ph.D. student of the Division of Plant Pathology, Faculty of Horticulture SKUAST Kashmir Shalimar

KAU Vellayani

Awareness Programmes to farmers

- The centre conducted two awareness programme to farmers on the potential of use of biopestcides in major crops of Kerala at two different panchayaths, Malayinkeezh (22.12.2021) and Maranalloor(17.03.2022).
- 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 25 participants per programme.
- Agricultural assistants of the panchayath also pearticipated in the programme

Fig 93. Awareness programme at Malayinkeezhu Distirbution of bioagents

Fig 94. Awareness programme at Maranaloor Panchayath

Fig 95. Disstribution of biopesticides to farmers of Maranalloor

DRYSPUHF, Solan

- Organized one day farmers training on Eco-friendly management of insect-pests of crops on 23-07-2021 at Tandi, district Lauhal&Spiti; 30 farmers participated.
- Organized one day farmers training on Eco-friendly management of insect-pests of crops on 24-07-2021 at Udaipur, district Lauhal&Spiti; 30 farmers participated.
- Organized one day farmers training on Eco-friendly management of insect-pests of crops on 23-11-2021 at Poorbani, district Kinnaur; 50 farmers participated.
- Organized one day farmers training on Eco-friendly management of insect-pests of crops on 24-11-2021 at Roghi (Kalpa), district Kinnaur; 50 farmers participated.
- Organized one day farmers training on role of bioagents under Subhash Palekar Natural Farming system on 15-12-2021 at Gadog (Ochhghat), district Solan.

- Organized one day farmers training on role of bioagents under Subhash Palekar Natural Farming system on 16-12-2021 at Kurgal, district Sirmaur.

PAU, Ludhiana

Guest Lectures organized

Organized guest lecture on ‘Biocontrol for sustainable agriculture’ for students and faculty members of Entomology Department – Speaker Dr. Chandish Ballal (Ex Director ICAR-NBAIR)

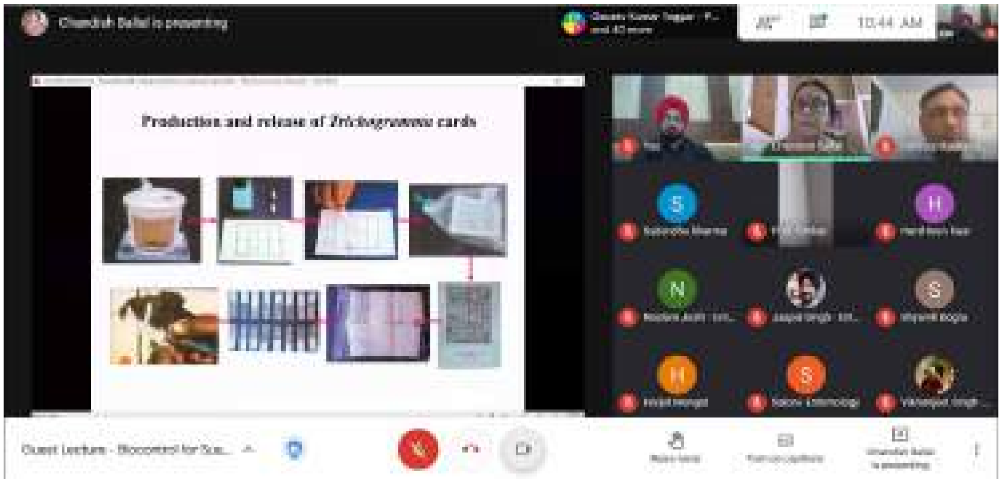


Fig 96. Guest lecture (online) by Dr Chandish Ballal (Ex Director ICAR-NBAIR)

Organized guest lecture on ‘Registration requirements and regulatory approaches for commercialization of biopesticides’ for students and faculty members of Entomology Department – Speaker Dr SJ Rehman (University Head – Entomology, PJTSAU, Hyderabad)

Fig 97. Awareness regarding biocontrol to the students of Diploma in Agricultural Extension Services Candidates for Inputs Dealers organized by Agricultural Technology Management Agency (ATMA) and PAMETI Ludhiana

GBPUAT, Pantnagar

Conducted 08 trainings at farmer's field on

Use of Polythene sheet for nursery soil solarization of Rice

Use of Biocontrol agent for soil treatment

Use of Biocontrol agents for seed treatment

Use of Biocontrol agents for seed treatment

Use of Biocontrol agents for seedling root treatment and foliar spray

Use of Pheromone traps for the control of stem borer in rice

Organic Vegetable cultivation for kitchen garden

Use of Bioagents in vegetables like Pea, Coriander, Spinach, Fenugreek and Radish.

Organised 02 Field Days

- Organised On-campus farmer's meeting on the occasion of 75 years of independence Azadi Ka Amrit Mahotsav
- Organised farmers meeting at farmer's field on the occasion of 75 years of independence Azadi Ka Amrit Mahotsav.









Fig 98. Extension Activities: Trainings/field day/ 75 years of independence programmes / Azadi Ka Amrit Mahotsav

UAS, Raichur

Table 244.

Sl.No.	Date	Place	Activity
1.	22nd Feb,2022	Seminar Hall, MARS, Raichur	Interaction of farmers and scientists about the use of biocontrol agents
2.	10-03-2022 to 19-03-2022	College of Horticulture, Bidar (20 students)	10 Days Training on "Entrepreneurship Development in production of Biocontrol agents and Food Processing

VI. 33.7. Radio/TV talk

AAU, Jorhat

Television/ Radio Programme

Radio programme on "Ecological Engineering for pest management" (AIR NAGAON) (Recorded on 02.08.2021).

Hello Krishi darshan (Door Darshan Programme) [Telecasted on 04.08.2021 (5.30pm)]

Fig 99. Hello Krishi darshan (Door Darshan Programme) on 04.08.2021	Radio programme by (AIR NAGAON) (Recorded on 02.08.2021)

VI. 33. 8 Post/Under graduate teaching

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.

TNAU

UG courses

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

PAU, LUDHIANA

Table 245. Post/under graduate teaching

Teacher	No. of courses taught	
	PG	UG
Dr Neelam Joshi	4	1
Dr Parminder Singh Shera	2	2
Dr Rabinder Kaur	1	1
Dr Sudhendu Sharma	1	2
	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	-
Dr Sudhendu Sharma	-	1

IGKV, RAIPUR

Teaching
M.Sc. (Ag.) Prev.
ENT-501 - Insect Morphology- (I semester)
ENT-502-Insect Anatomy, Physiology and Nutrition-(II semester)

Ph.D.
ENT-606-Recent Trends in Biological Control -(I semester)
ENT-611-Molecular Approaches in Entomological Research -(II semester)
Student Guidance:8 (4+4)
M.Sc. (Ag.) Final Year (4 students)
Parul Dahariya
Vipin Kumar Yadav
Smriti Yadu
Dheeraj Kumar
Ph.D. (4 students)
Jharna Chaturvedani
Sonia Soni
Berendra Anant
Priyanka Nagdev

VI. 33. 9. LIST OF PUBLICATIONS

AAU, Jorhat

Research papers

- Borkakati, R. N., Saikia, D. K. & Venkatesh, M. R. 2021. Influence of meteorological parameters on population build-up of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Journal of Agrometeorology*, 23 (2) : 249-25.

Extension Bulletin

- Borkakati, R. N., Saikia, D. K. & Gayan, J. 2021. Dhan Khetir Khsatikaree Keet-Potongor Niyantronar Diha (AAU/DR/21/BU/437/2021-22).

Popular articles

- Borkakati, R. N. 2021. Paripusti aru ayor utsha rupe khadyajugya potanga. Prantik. *Fortnightly Assamese Journal*, 40(17): 32-33.

- Saikia, D. K. & Borkakati, R. N. 2021. August Mahar Sambhabya keet potangor Byabasthapona. *Ghare Pothare* (Fortnightly Newspaper). 42(15):1-4.

- Borkakati, R. N. 2021. Kakati Foring- Satarka Thakok aru Dristi Rakhak. *Ghare Pothare* (Fortnightly Newspaper). 42(13):1-2.

- Borkakati, R. N. 2021. Kakati Foring- Satarka Thakok aru Dristi Rakhak. *Ghare Pothare* (Fortnightly Newspaper). 42(12):1-4.

- Saikia, D. K. & Borkakati, R. N. 2021. June Mahar Sambhabya keet potangor Byabasthapona. *Ghare Pothare* (Fortnightly Newspaper). 42(12):1-4.

- Saikia, D. K. & Borkakati, R. N. 2021. May Mahar Sambhabya keet potangor Byabasthapona. *Ghare Pothare* (Fortnightly Newspaper). 42(9):2-3.
- Saikia, D. K. & Borkakati, R. N. 2021. Ei Mahar Sambhabya Keet Potangor Byabasthapona. Asomiya Khabor : 9.

AAU, Anand

Research articles

- Raghunandan, B. L., Patel, N. M. & Patel, N. B. 2021. Diversity of spiders in paddy ecosystem of middle Gujarat. *Biol Forum- An Int J*, 13(4):1141-1144.
- Patel, N. B., Bhagora, J. K., Raghunandan, B. L. & Patel, N. M. 2022. First report of new invasive thrips, *Thrips parvispinus* (Karny) (Thripidae: Thysanoptera) in chillifields of Umreth in Anand District of Gujarat state. *Int J Environ Climate Change,* 12(3): 73-78.
- Patel, N. B., Raghunandan, B.L., Patel, N. M. & Sivakumar, G. 2021. Field efficacy of biocontrol agents against shoot and fruit borer, *Earias vittella* (Fabricius) (Lepidoptera: Noctuidae) in okra. *J Biolo Control*, (MS No. 29112, Accepted for publication in Sep issue of 2021)
- Patel, P. H., Sisodiya, D. B., Raghunandan, B. L., Patel, N. B., Patel, D. R. & Chavda K. M. 2021. Survey and surveillance of fall armyworm, *Spodoptera frugiperda* (J. E. Smith) and its associated natural enemies (Lepidoptera: Noctuidae) in maize in Anand district of Gujarat. *J Biolo Control*, (MS Number 29113, Accepted for publication in Sep issue of 2021)

Technical bulletin

- Raghunandan, B. L., Borisagar, H. K., Patel, N. B. & Sivakumar, G. 2021. Compendium of commercial /brand/ trade names of microbial biopesticides used in agro-ecosystem. No. RES:15:5:2021:2000
- Raghunandan, B. L., Raval, D. B., Bhatiya, Y. B. & Patel, N. B. 2021. Glimpse of DNA barcoding & sequence submissions made from Biological Control Research Laboratory. No. RES:15:6:2021:1000

Popular articles – English

- Baldaniya, A. M., Patel, N. B. & Raghunandan, B. L. 2022. Nano urea: A better substitute of urea. *Krishi Science-e Magazine for Agricultural Sciences*, 3(1): 6-8.
- Baldaniya, A. M., Raghunandan, B. L. & Patel, N. B. 2022. Biopesticides- An ecofriendly approach for pest management. *Krishi Science-e Magazine for Agricultural Sciences,* 3(1): 9-12.

Popular articles – Vernacular language

- Patel, N. M., Raghunandan, B. L. & Patel, N. B. 2021. Ambush bag- aekupyogiparbhaxeekitak. Krushi Vigyan. 25.
- Patel, N. B., Baldaniya, A. M. & Raghunandan, B. L. 2021. Marchinapak ma sanklitjeevatvyavsthapan. Krushi Prabhat, 13, 11 Nov-2021.
- Baldaniya, A. M., Patel, N. B. & Raghunandan, B. L. 2021. *Metarhizium anisopliae* – Jaivikkitnashak fug. Krushi Prabhat 13, 12 Nov-2021.
- Patel, N. B., Raghunandan, B. L. & Patel, N. M. 2021. Chananee Vaignanik Khetima Biyarannee Yogya Pasandgeenee Jarur. Krushi Prabhat.15. 25 Nov-2021

- Patel, N. B., Raghunandan, B. L. & Patel, N. M. 2021. Chananeevaignanikkhetipaddhatimabeejmavjatanenindamanniupayogimahiti. Krushi Prabhat.15. 26 Nov-2021.
- Patel, N. B., Raghunandan, B. L. & Patel, N. M. 2021. Chananeenafakarkkhetipaaksanraxanagatyanupareebalanetenunivaran, Krushi Prabhat.15. 27 Nov-2021
- Baldaniya, A. M., Raghunandan, B. L. & Patel, N. B. 2021. Dungali no mukhyashatru – Thrips. Krushi Prabhat, 12, 29 Nov-2021.
- Baldaniya, A. M., Raghunandan, B. L. & Patel, N. B. 2021. Khedutnamitrakitak – Parbhakshi Ladybird beetle. Krushi Prabhat, 15, 01 Dec-2021
- Dabhi, Sandip S., Chauhan, Dipak, A., Raghunandan, B. L. & Patel, N. B. 2021. Trichogramma-Ekagtynuparjeeveekitak, Krushi Prabhat.11. 04 Dec-2021
- Chavda, Divya J., Mesariya, Dimpal R., Raghunandan, B. L. & Patel, N. B. 2021. Batataneechoosiyaprakaraneejeevatoanetenuvyavasthapan. Krushi Prabhat, 11. 6 Dec-2021
- Patel, N. M. Patel, N. B. & Raghunandan, B. L. 2021. Tametimapankoriyu v falvedhaknusanklitvyavstahpan, Krushi Prabhat.11, 07 Dec-2021
- Mesariya, Dimpal R., Chavda, Divya J., Raghunandan, B. L. & Patel, N. B. 2021. Dungalinapakmaaavtarogoanetenuniyantran. Krushi Prabhat, 11. 7 Dec-2021
- Mesariya, Dimpal R., Chavda, Divya J., Raghunandan, B. L. & Patel, N. B. 2021. Dungalinapaakmaaavatasadaaanekaalifoognenivarvanaupaayo. Krushi Prabhat, 13. 8 Dec-2021
- Patel, N. B., Raghunandan, B. L. & Patel, N. M. 2021. Chananeevaignanikkheteepadhhtianebiyaranneepasandgee, Krushi Prabhat.11. 09 Dec-2021.
- Patel, N. B., Raghunandan, B. L. & Patel, N. M. 2021. Chananeekheteemapiyatanepaksamraxanivaignanikpadhhtio, Krushi Prabhat.11. 10 Dec-2021.
- Chauhan, Dipak, A., Dabhi, Sandip S., Raghunandan, B. L. & Patel, N. B. 2021. Chrysoperla - Ekagtynuparbhaxikitak, Krushi Prabhat.13. 14 Dec-2021.
- Baldaniya, A. M., Raghunandan, B. L. & Patel, N. B. 2021. Aamba ma nukshankartinavinjeevat – Magiyaeeyal. Krushi Prabhat, 13, 15-Dec-2021.
- Dabhi, Sandip S., Chauhan, Dipak, A., Raghunandan, B. L. & Patel, N. B. 2021. Kobijanekolifalvarnapaknenukshankartiagtyaneejivat- Hirafundi, Krushi Prabhat.15. 18 Dec-2021.
- Mesariya, Dimpal R., Chavda, Divya J., Raghunandan, B. L. & Patel, N. B. 2021. Aambaneekereenagotalaanuchaachvuanetenuvyavasthapan. Krushi Prabhat, 15. 18 Dec-2021.
- Patel, N. B. & Raghunandan, B.L. 2021. Ambaneevikrutianetenusanklitvyavasthapan. Krushi Prabhat, 13. 19 Dec-2021.
- Patel, N. B. & Raghunandan, B. L. 2021. Ambanomadhiyoanetenuniyantran. Krushi Prabhat, 13. 20 Dec-2021.
- Bhagora, J. K., Patel, N. B. & Raghunandan, B. L. 2021. Valodpapadimachusiyaprakarnijivatoneolakho, Krushi Prabhat.13. 21 Dec-2021.

- Bhagora, J. K., Patel, N. B. & Raghunandan, B. L. 2021. Valodpapadimachusiyaprakarnitadtadiyaanesafedmakhinuvyavasthapan, Krushi Prabhat.13. 22 Dec-2021.
- Chavda, Divya J., Mesariya, Dimpal R., Raghunandan, B. L. & Patel, N. B. 2021 Chananaapaakamaaavatavividhrogoneolakho. Krushi Prabhat, 15. 23 Dec-2021.
- Borisagar, Harshit K., Raghunandan B. L. & Patel N. B. 2021. Sajivkhetimaagatyanajaivikkitnashakovisheagatyanimahiti, Krushi Prabhat.13, 28 Dec-2021.
- Raghunandan, B. L., Dabhi, Sandip S., Chauhan, Dipak, A & Patel, N. B. 2021. Chananaanetuvernapakmaliliiyalnuniyatran, Krushi Prabhat.13. 28 Dec-2021.
- Borisagar, Harshit K., Raghunandan B. L. & Patel N. B. 2021. Sajivkhetimaagatyanajaivikkitnashako, Krushi Prabhat.13, 31 Dec-2021.
- Baldaniya, A. M., Raghunandan, B. L. & Patel, N. B. 2022. Bheendanapak ma sankalitjeevatvyavsthapan. Krushi Prabhat, 15, 04 Jan-2022.
- Chauhan, Dipak, A., Dabhi, Sandip S., Raghunandan, B. L. & Patel, N. B. 2022. Kobijtathacauliflowermadado kornariyal (Lili Iyal) nu jaivikniyantran, Krushi Prabhat, 15, 11 Jan-2022.

Book chapters

- Patel, H. K., Jhala, Y.K., Raghunandan, B.L. & Solanki, J. P. 2022. 'Role of mycorrhizae in plant-parasitic nematodes management', in Soni et al (eds) *Trends of Applied Microbiology for a Sustainable Economy*, Elsevier Book Series. *In press*
- Gohel, N. M., Raghunandan, B. L., Patel, N. B., Parmar, H. V. & Raval, D. B. 2022. 'Role of fungal biocontrol agents for sustainable agriculture', in: Vijayrani Rajpal et al (eds) *Fungal Diversity, Ecology and Control Management. Springer Nature Publications*. *In press*.

Book chapters in vernacular language

- Patel, N. B., Patel, N. M., Raghunandan, B. L. & Bhagora, J. K. 2021. Jaivikniyatranmavapratijaivikkitnashakdavaonoitihas. Souvenir-Jivatoanerogonajaivikniyatrandvarabagayatianekhadhyapakonigunvataanesalamatinijadvani. A seminar organized jointly by NAHEP-CAAST, Navsari Agricultural University & Plant Protection Association of Gujarat, 9-12 on 30th December, 2021.
- Patel, N. B., Bhagora, J. K., Raghunandan, B. L. & Patel, N. M. 2021. Jaivikniyantrannumahtav. Souvenir-Jivatoanerogonajaivikniyatrandvarabagayatianekhadhyapakonigunvataanesalamatinijadvani. A seminar organized jointly by NAHEP-CAAST, Navsari Agricultural University & Plant Protection Association of Gujarat, 13-15 on 30th December, 2021.

Extension folders – English

- Kapadiya, T. B., Patel, N. M., Raghunandan, B. L. & Patel, N. B. 2021. Natural enemies of fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). (No. RES:15:1:2021:2000).
- Raghunandan, B. L., Chauhan, Dipak, A., Borisagar, Harshit, K. & Patel, N. B. 2021. Nuclear Polyhedrosis Virus (NPV) of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae): Glimpse of its production and its use. (No. RES:15:2:2021:2000)

Extension folders-Vernacular language

- Patel, N. M., Kapadiya, T. B., Raghunandan, B. L. & Patel, N. B. 2020. Fall armyworm, *Spodoptera frugiperda* nu NPV. (No. RES:15:1:2020:2000).
- Raghunandan, B. L., Bhatiya, Y. B., Raval, D. B. & Patel, N. B. 2021. Jaivikkitnashk *Metarhizium anisopliae* nuutpadankarvanisaralpadhhti. (No. RES:15:4:2021:5000).

ANGRAU at RARS, Anakapalle

Research Papers

- Visalakshi, M., Selvaraj, K., Poornesha, B. & Sumalatha, B. V. 2021. Biological control of invasive pest, rugose spirallying whitefly in coconut and impact on environment. Journal of entomology and zoology studies. *Journal of Entomology and Zoology studies*, 9(1):1215-18.
- Manisha, B. L., Visalakshi, M., Sairam Kumar, D. V. & Kishore Varma, P. 2022. Exploring the ethology of gravid trichogramatids towards heterospecific hosts. *J.Exp.Zool.India*. 25(1): 897-901.

Technical Bulletin

- Richavarshey., Ankita Gupta., Omprakash Navik., Shylesha , A. N., Lalitha, Y., Raghunandan, B. L., Shyam Prasad, G., Visalakshi, M. & Sharad Galande. 2021. Parasitoids and predators of fall army worm and their utilization for FAW management. Attempts to rub the PAW marks of FAW Scans Chemicals ICAR-NBAIR Technical Bulletin July, 2021.
- Rangeswaran, R., Visalakshi, M., Bhagaban Patro., Raghunandan, B. L. & Apoorva, V. 2021. *Bacillus thuringiensis as* a microbial Biocontrol agent for the management of fall army worm. Attempts to rub the PAW marks of FAW Scans Chemicals ICAR-NBAIR Technical Bulletin July, 2021.

Reports/Manuals

- Dr. M. Visalakshi, P. S. (Entomology) compiled the Annual report of RARS, Anakapalle, 2020 in July, 2021

Books/Book Chapters

- Jeevaniyantrana paddathuladwara purugulu mariyu thegulla yajamanyam- Sikshana Karadeepika (Telugu).
- Visakha jillalo mukyamaina pantalalo Sendriya sagu vidhanalu (Telugu).
- Rythusthayilo Jeevaniyantrana karakalu (Biocontrol agents and Biopesticides) thayari paddathulu (Telugu).
- Sendriya Vyavasayam Susthira saguku sopanam (Telugu).
- Major Cropping systems and scope for diversification in Northcaostal zone of Andhra Pradesh.
- Biological control – A sustainable technology for Ecofriendly pest management.
- Empowering Tribal Farmers of Visakhapatnam District through ICAR-Tribal Sub Plan Programme – Realizing the vision of prime minister of India.

MPUAT

Research Paper

- Ahir, K. C., Mahla, M. K., Dangi, N. L., Kuldeep Sharma. & Singh, B. 2021. Population dynamics of cob worm, *Helicoverpa armigera* (Hubner) in maize (2021). *The Pharma Innovation Journal*, 10(12): 637-639.
- Ahir, K. C., Mahla, M. K., Dangi, N. L., Ashok Kumar & Kuldeep Sharma. 2021. Spatial Distribution of Maize Stem Borer, *Chilo partellus* (Swinhoe). *Frontiers in Crop Improvement,* Volume 9 (Special Issue-V).
- Ahir, K. C., Mahla, M. K., Kuldeep Sharma., Ramesh Babu, S. and Kumar, A. 2021. Bio-efficacy of insecticides against fall armyworm. *Indian Journal of Agricultural Sciences*, 91 (12): 1796–1800.

PJTSAU, Hyderabad

Research Papers

- Anitha, G. 2021. Biology and life cycle of *Phenococcus solenopsis* on potato sprouts. *Journal of Entomology and Zoology studies*, 9(1):756-759.
- Chaitanya, M. S., Anitha, G., Shanker, C. & Bharati Bhat. 2022. Diversity and abundance of Hemipteran and Hymenopteran natural enemies in different organic rice regimes. *Journal of Entomological Research*, 46(1): 32-39.
- Kumari, D. A., Suresh,V., Anitha, G. & Lavanya, G. 2022. Insescticidal and IPM modules for the management of *Phthorimoaea absoluta* in tomato. *Indian Journal of Ecology* (Under Review).
- Anitha, G., Kumari, D. A., Mahendra, K. R. & Madhu E. H. 2022. Spider Assemblages in major crops of Rajendranagar, Telangana, India. *Egyptian Journal of Biological Pest Control*, (Under Review).

Review Paper

- Anitha Kumari., Anitha, G., Naik, H. & Suresh, V. 2021. *Tuta absoluta* : A review of its biology and management. *Journal of Entomological Research*, 45: 1050-1058.

CPCRI

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- Adlin Pricilla Vasanthi, E. & S Jeyarajan Nelson. 2021. Biopesticidal effects of *Dodonea viscosa* plant extracts on subterranean termite, *Odontotermes wallonensis* (Wasmann) (Termitidae: Isoptera). Pestologt, XLV (9): 28-34
- Jeyarajan Nelson, S. & Aravind, A. 2021. Biointensive pest management strategies for the control of insect pests of brinjal. In: TNAU-Golden Jubilee International Conference – Global Perspectives in Crop Protection for Food Security, Dec.8-10, 2021, TNAU, Coimbatore.
- Jeyarajan Nelson, S., Elango, K. & Malathi, P. 2021. Bioefficacy of Chlorantraniliprole 18.5% w/w SC against fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in Maize. In: TNAU-Golden Jubilee International Conference – Global Perspectives in Crop Protection for Food Security, Dec.8-10, 2021, TNAU, Coimbatore.

Folders

- Jeyarajan Nelson, S., Alagar, M., Srinivasan, T., Hariprabu, S., Elaiyabharathi, T., Naseer, H., Krishnamoorthy S. V. & Prabakar. K. 2022. Coconut Rugose Spiralling Whitefly *Aleurodicus rugioperculatus* management.

UBKV

Research Papers

- Mounika, T., Sahoo, S. K., Chakraborty, D. & Debnath, M. K. 2022. Bio-efficacy of botanicals against pulse beetle, *Callosobruchus chinensis* L. in stored chickpea. *J Eco-friendly Agri.* 17(1): 94-99.
- Mounika, T., Sahoo, S. K. & Chakraborty, D. 2021. Evaluation of some botanicals against *Callosobruchus chinensis* L. infesting stored chickpea seeds and bio-chemical analysis of used botanicals. *Int. J. bio-resour. stress Manag,*12(6): 679- 686.

- Dutta, A., Mandal, K. N., Sahoo, S. K., Das, R., Roy, S., Sarkar, S., Patra, S. R., Shankar Bhujbal, Rai, A., Sanjay, J. & Jambhulkar. 2021. Sanchita (YSWB 2014/2) and Anushka (YSWB 2011-10-1) -two yellow sarson (*brassica rapa* var. yellow sarson l.) varieties notified for West Bengal. *J Oilseeds Res.*38(2): 207-210.

Papers popular articles

- Bideshi Potongo Rugose Spiralling Sada Machhir Saamprotik Aakromon O Taar Protikaar. Published in the Bengali Newspaper Sangbad Pratidin dated 18.08.2021.
- Joibo Upaaye Fosoler Rog-Poka Domon. Published in the Bengali Newspaper Sangbad Pratidin dated 03.11.2021.

KAU Vellayani

Research Papers

- Remya, S. & Reji, R. O. P. 2021. Shelf life of capsules of the entomopathogenic fungi *Metarhizium anisopliae* and *Beauveria bassiana*. *Indian Journal of Entomology*, 83(2):226-230.
- Remya, S. and Reji, R. O. P. 2021. Development of capsule formulation of *Beauveria bassiana* (Balsamo) Vuillemin. *Journal of Biological Control*, 34(3): 173-179.

No. of Leaflets published on biocontrol

- Trichocard for pest management in rice and vegetables.
- Use of Pheromon traps in vegetables.

GBPUAT, Pantnagar

Research Papers

- Anshul Arya, Sujata Singh, Kushwaha, K. P. S., Yogita Bohra, Arun Kushwaha & Roopali Sharma. 2021. Genetic and morphological variability among the isolates of *Fusarium oxysporum* f. sp. *lentis* causing wilt of lentil. *Legume Research*.
- Shubham Kumar, Roopali Sharma, Satya Kumar & Bhupesh Chandra Kabdwal. 2021. Biointensive management of *Meloidogyne enterolobii* in tomato under glasshouse conditions. *Pantnagar Journal of Research*, 19 (3): 435-445.
- Suyal, P., Maurya, R. P., Chaudhary, D. & Dobhal, P. 2021. Effect of live and freeze killed larvae of preffered hosts on the biological attributes of predatory bug, *E. furcellata*. *J Entomol Zool Stud*, 9(1): 1554-1558.
- Patwal, H., Maurya, R. P., Brijwal, L., Bhojendra, Suyal, P. & Dobhal, P. 2021. Genetic variability of coccinellid predators in different crop ecosystems of tarai region of Uttarakhand. *J Ent Res.*, 45 (3): 422-429.
- Bhojendra, Maurya R. P., Brijwal, L., Patwal, H. & Suyal, P. 2021. Host range and distribution of predatory stink bug, *Andrallus spinidens* (F.) in Uttarakhand*. Indian J Entomol.* 83.
- Radha Koranga & Maurya, R. P. 2021. Natural enemies of papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink in Tarai region of Uttarakhand. *Pantnagar J Res,* 19 (2): 214-219.

Papers popular articles

- Koranga, R., Maurya, R. P., Anees, M. M. & Saran, S. 2021. Implication of sensors for pest detection and monitoring in crops. *Agriculture and Food: E-newsletter*, 3(8):406-407.

- Maurya, R. P., Koranga, R. & Mehta, V. 2021. Pesticide Production scenario and its usage in India. *Agri Cos e-newsletter*, 02 (07): 111-113.
- Koranga, R., Maurya, R. P., Dubey, V. K. & Dobhal, P. 2021. Mealybug, An emerging pest and its biological control. *Vigyan varta*, 02 (08):9-12.
- Sreedhar, M. & Maurya, R. P. 2022. The importance of ecological Engineering in pest management and its current outlook. *Agriculture & Food: e–Newsletter*, 4(1): 154-156.
- Maurya, R. P., Nath, A. & Sreedhar, M. 2022. Outlook of storage pests and their natural enemies. *Agriculture & Food: e–Newsletter*, 4(1): 189-191.
- Sreedhar, M. & Maurya, R. P. 2022. Outlook of Fall Army worm (*Spodoptera frugiperda* (Smith); Noctuidae; Lepidoptera) and its Management. *Agriculture & Food: e–Newsletter*, 4(1): 78-80.
- Maurya, R. P., Koranga, R. & Sreedhar, M. 2022. Nano-Pesticides in Pest Management: Present and Future Prospects. *Agriculture & Food: e–Newsletter*, 4(1): 112-114.

Books/Book Chapters

- Maurya, R. P., Sreedhar, M., Vasudha, A., Koranga, R. & Dobhal, P. 2022. The importance of ecological engineering in pest management and its current outlook. In: Ratnesh Kumar Rao (Ed.). Recent advances in agricultural science and technology for sustainable India (Part–Mahima Research Foundation and Social Welfare, Karaundi, BHU, Varanasi-221005, UP, India. ISBN: 978-81-953029-5-6. pp 118-133.

Conference papers

- Roopali Sharma, Sapna, Manju Sharma, Shubham Kumar & 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. National Conference on Biological Control: Innovative Approaches for Green India. ICAR-NBAIR, Society of Biological Advancement, Bengaluru, India, held on March 03-05, 2021. Pp105.
- Bhupesh Chandra Kabdwal, Roopali Sharma, & Kumar, J. 2021. Bio-Intensive Management of Major Diseases in Vegetable Cultivation in Uttarakhand. National Conference on Biological Control: Innovative Approaches for Green India. ICAR-NBAIR, Society of Biological Advancement, Bengaluru, India, held on March 03-05, 2021. Pp106.
- Maurya, R. P., Patwal, H., Suyal, P. & Dobhal, P. 2021. participated and presented an oral paper entitled “Coccinellid predators in different crop ecosystems of Tarai region of Uttarakhand” at Sixth National Conference on Biological Control: Innovative Approaches for Green India held at Bengaluru, 3-5 March, 2021.

UAS, Raichur

Research Papers

- Sowmya, E., Arunkumar Hosamani & Mamatha, M. 2021. Field evaluation of *Metarhizium rileyi* (Deutromycotina: Hypomycetes) a mycoinsecticides for the management of lepidopteran pests, *Frontiers in Crop Improvement*, pp. 281-285.

Technical Leaf folder

- Arunkumar Hosamani, Veena, K., Sowmya, E. and Harishchandra, Naik. 2022. Exploration of Trichogramma a egg parasitoid on the management of sugarcane early shoot borers UAS, Raichur 4pp.

- Arunkumar Hosamani, Veena, K., Sowmya, E. and Harishchandra, Naik. 2022. Use of *Lecanicillium lecanii* for the management of sucking pest UAS, Raichur 4pp.
- Arunkumar Hosamani, Veena, K., Sowmya, E. and Harishchandra, Naik. 2022. Use of *Beauveria bassiana* for the management of sucking pest and lepidopteran pests UAS, Raichur 4pp.

33.10 Participation in Seminor/Symposia/Workshops, etc

AAU, anand

Participation in meetings

- Dr. N. B. Patel attended the ZREAC meeting held on 1st Nov 2021 & 9th Feb 2022 at AAU, Anand.
- Dr. N. B. Patel and Dr. Raghunandan B.L. attended 18th Plant Protection Sub-Committee (PPSC) meeting held during 4-5th March 2022 at AAU, Anand.

ANGRAU at RARS, Anakapalle

International and National Conferences

- Dr.M.Visalakshi, PS (Entomology) participated in International Conference on Sugarcane Research (Cane Con 2021) a virtual Event organized by ICAR- and SSRD, Coimbatore, Tamilnadu from 19-22 June, 21 and presented short oral paper on Occurrence of Fall army worm and its natural enemies in sugarcane on 20.6.2021.
- Participated in International Web Conference on Innovative and current researches in agriculture and allied sciences (ICAAAS2021) organized by Society for scientific development in agriculture and technology, Meerut, India from 19-21 July, 21 and presented poster on Endophytic entomopathogenic fungi as Biological Control agents against stem borer in maize.
- Dr.M.Visalakshi, PS (Entomology) participated in International web Conference on Innovative and current researches in agriculture and allied sciences (ICAAAS 2021) during 22-24, October, 2021 and presented paper on Endophytic entomopathogenic fungi as Biological Control agents against stem borer in maize on 22.10. 2021.

Trainings undergone

- Dr.M.Visalakshi, PS (Ento) undergone faculty development programme on statistical data analysis using R –Studio organised by faculty of agriculture, Sri Sri University, Cuttack, Odisha on 5-6, Feb, 2022.
- Dr.M.Visalakshi, PS (Ento) undergone three days workshop on use of reference manager tools and software in research article writing organized by UAS, Raichur on 25-27, march, 2022.

Webinars attended

- Attended national webinar on promise of biological control for sustainable pest management organized by dept. of Entomology, Rajasthan college of Agriculture, MPUAT, Udaipur on 17.5.2021.
- Attended nationa webinar on creative effective online learning environments : a Strategy orgain sed by ANGRAU, Andhra pradesh on 18.5.21
- Attended town talk series -006 orgainsed by NBAIR, Bangalore on on the occasion of World Bee day 2021 on 20.5.21.

- Attended monthly talk orgainsed by IIHR, Bangalore on plant immunity, Immunity in insects versus Human on 29.5.21.
- Dr.M.Visalakshi, PS (Entomology) attended coleman Lecture – As webinar on plant health, food security and safety and a one health perspective by Dr.J.Kumar, GBPant University and Technology, Pantnagar organized by UAS,Bangalore on 16.6.2021 .
- Dr.M.Visalakshi, PS (Entomology) attended the monthly talk on infochemicals for the management of insect pests: Current status and futuristic trends by Dr. N.Bakthavatsalam, Director, ICAR-NBAIR, Bangalore organized by IIHR, Bangalore on 19.6.2021.
- Dr.M.Visalakshi, PS (Entomology) attended guest lecture on scope of biological control in organic agriculture organized by department of entomology, SV Agricultural college , Tirupati on 16.07.2021 .
- Dr.M.Visalakshi, PS (Entomology) participated in International web conference on innovative and current researches in agriculture and allied sciences (ICAAAS2021) organized by Society for scientific development in agriculture andtechnology, Meerut, India from 19-21 July, 21 and presented poster on Endophytic entomopathogenic fungi as Biological Control agents against stem borer in maize.
- Dr.M.Visalakshi, PS (Entomology) attended guest lecture on scope of biological control in organic agriculture organized by department of entomology, SV Agricultural college, Tirupati on 16.07.2021.
- Dr.M.Visalakshi, PS (Entomology) attended special lecture series: application of simulation and geospatial techniques in pest management organized by Indian institute of maize research, Ludhiana on 7.8.2021.
- Dr.M.Visalakshi, PS (Entomology) attended webinar on new paradigms in biological control of insect pests and diseases organized by IISR, Lucknow on 16.8.2021.
- Dr.M.Visalakshi, PS(Entomology) attended webinar on *Trichoderma* : a super star of biopesticide industry organized by NCIPM on 21.8.2021
- Dr.M.Visalakshi, PS(Entomology) attended national webinar on Entrepreneurship Development in processing of jaggery and its value added products organized by ICAR-AICRP on post harvest Engineering and Technology on 23.09.2021
- Attended Talk on Taxonomic diversity vis a vis functional diversity in insects – Back to basics but looking forward – given by Dr. Smt. Dhriti Banerjee, Director, Zoological survey of india, Kolkata on 6.10.21 organized by ICAR-NBAIR, Bangalore.
- Attended Plant protection association of India Golden Jubilee lecture I series on Novel approaches for simplified detection of plant viruses and virus like pathogens given by Dr. V.K.Baranwal, professor, Divivion of plant pathology, IARI, New Delhi on 22.10.21
- Attended national webinar on commercial production of biocontrol agents for crop pests: new opportunities for enterpreneur seekers organized by IDP- NAHEP, College of Horticulture and Forestry, CAU (Imphal),Pasighat, Arunachal Pradesh from 25.10.21 to 27.10.21.
- Dr.M.Visalakshi, P S (Entomology) attended national webinar on teachers shape young minds and inspire them to be leader of tomorrow organized by SKN Agricultutral University, Jobner on 20.11.2021
- Dr.M.Visalakshi, PS (Entomology) attended national webinar on enterpreneurship development throough cultivation of medicinal and aromatic plants organized by College of Horticulture and

forestry, Central Agricultural University, Passighat, Arunachalapradesh on 17.12.2021 and 18.12. 2021

- Dr.M.Visalakshi, PS (Entomology) attended webinar of plant protection association of india golden jubilee lecture series on topic: Plant Biosecurity system needed for managing biological threat incursions on 18.01.2022.
- Dr.M.Visalakshi, PS (Entomology) attended webinar talk on application of genome editing in insect pest management organized by ICAR- NBAIR, Bangalore on 20.01.2022.
- Dr.M.Visalakshi, PS (Ento) attended Webinar- success master class personality development with soft skill learning organized by college of horticulture and forestry , Central Agricultural University (Imphal), Passighat on 05.02.2022
- Dr.M.Visalakshi, PS (Ento) attended webinar talk on the progress and future of green pesticides in India organized by ICAR- NBAIR, Bangalore on 29.04.2022.

Dr.YSR Polambadi District workshop

- Dr.M.Visalakshi, PS (Entomology) attended Dr.YSR Polambadi District workshop meeting organized by JDA, Visakhapatnam at Farmers Training Centre, Anakapallle on 12.10.2021 and discussed on implementation of pest management with biological control in organic farming in the district with stake holders.

PJTSAU, Hyderabad

Guest Lectures Delivered

- On “Spiders and their potential as biocontrol agents in integrated pest management” to students and staff of Dept. Of Entomology, Punjab Agricultural University, Ludhiana
- “Basics of Entomology and Pest Management” on 29.1.2022 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
- “Integrated Pest Management in different Crops” on 9.2.2022 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
- “Basics of Entomology and Pest Management” on 19.3.2022 to Agricultural Graduates at NGO, Access Livelihoods, Saidabad, Hyderabad
- Role of Biopesticides for pest management to farmers of Telanagan organized by Farmers’ Training Centre, Rajendranagar on 1 April, 2022
- Role of Biopesticides for pest management in various crops organized by Brahmakumaris on 26 November, 2021
- Role of Biological alternatives in management of Maize pests for farmers under TSP on 22 March, 2022 organized by maize Research Centre, Rajendranagar.
- Role of Biological alternatives in management of Maize pests for farmers uner TSP on 25 December, 2021 organized by maize Research Centre, Rajendranagar.

CPCRI

Presentations in workshops/Seminars/Symposia

- Anes K.M., Josephrajkumar A., Chandrika Mohan, Merin Babu and Kalavathi S. (2021) *Proceedings of National Seminar on Advances in Biological Suppression of Pests*, September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 32p.

- Chandrika Mohan (2021) Advances in bio-suppression of coconut pests. First Dr. K.K. Nirula Memorial Lecture-2021. *In Proceedings of National Seminar on Advances in Biological Suppression of Pests*, Eds Anes*et al*. September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 3-4p.

- Amala Mohan, Anes K.M., Merin Babu and Josephrajkumar A. (2021) Isolation and characterization of entomopathogenic nematodes from coconut inter crops. *In Proceedings of National Seminar on Advances in Biological Suppression of Pests*, Eds Anes*et al*. September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 16 p.

- Arsha G. Madhu, Anes K.M., Merin Babu, Indhuja S., Vidya J. and Josephrajkumar A. (2021) Antagonistic interaction of bacterial symbionts of entomopathogenic nematodes against fungal pathogen associated with coconut leaf rot disease. *In Proceedings of National Seminar on Advances in Biological Suppression of Pests*, Eds Anes*et al*. September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam 7p,

- Josephrajkumar A. (2021) Advances in pest management in coconut system. *Abstract of the Technical Paper presented during the Technical Session held on September 02, 2021*. *Indian Cocon. J.* 64(3): 7.

- Rajesh, M.K., Josephrajkumar A., Prathibha V.H., Daliyamol, Jilu V. Sajan, Merin Babu and Thava Prakasa Pandian (2021) *Abstracts of National Symposium on Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies*, December 1-3, 2021, ICAR-CPCRI, Kasaragod, 122p.

- Vidya J and Josephrajkumar A. (2021) Endophytic bacteria as a potential biocontrol agent against phytopathogens and pests. *In Proceedings of National Seminar on Advances in Biological Suppression of Pests*, Eds Anes*et al*. September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 32p.

Special compilations/documentation

- Josephrajkumar, A., Merin Babu, Anes, K.M. and Chandrika Mohan (2021) Absence of *Oryctes rhinoceros* nudivirus insensitive Guam-haplotype coconut rhinoceros beetle. *Kalpa Newsletter* 40(1): 6

- Anes, K,M, Merin Babu, Amala Mohan and Josephrajkumar, A. (2021) Occurrence of a new rhabditid nematode. *Kalpa Newsletter* 40(1): 6

- Josephrajkumar, A., Anes, K.M., Chandrika Mohan and Thomas, R.J (2021) Abundant harvest potential of Kalpa Sankara hybrid from root (wilt) disease tract. *Kalpa Newsletter* 40(2): 3

- Josephrajkumar, A., Anes, K,M, Merin Babu and Chandrika Mohan (2021) Nut crinkler (*Paradasynus rostratus*) induced nut drop in coconut. *Kalpa Newsletter* 40(3): 3.

- Anes, K.M., Merin Babu and Josephrajkumar A (2021) Characterization of *Pochonia chlamydosporia*, a potential fungal bio-agent against plant parasitic nematodes.*Kalpa Newsletter* 40(3): 4

KAU, Thrissur

Table 246. Participation of Scientists in conference, meetings, seminars, workshops, symposia, training extension etc. in India and abroad

No	Date	Conference/meeting/seminar/ Workshop	Organised by
1	24-09-21	One day online international webinar on Biocontrol – A global sustainable approach for ecofriendly agriculture"	NIPHM, Hyderabad
2	26-09-21	Genome editing for biotic stress management	ICAR-NBAIR, Bengaluru
3	6-10-21	Entomology Webinar Series I – Potassium channels – a new site for insecticide development	Dept. of Agricultural Entomology, CoA, Vellanikkara, Thrissur
4	2-11-21	Webinar on Microbes or IPM and its importance in sustaninable crop production	NBAIR, Bengaluru
5	18 to 20-02-22	Online training programme on data analysis and hands on training in statistical methods	Dept. of Agrl. Statistics, CoA, Vellayani, Thiruvananthapuram
6	4-3-22 & 5 -3-22	Two days online workshop on 'Identification of phytophagous mites with special reference to Tetranychidae	Dept. of Agrl. Entomology, CoA, Vellanikkara, KAU
7	16-03-22	Webinar on "Taxononomy, mimicry, ecology and use of hover flies (Diptera: Syrphidae)	Dept. of Agrl. Entomology, CoA, Vellanikkara, KAU

Meetings attended

- Attended virtual pre-review meeting of AICRP-BC on 10-07-21
- Attended virtual review meeting of AICRP-BC on 14 & 15 -07-21
- Attended virtual AICRP-BC meeting on 22-07-21
- Attended virtual kharif review meeting of AICRP on BCCP on 4-9-21
- Attended virtual kharif review meeting of AICRP on BCCP on 25-9-21
- Attended Prime minister's address to farmers, inauguration of various programmes and release of varieties
- Attended virtual midterm review meeting of AICRP-BC on 25-9-21

DRYSRHU, Ambajipeta (HRS)

Trainings attended/conducted

- On 21.05.2021 and 26.05.2021 Dr.N.B.V. Chalapathi Rao, Principal Scientist (Ent.) participated in crop wise Virtual Training Programme for controlling measures of Rugose spiraling white fly on coconut & other Horticultural crops organized by Department of Horticulture, Amalapuram, Government of Andhra Pradesh

- On 16.07.2021, Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ent.) Ambajipeta participated in Virtual Brainstorming Session on Invasive whitefly complex on plantation crops: Technical knowledge and Technological interventions for management was organized by ICAR-Indian Institute of Oil Palm

Research, Pedavegi, West Godavari, Andhra Pradesh and gave a presentation on 'Biocontrol based management of rugose spiralling whitefly in plantation crops'.

- Smt. B.Neeraja, Scientist (Plant Pathology) has completed 5 days online training programme on "Farm production of Bio-control agents and microbial Bio-pesticides organized by National Institute of Plant Health Management, Hyderabad from 8th to 12th November, 2021.
- Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ent.) participated in online training programme on Executive Development Programme (EDP) on Leadership Development (for the Senior Officials of Dr YSRHU, AP) from 30th November to 04th December 2021 organized by ICAR-National Academy of Agricultural Research Management (NAARM), Rajendranagar, Hyderabad.
- Extension Activities (Text format Farmers seminar/ meeting/ exhibitions/ field day/ 75 years of independence programmes with pictures / Azadi Ka Amrit Mahotsav programmes with pictures etc
- Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ent.) participated in Hon'ble Agriculture Minister programme at Dr.YSRHU, VR Gudem and arranged an exhibition stall displaying live samples of coconut varieties, crop production and protection technologies on 19.01.2021.
- Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ent.) conducted field diagnostic survey, rugose spiraling white fly in Damireddypalli village of Kadiyam mandal of East Godavari district and explained management practices for controlling of rugose spiraling whitefly on 23.01.2021.
- A diagnostic field survey was carried out by Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ento.), HRS, Ambajipeta in Rugose spiraling whitefly infested coconut gardens at Ramachandrapuram and Peddapuram of East Godavari district on 09.02.2021.
- On 21.06.2021 Dr. N.B.V.Chalapathi Rao, Principal Scientist (Ent.) participated and showcased the biocontrol agents during the inaugural of Horticulture Business incubation centre at College of Horticulture, Venkataramanagudem, by Dr. S.S.Sridhar, IFS, Commissioner of Horticulture to Government of A.P.
- On 07.07.2021 Dr. N.B.V.Chalapathi Rao, Principal Scientist (Ent.), visited Kesanapalli, G.Pallipalem, Toorpupalem and Gollapalem villiages of Malikipuram mandal for diagnostic field visit to identify unusual death of coconut palms and collected soil, water and leaf samples.
- On 29.10.2021 Dr.N.V.Prasad, Principal Scientist (Extension), Dr.Amrutha Lakshmi, Scientist (Pl. Path), Indian Institute Of Oil Palm, Pedavegi along with the 20 farmers visited the Horticultural Research Station, Ambajipeta as a part of exposure visit. The scientist briefed about crop production, technology coconut based intercrops and pest and diseases management.

SKUAST-Jammu

Training/conference/ kisanmela attended

- 5 days online training on "Pest Surveillance" organized by National Institute of Plant Health Management, Hyderabad from 23rd to 27th August, 2021.
- As an expert in the village and Revisit programme on 6-11-2021 at Channi Manhasa Vijaypur Organizes by Directorate of Extension SKUAST-Jammu.
- As an expert in the village and Revisit programme on 04-02-2022 at Suba Chak Kathua organizes by Directorate of Extension SKUAST-Jammu

- As an expert in the village and Revisit programme on 11-02-2022 at Channi Manhasa Vijaypur Organizes by Directorate of Extension SKUAST-Jammu.
- Attended one day online Webinar on "Mass Production of fungal and bacterial agents A, scope for budding start up organized by College of Horticulture and Forestry, Central Agricultural University (Imphal), Pasighat, Arunachal Pradesh, under Institutional Development Plan of National Agricultural Higher Education project held on 2nd and 03rd November, 2021.
- Prepared and Displayed exhibits pertaining to available IPM techniques for Kisan Mela organized by SKUAST-Jammu w.e.f. 7th to 11th October, 2021.
- Prepared and Displayed exhibits pertaining to available IPM techniques during five days Kisan Mela organized by SKUAST-Jammu w.e.f. 21st to25th March, 2022.

फाल आर्मी वर्म से निपटेंगे ट्राइकोग्रामा किलोनिस के अंडे

Fig 100.

SKUAST-K

Dr. Malik Mukhtar

- Incidence of saffron bulb mite *Rhizoglyphus* sp. (*Sarcoptiformes:* Acaridae) on saffron corms in Kashmir" in the "National Seminar on Technological Options and Market Intelligence for Enhancing Profitability in Horticulture" from 27-28 March 2021
- Performance of various pesticides under different water pH regimes" in the "National Seminar on Technological Options and Market Intelligence for Enhancing Profitability in Horticulture" from 27-28 March 2021

KAU, Kumarakom

Trainings attended/conducted

- Faculty induction training programme of Kannur University, January 2022 attended by Mrs. Pallavi Nair (Co-PI)
- Data analysis and hands on training in statistical methods, February 2022 attended by Mrs. Pallavi Nair (Co-PI)
- Identification of phytophagous mites with special reference to Tetranychidae, March 2022 attended by Mrs. Pallavi Nair (Co-PI)

PAU, Ludhiana

Participation of scientists in conference, meetings, seminars, workshops, symposia, training extension etc. in India and abroad

- Dr. Neelam Joshi, P.S. Shera, Rabinder Kaur and Sudhendu Sharma participated in 30th Biocontrol Workers' Group Meeting of All India Coordinated Research Project on Biological Control of Crop Pests (Online) July14-15, 2021
- Dr. Neelam Joshi and Dr P.S. Shera participated in the research proposal on management of gram caterpillar, *Helicoverpa armigera* in gram with Helicop 2 % AS (HaNPV) in the Research Evaluation Committee meeting held on August 9, 2021
- Dr. Neelam Joshi attended online Webinar on "Programme planning and Evaluation" organized by Director of Extension, PAU Ludhiana on August 13, 2021
- Dr. P.S. Shera participated and presented new recommendation on management of gram caterpillar, *Helicoverpa armigera* in gram with Helicop 2 % AS (HaNPV) in the Research and Extension Specialists' Workshop for *Rabi* crops held on August 18, 2021
- Dr. Neelam Joshi, Rabinder Kaur and Sudhendu Sharma attended online meeting of research and extension officer's Workshop for Rabi crops on August 18, 2021
- Dr. Neelam Joshi and P.S. Shera attended virtual meeting to review the status of progress of ongoing experiments of AICRP-Biocontrol in the *Kharif* season on September 4, 2021
- Dr. Neelam Joshi and Sudhendu Sharma participated in International Webinar on "Biological Control: A Global Sustainable Approach for Eco-friendly Agriculture" organized by NIPHM, Hyderabad on September 24, 2021
- Dr P.S. Shera attended National training cum webinar on "On-Farm and Mass Production Protocols of Bioagents and Microbial Agents for FAW Management for NWPZ" organized by ICAR-IIMR, Hyderabad from October 25-27, 2021
- Drs P.S. Shera, Rabinder Kaur and Sudhendu Sharma participated in 9th Coordination Committee Meeting of Network Project on Conservation of Lac Insect Genetic Resources (Online) on January 20, 2022
- Dr P.S. Shera attended Intstitute-NRG Stakeholders Meet on Enhancing Value Addition and Domestic Consumption of Lac and other NRGs organized by ICAR-IINRG, Ranchi on January 28, 2022
- Dr Neelam Joshi participated in 25th Punjab Science Congress held at Sri Guru Teg Bahadur Khalsa College, Sri Anandpur Sahib on February 7-9, 2022

IGKV, RAIPUR

- Co-PI. Dr. Rashmi Gauraha attended 5- daysonline training program on 'Fruitfly Surveillance and Management' organized by National Institute of Plant Health Management, Hyderabad from 17th to 21st January, 2022.
- Co- PI. Dr. Rashmi Gauraha, attended 5-days online training on 'Pest Risk Analysis' organized by National Institute of Plant Health Management, Hyderabad from 14th to 18th February, 2022.

GBPUAT, Pantnagar

Trainings attended/conducted

- Participated in 5 days online training entitled "On-Farm Production of Bio-Control Agents and Microbial Bio-Pesticides" organized by National Institute of Plant Health Management, Hyderabad from 13th to 17th September, 2021.

- Attended online lecture entitled "Phytoplasmas: Symptoms, diagnosis and phylogeny". Organized by University of Ruhana, Matara, Srilanka on 05th January, 2021.
- Attended online lecture entitled "Issue of biological control of soil borne plant pathogens". Organized by University of Ruhana, Matara, Srilanka on 11th January, 2021.
- Attended online lecture entitled "Model assisted plant disease forecasting". Organized from Institute of Crop Science and Resource Conservation, University of Bonn, Germany on 26th January, 2021.
- Attended online webinar entitled "New paradigms in biological control of insect-pests and diseases". Organized by ICAR-Indian Institute of Sugarcane Research, Lucknow on 16th August, 2021.
- Attended online webinar entitled "Trichoderma: A superstar of biopesticide industry". Organized by ICAR-National Research Centre for Integrated Pest Management. New Delhi on 21st August, 2021.

Participation in meetings

- Participated in National Conference on Biological Control: Approaches for Green India. Organized by ICAR-NBAIR, Society of Biological Advancement, Bengaluru, held on 3-5 March, 2021.
- Participated in 30th Annual Group Meet Online Webinar of AICRP on Biological Control organized by ICAR-NBAIR. GBPUA&T, Pantnagar, held on 14th July, 2021.
- Participated in review meeting, online of AICRP on Biological Control organized by ICAR-NBAIR. GBPUA&T, Pantnagar, held on 22nd July, 2021.

V. 33. 11. Technologies included

AAU, Anand

Details of technologies transferred to KVK/Agri &Horti. departments/NGOs

KVK Vyara, NAU, Navsari – BIPM in okra

- The spraying of *Bacillus thuringiensis* var. *kurstaki* 1% WP @ 50 g/10 lit. water or NSKE 5% (500 g/10 litre water) at fifteen days interval for three times or six releases of *Trichogramma chilonis* @ 50,000/ha at weekly interval starting from the initiation of shoot and fruit borer (*Earias vittella*) is advised for the effective control of the pest in okra.

KVK, Gandhinagar – BIPM in cabbage

- Two sprays of *Beauveria bassiana* (2 x 10^8 cfu/g)or *Lecanicillium* (*Verticillium lecanii* (2 x 10^8 cfu/g) @ 30 g/10 litre water at the initiation of pest incidence for suppression of aphid and head borer (*Helicoverpa armigera*)

PJTSAU, Hyderabad

Technologies assessed and transferred

- 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
- 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.
- 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.

DRYSRHU, Ambajipeta (HRS)

- Mass Production technology of entomopathogenic fungi *I. fumosorosea* on broken rice grains effective against Rugose spiralling whitefly in coconut and oil palm was transferred to KVK, Venkatramangudem, West Godavari district and KVK, Kalanacharla East Godavari district, Andhra Pradesh .
- Mass production technology of predator *Pseudomallada astur* against rugose spiralling whitefly was commercialised to Oil palm processing companies 3F Oilpalm Tadepalligudem, Godrej Agrovet, Chintalapudi Godavari district of Andhra Pradesh and private firms viz., and SSD enterprises, Gopalapatnam West Godavari district GIFT Farmer producer organization, Rollapalem, PACS Devaguptam of East Godavari district in Andhra Pradesh and to Cryptox biosolutions, Kanyakumari and Echocare limited, Trichy of Tamil Nadu.

PAU

Technology transferred/demonstrated

- Large scale demonstrations of biocontrol technologies using bioagents, *T. chilonis* and *T. japonicum* for the management of sugarcane borers conducted over an area of 2915 ha at farmers' fields in collaboration with sugar mills of Punjab
- Large scale demonstrations of biocontrol based pest management technologies using bioagents, *T. chilonis* and *T. japonicum* conducted over an area of 139 ha for the management of leaf folder, *Cnaphalocrocis medinalis* and yellow stem borer *Scirpophaga incertulas* at farmers' fields in organic *basmati* rice
- Large scale demonstrations on the bio-suppression of stem borer, *Chilo partellus* using *T. chilonis* conducted over an area of 2 ha at farmers fields in maize crop

SKUAST-K

- Integrated management of Codling moth, *Cydia pomonella* infesting apple in Ladakh

DRYSPUHF, solan

- Details of technologies transferred to KVK/ Agri &Hort departments/ NGOs (Text format)
- Management of apple root borer, *Dorysthenes hugelii* by using *Metarhizium anisopliae.* The technology comprised of application of *M. anisopliae* @ 30g/ tree basin mixed in well rotten farm yard manure (FYM). It was as effective as chemical treatment comprising of chlorpyriphos (0.06%).
- Bio-intensive management of *Tuta absoluta* in tomato. Bio-intensive Integrated Pest Management (BIPM) module 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).

GBPUAT, Pantnagar

Details of technologies transferred to KVK/ Agri & Hort departments/ NGOs

- 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: @ 10 g/ liter on standing crop at 10-12 days intervals.
- Drench: @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.

ANGRAU

Table 247. Details of technologies transferred to KVK/ Agri & Hort departments/ NGOs

S.no	Technology
1.	**Bio-intensive pest management in Rice:** Seed treatment with *Pseudomonas flourescens* @ 10 g/lt ;Spraying *Pseudomonas flourescens* @ 5 g/lt against foliar diseases (blast , sheath blight) two times from 30 -40 days after transplanting; Field release of *Biocontrol agent, egg parasitoid, Trichogramma chilonis* @ 50,000/ha, 3 times for leaf folder and *Trichogramma japanicum* @ 50,000/ha/ release, 3 times for stem borer from 25 days after rice transplanting in rice after monitoring the adults
2.	Management of white grub, *Holotrichia* spp in sugarcane using entomopathogenic fungus, *Metarhizium anisopliae* (NBAIR Ma 4) : Soil application of entomopathogenic fungus, *Metarhizium anisopliae* (NBAIR Ma 4) @ 2.5 kg/ ha enriched in 250 kg farmyard manure per hectare two times at one month interval or at onset of mansoon rains (June/ July months)
3.	Evaluation of *Bacillus thuringiensis* (NBAIR Bt G4) on pigeon pea against pod borer complex: Spraying *Bacillus thuringiensis* (NBAIR Bt G4) 2% as three sprays at preflowering, flowering and pod formation stages in pigeon pea against pod borer complex
4.	Management of fall armyworm in maize using biocontrol agents and Biopesticides : Release of Biocontrol agent, *Trichogramma chilonis* @ 50,000/ha from 7 days after seedling emergence, 2 times and spraying Biopesticides, *Bacillus thuringiensis* (NBAIR Bt 25) @ 2 ml/lt or *Metarhizium anisopliae* (NBAIR Ma 35) @ 5 g/lt from 20 days after seedling emergence 3 times at 10 day interval for the management fall armyworm , *Spodoptera frugiperda* in maize.
5.	Management of Coconut Rugose Spiralling Whitefly using entomopathogenic fungus, *Isaria fumosorosea* and *Encarsia guadeloupae* parasotoid : *Isaria fumosorosea* (NBAIR- Pfu5) @ 5 g/lt with sticker @ 10 ml/lt two sprays + release of parasite, *Encarsia guadeloupae* at 15 days after *Isaria fumosorosea* first spraying

34. ACRONYMS

Table 248.

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
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

AICRP on Biological Control of Crop Pests

ICAR-National Bureau of Agricultural Insect Resources

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