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AICRP on Biological Control of Crop Pests
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Annual Progress Report 2022 AICRP on Biological Control of Crop Pests ICAR–NBAIR, Bengaluru

भाकृअनुप ICAR

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INTERNATIONAL YEAR OF MILLETS 2023

All India Coordinated Research Project on Biological Control of Crop Pests

Annual Progress Report 2022

Compiled and Edited

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 and S N Sushil

भाकृअनुप - राष्ट्रीय कृषि कीट संसाधन ब्यूरो
बेंगलूरु, भारत
ICAR-NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
Bengaluru, India

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

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July 2023

Cover design: G. Mahendiran

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Citation
ICAR–NBAIR. 2023. Annual Progress Report 2022. ICAR–National Bureau of Agricultural Insect Resources, Bengaluru, India, viii + 232pp.

Printed at
CNU Graphic Printers
35/1, South End Road
Malleswaram, Bengaluru 560 020
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Technical Programme for 2022
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

The diversity of native *Trichogramma* species under released and non-released conditions was examined. Five species of trichogrammatids viz. *Trichogramma achaeae* Nagaraja & Nagarkatti, *T. chilonis* Ishii, *T. danausicida* (Nagaraja), *Trichogrammatoidea bactrae* Nagaraja and *Trichogrammatoidea armigera* Nagaraja were recovered from the area released with *Trichogramma* spp. whereas six trichogrammatid species viz. *T. achaeae*, *T. chilonis*, *T. chilotrae* Nagaraja & Nagarkatti, *T. danausicida*, *Tr. bactrae* and *Tr. armigera* were recovered from the non-released area.

Trichogramma chilotrae was collected from the eggs of *Catopsilia pyranthe* (Linnaeus) infesting *Senna occidentalis* (L.) from the non-released area. Occurrence of *T. achaeae* and *T. chilotrae* were recorded on the eggs of *C. pyranthe* infesting *S. occidentalis* with a parasitism per cent of 3.7 and 5.71, respectively. Similarly, the occurrence of *T. chilonis* and *T. achaeae* were recorded on the eggs of *Helicoverpa armigera* Hubner and *Thysanoplusia orichalcea* (Fabricius) infesting methanol mint with 34.78 and 27.78 per cent egg parasitism, respectively.

Two species of tachinids were identified with their associated hosts. The identified tachinids were *Palexorista* sp. which was reared from *Spodoptera frugiperda* (J. E. Smith) and *Carcelia* sp. from a black hairy caterpillar of sandalwood.

I. 1. 2. Spider diversity in cassava ecosystem

Spiders feeding on the Cassava mealybug (CMB) (as pest) and grubs of *Hyperaspis maindroni* Sicard, adults of *Spalgis epius* (Westwood) affirmed its role as a general predator. Intra-guild predation of *Thyene imperialis* (Rossi) feeding on the juveniles of *Carrhotus viduus* (K.L. Koch) was observed. The presence of orb-weaver spiders in the CMB colonies was very limited except for *Neoscona* sp. Euryphagous spiders in great numbers against low-density CMB population at the initial stage of the crop resulted in the complete exclusion of CMB without warrant of other bioagents.

I. 1. 3. Laboratory study on the effect of *Lecanicillium lecanii* (ICAR-NBAIR Vl-8) on biology, feeding potential and prey preference of *Blaptostethus pallescens* fed on infected thrips *Frankliniella schultzei*

Biology, feeding potential and prey preference was studied for anthocorid bug, *Blaptostethus pallescens* when *Lecanicillium lecanii* (ICAR-NBAIR Vl-8) infected thrips (*Frankliniella schultzei*) and uninfected thrips were offered as prey. The total nymphal duration of *B. pallescens* was significantly higher when fed on *L. lecanii* (ICAR-NBAIR Vl-8) treated thrips (*F.schultzei*) as compared to those fed on untreated thrips. All instars and adults of *B. pallescens* preferred uninfected thrips over *L. lecanii* Vl-8 infected thrips. However, *L. lecanii* (ICAR-NBAIR Vl-8) does not affect the biological parameters of the predatory mirid, *Dortus primarius*.

I. 1. 4. Collection of Entomopathogenic Nematodes

Seven isolates of *Heterorhabditis indica* and one species of *Steinernema* were isolated from Chhattisgarh and added to NBAIR's repository of entomopathogenic nematodes EPN. A total of 125 isolates/species of *Steinernema*, *Heterorhabditis* and *Oscheius* nematodes were maintained on wax moth larvae.

I. 1. 5. First report of *Encarsia cubensis* on palm infesting whitefly, *Aleurotrachelus atratus*

Encarsia cubensis, a potential parasitoid of palm infesting whitefly, *Aleurotrachelus atratus*. During the surveys, the immature stages of the Neotropical palm infesting whitefly, *Aleurotrachelus atratus* were found parasitized by an aphelinid parasitoid, *Encarsia cubensis* (Hymenoptera: Aphelinidae). The parasitoids were collected and identified by their morphological characteristics and also characterized by DNA barcoding of adult parasitoids using partial (658 bp) mitochondrial cytochrome oxidase 1 (CO1) gene (GenBank accession number ON881119). The first report of the occurrence of *E. cubensis* as primary parasitoids on *A. atratus* in India and its natural parasitism o 46–68% on coconut across the different locations in Karnataka was reported.

I. 1. 6. Sub-lethal effect of *Spodpotera frugiperda* NPV

Sub-lethal effect of *Spodpotera frugiperda* NPV (SpfrNPV) on the growth and development of fall armyworm was observed. It caused a reduction in egg hatchability in the subsequent generation. The highest yield of SpfrNPV i.e 4.69×10^5 occlusion bodies (OBs) from a single third instar larva was obtained when the larva was inoculated with SpfrNPV @ 1×10^8 OBs/ml. The third instar larva was found optimum for harvesting the maximum of SpfrNPV at 7 days after inoculation.

I. 1. 7. Laboratory and field evaluation of fungal and bacterial entomopathogens for the management of invasive South East Asian Thrips, *Thrips parvispinus*

A novel *Pseudomonas entomophila* NBAIRPEOWN strain with excellent insecticidal activity for management of shoot and fruit borer of brinjal. Three promising entomofungal pathogens viz. *Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium fusisporum* and two bacterial strains viz. *Pseudomonas fluorescens* and *Bacillus albus* were effective in the management of invasive *T. parvispinus* under laboratory and field conditions. The extent of the reduction of thrips population under field conditions ranged between 60–70 percent in Chinthamani and Raichur areas in Karnataka.

I. 1. 8. Shatpada Treat

A simple and cost-effective mass production and application technology for *Typhlodromus* (*Anthoseius*) *transvaalensis* has been developed for the first time in the world. *T.* (*A.*) *transvaalensis* is an effective biocontrol agent for the broad mite (*Polyphagotarsonemus latus*), spider mites (e.g., two spotted spider mite, *Tetranychus urticae*) and thrips (e.g., *Scirtothrips dorsalis*).

Research Progress and achievements

I. 2. Table 1. Biodiversity of biocontrol agents from various agro ecological zones

Sl. No.	Centres	Sites of collections	Crop eco-system and the host insects	Biocontrol agents observed	
				Parasitoids/ Predators/ Entomopathogens etc	Parasitism (%) /predatory potential (%)/ Natural occurrence of entomopathogens (%)
1	ANGRAU Ankapalle	Anakapalle	Maize: *Spodoptea frugiperda*	*Metarhizium rileyi*	6.2%
		Anakapalle	Maize: *S. frugiperda*	NPV	1.1%
		Chinthapalli	Maize: *S. frugiperda*	*Metarhizium rileyi*	5.9%
2	ICAR-CPCRI, Kayamkulam	Kayamkulam, Kerala	Coconut: Coreid bug, *Paradasynus rostratus*	Egg parasitoid, *Anastatus* sp.	40% to 45%
		Kayamkulam, Kerala	Coconut: Exotic whiteflies	*Aschersonia* sp.	<10%
		Kayamkulam, Kerala	Coconut-eriophyid mite, *Aceria guerreronis*	*Hirsutella thompsonii*	10% to 15%
		Kayamkulam Kerala	Coconut system	*Steinernema* sp. (CPCRIS0804), bacterial symbiont has 98.99% homogeneity with *Xenorhabdus griffinae*	High shelf life surviving for >7 months under ambient condition. High infectivity on grubs of red palm weevil.
3	IGKV, Raipur	Raipur	Tuberose: *Thrips parvispinus*	Thrips predator big eyed bug	–
		Raipur	Chilli: *Thrips florum, Thrips hawaiiensis*	*Blaptostehus* sp.	50%
		Raipur	Pigeonpea: *Megalurothrips distalis, Megalurothrips usitatus*	Thrips predator (Ficus plant) (unidentified) *Chrysoperla* spp.	80% predation under lab condition
		Raipur	Cowpea:*Frankliniothrips vespiformis, Thrips palmi*, *Bathrips melanicornis*	*Chrysoperla* sp. (Brown colours) (without exuviae)	60% predation under lab conditions
		Raipur	Soybean: *Ayyaria chaetophora* (thrips)	*Chrysoperla* sp. (Green colours) (without exuviae)	40% predation
		Raipur	Marigold: *Frankliniella schultzei*	Big egged bug	80% under lab condition

		Raipur	Organic rice	*Trichogramma* sp.	2% parasitism
		Raipur	Chemically treated Rice field	*Trichogramma* sp.	2.5% parasitism
		Raipur	Oleander	*Trichogramma* sp.	5% natural parasitism
		Raipur	Organic tomato: sentinel cards	*Trichogramma chilonis* & *Trichogramma* sp.	5% parasitism
4	KAU, Thrissur	Palakkad	Rice pests: spiders	Spiders	–
		Thrissur and Palakkad	Rice stem borer	Egg parasitoids	43.33%
		Thrissur	Rice bug	Entomopathogen	EPF–8 (Characterisation of fungus is in progress)
		Thrissur	Cassava: mealybug complex	Entomopathogens	*Simplicillium formicae* (EPF – 6), *Purpureocillum lilacinum* (EPF – 7)
5	Dr YSPUHF, Solan	Nauni, Solan	Tomato: *Tuta absoluta, Trialeurodes vaporariorum, Helicoverpa armigera, Liriomyza trifolii, Tetranychus urticae, Macrosiphum euphorbiae*	*Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, Diglyphus horticola Chrysoperla zastrowi sillemi*	6-8 bugs/plant 15-20% parasitism, 1-2egg masses/plant
		Nauni, Solan	Cauliflower/ cabbage/ Broccoli: *Brevicoryne brassicae,* *Pieris brassicae* *Plutella xylostella*	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Oenopia sexareata* *Episyrphus balteatus, Episyrphus confrater, Ischiodon scutellarus, Sphaerophoria indiana, Scavea pyrastri, Syritta pippens, Melanostoma orientale, Betasyrphus isaaci, Eupeodes corollae, Eupeodes confrater, Eupeodes pseudonitens, Eupeodus viridaerus, Scaeva latimaculata Diaeretiella rapae, Cotesia glomerata*	2-5 beetles/ plant 4-6% parasitism
		Nauni, Solan	Pea: *Chromatomyia horticola*	*Diglyphus horticola*, *D. isaea*, *Quadrastichus plaquoi*, *N. formosa*, *Chrysocharis* sp., *Chrysocharis indicus*, *Pediobius indicus*	10-25% parasitism

		Nauni, Solan	Cucumber- *Trialeurodes vaporariorum, Aphis gossypii*	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Oenopia kirbyi, O. sauzetii, O. sexareata, C. zastrowi sillemi, Encarsia formosa*	5-10 beetles/ plant 3-8 grubs/ plant 10-15% parasitism
		Nauni, Solan	Peaches: Aphid *Brachycaudus helichrysii* and thrips	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Anthocoris* sp. *Orius* sp. *Adalia* sp.	5-15 beetle/plant, 1-4 bugs/ leaf curl
		Nauni, Solan	Rose: *Macrosiphum rosae*	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Oenopia kirbyi, O. sauzetii, O. sexareata, Harmonia dimidiata, C. zastrowi sillemi*	2-4 beetles/plant 1-3larvae/plant 1-2egg masses/plant
		Kandaghat, Solan	Tomato: *Macrosiphum euphorbiae, Tuta absoluta, Trialeurodes vaporariorum, Helicoverpa armigera, Liriomyza trifolii*	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculatus Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, Diglyphus horticola*	1-2 beetles/plant 2-3 bugs/plant 10-15% parasitism
		Kandaghat, Solan	Peaches: *Brachycaudus helichrysi* and thrips	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Anthocoris* sp. *Orius* sp. *Adalia tetraspilota*	5-10 beetle/plant 1-3 bugs/ leaf curl
		Kandaghat, Solan	Cauliflower, Cabbage/ Broccoli: *Brevicoryne brassicae, Pieris brassicae, Plutella xylostella*	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Diaeretiella rapae, Cotesia glomerata, Diadegma semiclausum*	2-3 beetles/ plant 3-5% parasitism
		Rajgarh, Sirmaur	Tomato: *Tuta absoluta, Trialeurodes vaporariorum, Liriomyza trifolii, Macrosiphum euphorbiae*	*Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, Diglyphus horticola, Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata*	4-6 bugs/plant 5-10% parasitism 1-2 beetles/plant 2-3 grubs/plant

		Rajgarh, Sirmaur	Peaches: *Brachycaudus helichrysii* and thrips	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Adalia tetraspilota Anthocoris* sp. *Orius* sp.	3-5 beetle/plant, 1-2 grubs/plant 1-3 bugs/ leaf curl
		Sundernagar, 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% parasitism 1-2 larvae/ plant
		Rohru, Jubbal, Kotkhai, Chaupal, Theog- Shimla district	Apple: *Eriosoma lanigerum, Panonychus ulmi, Dorysthenus hugelii*	*C. zastrowi sillemi Aphelinus mali Coccinella septempunctata, Hippodamia variegata, Propylea lutiopustulata, Harmonia dimidiata*	1-2 egg / plant 10-12% parasitism 3-5 beetles/ plant
		Rekon Peo, Kalpa: Kinnaur district	Apple: *Eriosoma lanigerum, Panonychus ulmi, Dorysthenes hugelii, Quadraspidiotus perniciosus*	*Aphelinus mali Adalia tetraspilota, Chilocorus infernalis, Priscibrumus uropygialis, Harmonia dimidiata, Harmonia eucharis, Stethorus* sp.	10-15% parasitism 3-10 beetles/ plant
		Rekon Peo, Kinnaur district	Almond: Leaf curl aphid, thrips and scale	*Coccinella septempunctata, Cheilomenes sexmaculata, Adalia tetraspilota, Harmonia eucharis, Oenopea sauzetii*	8-15 beetles/ plant
		Tabo: Lahaul and Spiti district	Apple: *Eriosoma lanigerum, Panonychus ulmi, Dorysthenus hugelii, Quadraspidiotus perniciosus*	*Coccinella septempunctata, Hippodamia variegata, Priscibrumus uropygialis, Harmonia dimidiata, Harmonia eucharis, Aphelinus mali*	15-20 beetles/ plant 10-15% parasitism
		Tabo: Lahaul and Spiti district	Almond: Leaf curl aphid, thrips and scale	*Coccinella septempunctata, Hippodamia variegata, Cheilomenes sexmaculata, Adalia tetraspilota, Harmonia eucharis, Oenopea sauzetii, Anthocoris* sp. *Orius* sp.	10-15 beetles/ plant 1-2 bugs/ leaf curl
		Mane (Spiti Valley), Lauhal & Spiti district	Cauliflower/ cabbage: *Brevicoryne brassicae, Pieris brassicae*	*Coccinella septempunctata, Hippodamia variegata, Diaeretiella rapae*	2-3 beetles/ plant

		Bharmour Tissa, Chamba district	Apple: *Eriosoma lanigerum, Panonychus ulmi, Dorysthenus hugelii*	*C. zastrowi sillemi, Aphelinus mali Coccinella septempunctata, Hippodamia variegata, Propylea lutiopustulata, Harmonia dimidiata*	1-2 egg mass/ plant 10-15% parasitism 3-5 beetles/ plant
		Bharmour Tissa, Chamba district	Pea: *Chromatomyia horticola*	*Diglyphus horticola*, *D. isaea*, *N. formosa*	5-10% parasitism
		Bharmour Tissa, Chamba district	Cabbage/ Cauliflower: *Brevicoryne brassicae,* *Pieris brassicae*	*Coccinella septempunctata, Hippodamia variegata, Diaeretiella rapae*	2-3 beetles/ plant 2-10% parasitism
		Jhanjeheli	Apple: *Eriosoma lanigerum, Panonychus ulmi, Dorysthenes hugelii, Quadraspidiotus perniciosus*	*Aphelinus mali Adalia tetraspilota, Chilocorusin fernalis, Harmonia dimidiata, Harmonia eucharis, Stethorus* sp.	10-15% parasitism 2-3 beetles/plant
6	UBKV, Pundibari	Pundibari	Rice: *Scirpophaga incertulas* and *Cnaphalocrocis medinalis*	Egg parasitoids Larval parasitoid	40% parasitism –
		Pundibari	Litchi: Litchi bark eating caterpillar	*Beauveria bassiana* (UBKVBb1)	70-75% natural mortality (deposited ICAR-NBAIM Mau, UP No. TF-3225)
7	SKUAST, Srinagar	Srinagar	Apple: *Eriosoma lanigerum*	*Aphelinus mali*	5% parasitism
		Srinagar	Apple: *Aphis pomi*	*Chilocorus* spp.	–
		Srinagar	Apple: Codling moth	*Fusarium* spp.	10% mortality in overwintering pupae of codling moth
		Baramullha	Kale: Cabbage butterfly larvae	*Cotesia glomerata*	7%
		Zainpora	Apple: *Leucoptera scitella*	–	–
		Kulgam	Mustard: Mustard aphid	Hover flies	5 larvae/colony
		Shalimar	Apple: *Aphis pomi*	4 species of coccinellids	0.50 beetles/tree
		Kulgam	Tomato	NPV	2% mortality

8	MPKV, Pune	Pune, Satara, Solapur, Nagar, and Sangli	Sugarcane: Sugarcane woolly aphid	*Coccinella septempunctata,Menochilus sexmaculatus, Scymnus* sp., *Dipha aphidivora, Micromus igorotus* Syrphid: *Eupeodes confrater* and *Encarsia flavoscuttellum*	0-7 larva/colony 0-5 grub/ colony 0-2 larva/colony 0-20 larva/colony (15% parasitism)
			Coconut: rugose spiralling whitefly	*Apterochrysa* sp. *Encarsia* sp.	0-2 beetle/colony
			Custard apple: Mealybug complex	*Menochelus sexmaculata, Brumoides suturalis, Scymnus coccivora*	0-10 grubs/colony 0-1 egg/colony
			Mango	*Mallada boninensis*	
			Maize: *S. frugiperda* *S. litura*	*Metarhizium rileyi*	
9	PAU, Ludhiana	Hoshiarpur, Jalandhar, Ludhiana	Maize: *S. frugiperda*	*Trichogramma chilonis* *Chelonus formosanus* *Chelonus blackburni* *Campoletis flavicincta* *Charops bicolor* *Temelucha* sp. *Microplitis* sp. *Callibracon* sp. *Coccigidium* sp.	5.03% 22.25% 1.23% 0.61 % 1.75% 1.23% 0.96% 0.17% 0.17%
		Hoshiarpur, Kapurthala, Ludhiana	Sugarcane: Pyrilla	*Fulgoraecia melanoleuca*	7.69%
		Fazilka, Abohar, Mansa, Bathinda, Ludhiana	Cotton: Sucking insect pests (leafhopper, whitefly, thrips)	Spiders *C. zastrowi sillemmi* *Coccinella septempunctata*, *Cheilomenes sexmaculata* *Brumus suturalis* *Serangium* sp. *Geocoris* sp.	1.1 to 1.1/ plant 1.1 to 1.2/ plant 0.0 to 0.3/ plant 0.0 to 0.2/ plant 0.0 to 0.2/ plant 0.0 to 0.1/ plant 0.0 to 0.1/ plant
		Mansa Ludhiana Bathinda	Cotton: Whitefly	*Encarsia sophia* & *Encarsia lutea*	7.42%
		Jalandhar, Barnala, Ludhiana, Kapurthala	Rice	Spiders *Neoscona theisi, Tetragnatha javana, Tetragnatha maxillosa* *Argiope catenulate* *Leucage decorateOxyopes kusumae* *Thomisus* sp. *Dolomedes fimbriatus* *Bianor* sp.	58.20% abundance 17.99% 14.81% 2.65% 2.12% 1.59% 1.06 % 1.06% 0.53%

		Ludhiana	Wheat/ aphid	*Coccinella septempunctata* *Cheilomenes sexmaculata*	0.1 to 1.0 /plant 0.1 to 0.3/plant
		Ludhiana	Cauliflower, mustard, Raya: Aphid	*Coccinella septempunctata*, *Cheilomenes sexmaculata*	0.4 to 5.7 / plant 0.1 to 0.2/ plant
		Ludhiana Mansa	Cauliflower, mustard, Raya, Cole crops/ Cabbage caterpillar	*Cotesia glomerata*	33.76%
		Ludhiana, Hoshiarpur, Jalandhar	Gram/ Gram caterpillar	*Campoletus chloridae*	13.86%
		Ludhiana, Muktsar, Gurdaspur	Wheat, Barley, Oilseeds, Vegetables, Fruits, Ornamental crops, Weeds	Predatory syrphids: *Episyrphus balteatus* *Ischiodon scutellaris* *Melanostoma scalare* *Sphaerophoria chongjini* *Eupeodes frequens* *Eupeodes corollae* *Metasyrphus confrater* *Betasyrphusserarius* *Chrysotoxum baphyrum*	42.89% abundance 25.17 % 8.65% 7.95% 7.06% 4.18% 3.45% 1.24% 0.02%
10	AAU, Anand	Chorvad, Junagadh	Coconut: Rugose spiralling whitefly	*Encarsia* sp.	0-2 adults/plant
		AAU, Anand	Brinjal: Shoot and fruit borer	*Bracon* sp.	
			Casuarina equisetifolia: Egyptian cottony cushion scale, *Icerya aegyptiaca*	*Novius fumidus*	
			Citrus: Aphid	*Aneglesis cardoni*	
			Cress: Aphid	*Coccinella transversalis*	
			Maize: Aphid	*Harmonia octomaculata* and *Prophyla dissecta*	
			Chilli	*Illias cincta*	
			Dodi: Aphid	*Chilocorus nigritus*	
			Brinjal: Shoot and fruit borer	NPV	
11	AAU, Jorhat	AAU campus	Cucumber: Fruit fly *Zeugodacus cucurbitae* pupae	Parasitoid (unidentified)	–
		Farmers field, Jorhat	Toria: Coccinellids Pupae	Hyper parasitoid (unidentified)	5% parasitism
		AAU campus	Brinjal: *Leucinodes orbonalis*	Parasitoid *Trathala flavoorbitalis*	7% parasitism

		AAU campus	Tomato: Aphid	Zoophytophagus predator	
12	TNAU, Coimbatore	Coimbatore	Maize, Brinjal	*Trichogramma chilonis*	
			Brinjal	*Trichogramma pretiosum*	1.5% parasitism
			Coconut, Banana, Custard apple	*Encarsia guadeloupae*	
			Papaya	*Acerophagus papayae*	0-50 adults/tree
			Cassava	*Anagyrus lopezi. Pseudleptomastix mexicana, Tetrastichus* sp.	
			Coconut, Papaya, Cotton, Cassava	*Apertochyrsa astur*	0-1 egg
			Cotton, Cassava, Curry leaf, Cabbage, Ornamentals	*Chrysoperla zastrowi silemmi*	
			Coconut, Papaya, Guava, Cassava, Crotons	*Cryptolaemus montrouzieri*	0-5 bettle/colony
			Coconut	*Chilocorus nigrita*	
			Coconut, Chilli, Cassava, Brinjal, Maize	*Cheilomenes sexmaculata*	0-10 beetles
			Coconut, Cassava	*Cybocephalus indicus*	0-5 beetles
			Guava	*Scymnus* sp.	0-10 beetles/colony
			Sugarcane	*Dipha aphidivora, Micromus igorotus*	0-10 beetles/colony
			Paddy	*Cyrtorhinus lividipennis* Spider-*Lycosa pseudoanulata*	
			Coconut	Spider *Argiopes* sp. and praying mantis	
13	CAU, Pasighat	Pasighat	Store grains: green gram bruchid	*Anisopteromalus calandrae*	
			Citrus: bark eating caterpillar cadavers	*Beauveria bassiana*	
			Litichi: Litchi bug cadavers	*Lecanicillium lecanii*	
14	UAS, Raichur	Yadagir, Ballari, Koppal	Maize: *S. frugiperda*	*T. chilonis*	1-5% parasitism

15	MPUAT, Udaipur	Badgaon, Sayara, Madar, Jaisamand, Dabok, Khokharwas, Intali, Mavali, Falichadakhedi, Fatehanagar, Vallabhnagar	Maize chickpea & tomato	*Nesidiocoris tenuis*	
				Neochrysocharis formosa	
				Goniozus sp.	
				Bracon sp.	0-2 cocoon/plant
				Campoletis chloridae	
				Cotesia flavipes	
				Eucanthecona furcellata	0-10 beetles/plant
				Preying mantid	
				Coccinellids	
				Reduvid bug	
				Green lacewing	
				Nesidiocoris tenuis	
16	GBPUAT, Pantnagar	Haldu, Chaur Dina	Mustard, Sugarcane, Wheat	*Trichoderma harzianum*	$1x10^3$ cfu/g of soil
		Golapar, Haldwani	Wheat, Garlic, Tomato	*T. harzianum*	
			Wheat	*T. viride*	
		Doliakhal, Dehradun	Pea	*T. harzianum*	
		CRC, Pantnagar	Rice, maize, wheat	*T. harzianum*	
		CRC, Pantnagar	Moong	*Trichoderma viride*	
		CRC, Pantnagar	Rice	*T. asperellum*	
		CRC, Pantnagar	Black gram, maize, soybean, Sorghum, chikpea	*T. viride*	
		VRC, Pantnagar	Coriander	*T. viride*	
		VRC, Pantnagar	Tomato, chilli	*T. harzianum*	
		Pithoragarh	Groundnut	*T. viride*	
		Tanakpur	Bajra	*T. harzianum*	
		Champawath	Beans	*T. harzianum*	
		Patal, Bhuvaneshwar	Groundnut	*T. asperellum*	
		Bazpur, Udham Singh Nagar	Rice	*T. viride*	

II. SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS

ANGRAU, Andhra Pradesh

II. 1. Surveillance for pest outbreak and alien invasive pests

Conducted 18 field visits in paddy, sugarcane, maize, coconut, chillies in Visakhapatnam, Vizianagaram, Srikakulam, Guntur, NTR districts of Andhra Pradesh during kharif and rabi, 2022-23 and the incidence of insect pests in different crops were presented in Table 2.

Table 2. Surveillance for pest outbreak and alien invasive pests

S. No.	Centres	Date of survey	Location	Crop	Pests/Diseases incidence	Chemical pesticides if any used	Infestation (%)
1	ANGRAU Ankapalle	29.07.2022	Atchutapuram, Haripalem, Anakapalle (Dt)	Rice	Blast	Nil	2-4%
2	ANGRAU Anakapalle	12.8.2022	Kondakarla Atchutapuram (M), Anakapalle (Dt)	Rice Bhendi	Hispa	Nil	<5%
3	ANGRAU Anakapalle	25.08.2022	Boni, Anandapuram Padmanabham, Thatithuru Visakhapatnam (Dt)	Rice Maize	Hispa, Termites FAW	Nil Neem, Emamectin benzoate	15-22% hispa, termites 6-15% FAW
4		26.09.2022	Haripalem, Atchutapuram (M), Anakapalle (Dt)	Rice	Leaf folder, stem borer, gall midge, sheath blight and blast	Acephate Chlorpyriphos	<5% stem borer, gall midge, leaf folder 10-15% Sheath blight blast
5		29.09.2022	Thogaram, Ragolu, Srikakulam (Dt)	Rice	Leaf folder	Monocrotophos	<10%
6		10.10.2022	Bheemili, Padmanabhamand anandapuram mandals, Visakhapatnam district	Rice	BPH Sheath blight	Monocrotophos	10-12 hoppers /hill >50% sheath blight
7		28.10.2022	Mungeru, Ravada, Bhogapuram (M), Vizianagaram (Dt), Subadrapuram, Etcherla (M), Srikakulam Dt	Coconut	RSW	Nil	33-60%
8		31.10.2022	Laxmipuram, Dibbapalem, Anakapalle(M) Visakhapatnam (Dt)	Rice	BPH & WBPH Leaf folder	Monocrotophos, Acephate	>30 hoppers/ hill <5%Leaf folder
9		4.11.2022	Tumpala, Dibbapalem Anakapalle (M), Visakhapatnam (Dt)	Rice	Panicle mite and sheath rot in rice	Nil	>15% panicle mite and Sheath rot

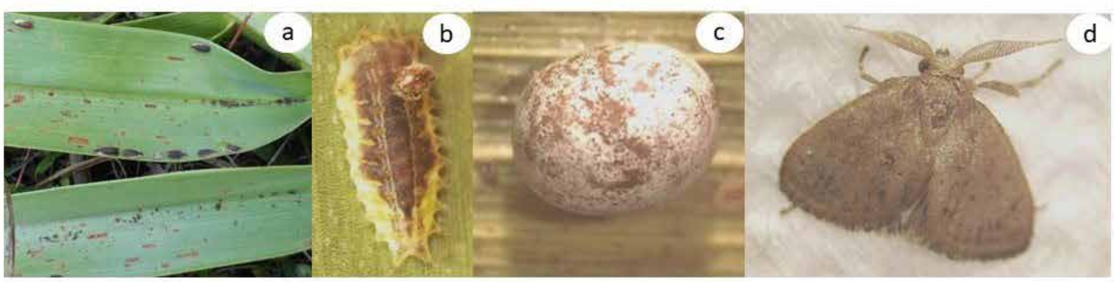
10		19.11.2022	Narsipatnam, Lambasingi, Chinthapalli, Visakhapatnam (Dt)	Rice	Leaf folder, Hoppers	Chlorpyriphos Acephate Monocrotophos	10-12% leaf folder 25-40 hoppers/ hill
				Maize	FAW	Emamectin benzoate	10-16%
11		30.11.2022	Venkupalem, Dibbapalem, Anakapalli(M) Visakhapatnam (Dt)	Rice	Panicle mite and Hoppers	Acephate-Monocrotophos	12-15% Panicle mite infestation 30 hoppers/ hill
12		01.12.2022	Venkataraopeta, Pathrapalli, Ranasthalam(M), Srikakulam (Dt), Chollangipeta Denkada (M), Vizianagaram (Dt)	Maize	FAW	Neem oil	5-8%
13		03.01.2023	VN Puram, Ranasthalam (M), Srikakulam (Dt)	Maize	FAW	Emamectin benzoate	6-8%
				Chillies	Flower thrips/ Black thrips	Imidacloprid	25-30%
14		05.01.2023	Adaviravulapadu, Bheemavaram, Vathsavayi, NTR District	Chillies	Flower thrips/ Black thrips Leaf crinckle virus	Neem, Fipronil, Imidacloprid	20-25 thrips/ flower 90-100% virus infestation
15		06.01.2023	Solasa, Yedlapadu, Thimmapuram, Basikapuram, Nudurupadu, Guntur dist	Chillies	Flower thrips/ Black thrips Leaf curl virus	Neem, Fipronil, Imidacloprid	3-31 thrips/ flower 20-100% leaf curl virus
16		13.01.2023	VN Puram, Venkataraopeta, Ranasthalam (M), Srikakulam (Dt) Chollangipeta, Denkada (M), Pusapatirega Vizianagaram (Dt)	Maize Coconut	FAW in maize and RSW in coconut	Emamectin benzoate in maize	5-10% FAW 22-57% RSW
		13.01.2023		Capsicum	Flower thrips/ Black thrips	Fipronil Imidacloprid	12-25%
17		13.02.2023	VN Puram, Venkataraopeta,Nagarapalem, Patharlapalli, Ranasthalam (M), Etcherla, Ragolu, Srikakulam (Dt)	Maize Coconut	FAW RSW	Monocrotophos, Emamectin benzoate in maize	Negligible to 1% in Tasseling to cob filling stage 28-57% RSW
18		23.02.2023	Paderu (M), Madugula (M), Alluriseetharamaraju (Dt)	Sugarcane Rice	Internode borer Brown spot	Nil	25-36% <5% Brown spot

II. 1.1. CPCRI, Kayamkulam

Table 3. Outbreak of emerging or exotic pests in coconut system

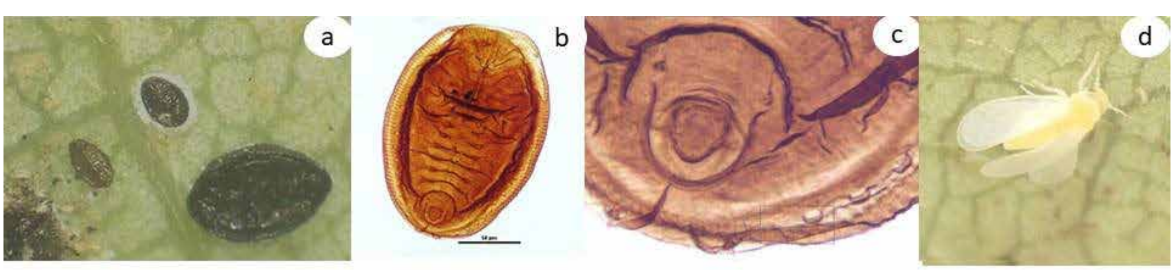
S. No	Centre	Date	Location	Crop	Pest incidence	Chemicals used	Infestation (%)
1	ICAR-CPCRI, Kayamkulam	April 2022	Kottayam, Kerala	Coconut	Slug caterpillar, *Contheyla rotunda* (Limacodidae: Lepidoptera)	Nil	15% to 20%
2	ICAR-CPCRI, Kayamkulam	May 2022	Kayamkulam, Kerala	*Coleus* sp. in coconut system	Whitefly, *Aleuroclava canangae* (Aleyrodidae: Hemiptera)	Nil	20% to 25% (First report from India)
3	ICAR-CPCRI, Kayamkulam	May 2022	Ambalapuzh, Kerala	*Gliricidia sepium* in coconut system	Legume whitefly, *Tetraleurodes acaciae* (Aleyrodidae: Hemiptera)	Nil	<10%, New distribution record from Kerala
4	ICAR-CPCRI, Kayamkulam	December 2022`	Kollam, Kerala	Coconut	Palm whitefly, *Aleurotrachelus atratus* (Aleyrodidae: Hemiptera)	Nil	10% to 15% New distribution record from Kerala
5	ICAR-CPCRI, Kayamkulam	April 2022 - March 2023	Kayamkulam, Kerala	Coconut	Absence of Guam haplotype of *Oryctes rhinoceros* (Scarabaeidae: Coleoptera)	Nil	Nil, No A to G transition at 288 nucleotide base pair
6	ICAR-CPCRI, Kayamkulam	June 2022	Kayamkulam, Kerala	Guava in coconut system	Exotic nematode *Meloidogyne enterolobii*	Nil	10% to 20%

Fig 1. *Contheyla rotunda*



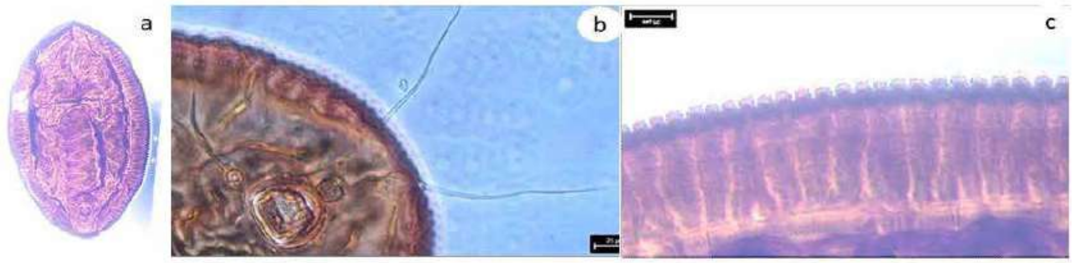
***Contheyla rotunda*: a) Leaf damage b) Caterpillar c) Pupa d) Adult moth**

Fig 2. *Tetraleurodes acaciae*



***Tetraleurodes acaciae*: a) Puparium on leaf b) Habitus c) Vasiform orifice d) Adult whitefly**

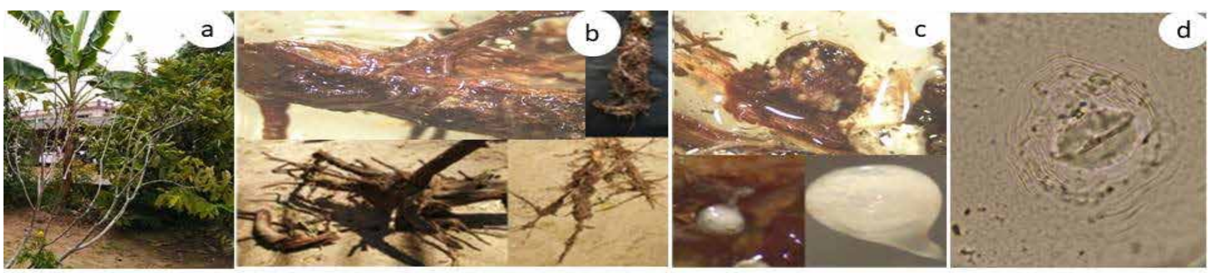
Fig 3. ***Aleurotrachelus atratus***



Aleurotrachelus atratus : a) Habitus b) Vasiform orifice & round lingula c) Submarginal globules in overlapping rows

Fig 4. Absence of Guam haplotype with no A to G transition at 288 bp

Fig 5. ***Meloidogyne enterolobii***



Meloidogyne enterolobii: a) Leaf symptoms b) Root damage c) Nematode galls d) Perineal pattern

II. 1.3. GBPUAT, Pantnagar

Table 4. Surveillance for pest outbreak and alien invasive pests

S. No	Date of survey	Location	Crop	Disease incidence (%) of sheath blight	Chemical pesticides if any used
1.	15.07.22 to 31.10.22	District Nainital	Rice	29.67	Dithane, Bavistin, Blitox Copper Blue, Ridomil Metalaxyl, Kocide Chlropyrifos, Avant Malathion, Imidacloprid Glyphosate, Butachlor Paraquat, Pendimethalin Streptocycline
		District U.S. Nagar	Rice	19.89	

II. 1. 4. IGKV, Raipur

Table 5. Survey for pest outbreak and alien invasive pests

S. No.	Date of survey	Location	Crop	Pests/Diseases incidence	Chemical pesticides if any used	Infestation (%)
1.	28.08.2022	Chilli field IGKV, Raipur (C.G.)	Chilli	Chilli thrips *Thrips parvispinus* Pests occurrence initial stage to fruit harvesting	Nil	40%

II. 1. 5. KAU, Thrissur

Table 6. Survey for pest outbreak and alien invasive pests

Sr. No.	Centre	Date of survey	Location	Crop	Pests/Diseases incidence	Chemical pesticides if any used	Infestation
Pest infestation							
1	AICRP on BCCP, KAU Thrissur	03-10-2022	Meloor, Thrissur	Cassava	*Spodoptera mauritia*	Recommended to use poison baits	50%
2		07-10-2022	Veluthoor, Thrissur	Rice	*S. mauritia*	Poison baits and water management	50%
3		02-12-2022	Karimbattta, Thrissur	Rice	*S. mauritia*	Poison baits and water management	40%
4		07-01-2023	Arimbur, Thrissur	Rice	Sheath blight and brown spot	Yes	50%
5		20-01-2023	Pattambi, Palakkad	Rice	BLB	Bleaching powder and antibiotics	100%
6		14-02-2023	Porathisseri, Thrissur	Rice	False smut	No. Seed treatment with chemicals recommended for next season	75 %
7		03-02-2023	Elanad, Thrissur	Banana	*Spodoptera litura*	Yes	60%
8		18-03-2023	Adat, Thris-sur	Rice	Blast	Yes (Tebuconazole 50%+ Trifloxystrobin 25% w/w WG)	100 %

II. 1. 6. NCIPM, New Delhi

S. No.	Date of survey	Location	Crop	Pests/Diseases incidence	Chemical pesticides if any used	Infestation (%)
1	28-06-2022	Manoli, Sonepat, Haryana	Sweet corn	Fall armyworm	Nil	50-60%

2	11-07-2022	Bhaini Chanderpal, Rohtak, Haryana	Cotton	Internal boll rot	Nil	>30%
3	08-08-2022	Bhaini Chanderpal, Rohtak, Haryana	Cotton	Internal boll rot CLCuD	Copper oxychloride, Flonicamid	5% 10-15%
4	02-09-2022	Village Badi, Gannaur, Sonipat, Haryana	Rice	Southern Rice Black-Streaked Dwarf Virus (SRBSDV)	Thiamethoxam, Dinotefuran	5-10 %, and up to 30-50 % in few fields
5	28-09-2022	Village: Ikla, Gautambudhnagar, UP	Rice	Yellow stem borer	Fipronil 5% SC	2-5 % white ear symptoms

Fig 6. Southern Rice Black-Streaked Dwarf Virus (SRBSDV) disease in rice

II. 1. 7. Dr. YSPUHF, Solan

Surveys were conducted in different locations in districts Bilaspur, Kangra, Mandi, Solan, Sirmour, Shimla, Lahaul and Spiti and Kinnaur for alien invasive pests like*, Aleurodicus dugessi, Phenacoccus manihoti, Paracoccus marginatus*, *Phenacoccus madeirensis, Phthorimaea absoluta* and, *Spodoptera frugiperda.* During the survey only two invasive pests *viz. P. absoluta* and *S. frugiperda* were recorded infesting tomato and maize, respectively. The details are given below in Tables 8 & 9.

Table 8. Incidence of *Phthorimaea absoluta* on tomato at different locations

S. No.	Date of Survey	Location	District	Plants infested (%)	Mines/leaf/ infested plant	Fruit damage (%)
1	04.07.2022	Nauni	Solan	25-44	0-3	1-4
2	05.07.2022	Kandaghat	Solan	22-36	0-3	1-3
3	07.07.2022	Dharampur:	Solan	10-36	1-2	1-3
4	08.07.2022	Rajgarh	Sirmaur	15-46	1-3	1-2
5	09.07.2022	Ghumarwin	Bilaspur	15-40	2-3	1-2

6	19.07.2022	Jachh	Kangra	27-44	1-3	1-3
7	20.07.2022	Dehra	Kangra	15-48	1-2	1-2
8	11.07.2023	Sundernagar	Mandi	26-45	1-3	1-4
9	05.10.2022	Bhar:	Lauhal &Spiti	Nil	Nil	Nil
10	04.10.2022	Mane	Lauhal &Spiti	Nil	Nil	Nil
11	10.9.2022	Rekongpeo	Kinnaur	Nil	Nil	Nil
12	09.09.2022	Kalpa	Kinnaur	Nil	Nil	Nil
13	06.10.2022	Pooh	Kinnaur	Nil	Nil	Nil

Table 9. Incidence of *Spodoptera frugiperda* on maize at different locations

S. No.	Date of survey	Location	District	Plants infested (%)
1	16.07.2022	Berthin	Bilaspur	25-55
2	22.07.2022	Pabowal	Una	40-50
3	28.07.2022	Samrod	Solan	20-30
4	21.07.2022	Bhota	Hamirpur	35-55
5	19.07.2022	Jachh	Kangra	45-60
6	20.07.2022	Dehra	Kangra	35-70
7	08.07.2022	Rajgarh	Sirmaur	25-35
8	22.07.2022	Neri	Hamirppur	25-45

II. 1. 8. UBKV, Pundibari

Table 10. Crop Pest Outbreak Report (2022-23)

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 quarter from April, 2022 to March, 2023 to assess the infestation of different pests in the field. The detailed Crop Pest outbreak report is as follows –

S. No.	Date of Survey	Location			Crop	Pest/ Disease Incidence	Chemical Pesticides used (if any)	Infestation (%)
1.	16.04.2022	GPS Co-ordinates	Name of Village	Block	Coconut	Rugose spiralling Whitefly	Yes Farmer sprayed Imidacloprid @ 1 ml/lit of water	Sakunibala: 10% Bararangras: 15% Singimari Paschimpar: 15% Kalarayerkuthi: 10% Madhupur: 5%
		26°43’76”N 89°39’17” E	Sakunibala	Coochbehar - II				

		26°43’81”N 89°40’04” E	Bararan-gras					
		26°47’83”N 89°35’74” E	Singimari Paschimpar					
		26°44’56”N 89°37’79” E	Kalarayer-kuthi					
		26°36’43”N 89°37’48” E	Madhupur					
2.	10.08.2022	27°04’13”N 88°28’30” E	Sangsay	Kalimpong - II	Mandarin orange	Trunk borer	No	Sangsay: 45% Icchey Gaon: 40%
		27°04’12”N 88°28’29” E	Icchey Gaon					
3.	22.11.2022	27°15’50” N 88°64’07” E	Sakyong	Kalimpong - II	Mandarin orange	Chinese fruit fly (*Bactrocera minax*)	No	Sakyong: 60% Bongbusty: 50% Mirikbusty: 70% Sitong: 60%
		26°98’24” N 88°44’15” E	Bongbusty	Kalimpong – I				
	29.11.2022	26°53’07” N 88°10’58” E	Mirikbusty	Mirik				
		26°70’83” N 88°42’68” E	Sitong	Kurseong CD				
4.	04.12.2022	26°34’50” N 89°43’50” E	Silkhuri Bas	Coochbe-har - I	Potato	*Myzus persicae*	No	Silkhuri Bas: 40% Pundibari: 10% Silkhuri Bas:10% Dungra Khas-mahal: 30% Tirpai: 10%
	05.12.2022	26°31’48” N 89°06’36” E	Pundibari	Coochbe-har - I	Pumpkin	*Brevicoryne bras-sicae*		
	09.12.2022	26°34’50” N 89°43’50” E	Silkhuri Bas	-do-	Guava	*Greenidia psidii*		
	15.12.2022	27°10’53” N 88°46’92” E	Dungra Khasmahal	Kalimpong – I	Chilli	i) *Myzus persicae* ii) *Aphis gossypii*		
	16.12.2022	27°06’64” N 88°46’63” E	Tirpai	Kalimpong – II	Cabbage	*Brevicoryne bras-sicae*		

II. 1. 9. SKUAST, Srinagar

Table 11. The incursion of new invasive insect pests and their infestation rate is being depicted in the below given table 11.

Sr. No.	Centre	Date of survey	Location	Crop	Pests/Diseases incidence	Chemical pesticides if any used	Infestation (%)
1.	SKUAST-K	18-07-2022	Nadihal	Apple	Codling moth	Yes,	10.00
2.	SKUAST-K	15-07-2022	Choor	Apple	Codling moth	Yes	8.00
3.	SKUAST-K	20-08-2022	Chaki-Gujri	Apple	Codling moth	Yes	20.00
4.	SKUAST-K	17-05-2022	Singpora	Apple	Codling moth	Yes	7.00
5	SKUAST-K	13-07-2022	Zainpora	Apple	Apple blotch leaf miner	Yes	30.00
6.	SKUAST-K	25-07-2022	Babapora	Apple	Apple blotch leaf miner	Yes	40.00
7	SKUAST-K	23-08-2022	Awneera	Apple	Apple blotch leaf miner	Yes	23.00
9	SKUAST-K	09-07-2022	Uthora	Apple	Light brown apple moth	Yes	5.00

10.	SKUAST-K	17-06-2022	Zainpora	Apple	Apple leaf cutting midge	Yes	1.00
11.	SKUAST-K	23-08-2022	Baramullha	Pear	Fruit fly	Yes	5.00
12.	SKUAST-K	20-07-2022	Budgam	Pear	Fruit fly	Yes	2.00
13	SKUAST-K	20-04-2022	Sopore	Apple	Leaf roller	Yes	10.00

II. 1. 10. KAU, Vellayani

Table 12. Surveillance for pest outbreak and alien invasive pests

S. No.	Centres	Date	Location	Crop	Pests/Diseases incidence	Chemical pesticides if any used	Infestation (%)
1.	KAU Vellayani	Jan 2022	Vellayani, Amalathara, TVM	Cassava	Mealy bug *P.manihoti*	NIL	50-70%
2.	KAU Vellayani	Feb 2022	Trivandrum	Maize	Vellayani	Ekalux, Chlorantraniliprole	Localised outbreak only in maize (80%)

II. 1. 11. MPKV, Pune

Fig 7. Biodiversity of natural enemies of pests from various agro-ecological zones

Fig 8. Survey and surveillance for pest outbreak and alien invasive pests on sugarcane crops in Ahmednagar district

Table 13. Survey and surveillance for pest outbreak and alien invasive pests

S. No.	Site of collections	Crop eco-system and the host insects	Biocontrol agents observed	Parasitism /Predatory potential / Natural occurrence of Entomopathogens (%)
1	Newasa and Shevgaon Dist-Ahmednagar	Sugarcane woolly aphid	*Dipha aphidivora* *Micromus igoratus* *Eupeodes confrator*	1-2 larvae/leaf 4-8 grubs/leaf 2-3%
2	Biocontrol Farm, COA, Pune	Cowpea aphid Cabbage aphid, chilli sucking pests	*Coccinella septempunctata* *Menochilus sexmaculata* *Apanteles angaleti*	2-3 grubs and beetles / plant 2-3 %
3	Pune Solapur, Ahmednagar	Sugarcane, Maize, Soybean, Mango, Brinjal, Okra, Beans	Spiders	1-2/10 plants

4	Pune Ahmednagar Solapur, Sangli	Soybean, Cabbage, Potato, Maize	Diseased cadavers of *Spodoptera frugiperda*, *S. litura*, diamond back moth, semilooper were collected from the fields	1-2 %
5	Pune District	Coconut and Guava	*Apertochrysa astur*	1-2 /leaf

Table 14. Survey and surveillance for pest outbreak and alien invasive pests

S. No.	Location	Crop	Pests/Diseases incidence	Infestation (%)
1	Biocontrol farm, AC Pune	Maize	Fall Armyworm	15-20 %
2	NARP, Ganeshkhind	Okra	Jassid, White fly and Shoot and Fruit borer	4-5%, 6-7% and 4-5 %/1-2 %
		Ashwagandha	*H. armigera*/ Anthracnose	7-8 %/ 6-7%
3	Newasa and Shevgaon Tahashil	Sugarcane	White grub and woolly aphids	40-50 % and 2-3%
4	AC Pune	Coconut	Rugose spiralling whitefly	24.33 %
5	AC Pune and NARP, Ganeshkhind	Mango	Mango hopper, Leaf webber	7-11 % and 2-3 %
6	Saswad	Custard apple	Mealy bug and Tea mosquito bug	62 %/ 4 %
7	Khed and Daund Tahshil of Pune District	Coconut	Rugose spiralling whitefly	2-36 %
8	Biocontrol farm, AC Pune	Chilli	Thrips Whitefly	15% 11%
9	North Solapur Tahashil	Maize	Fall Armyworm	20-22%

II. 1. 12. PAU, Ludhiana

Surveillance for pest outbreak and alien invasive pests

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). The status of insect pests recorded in different crops in Punjab during 2022-23 is given in Table 15.

Table 15. Status of insect pests on different crops in Punjab

S. No.	Date(s) of survey	Location (Districts)	Crop	Pests/Diseases incidence*	Chemical pesticides if any used	Infestation (%)
1.	6.5.22 11.5.22 18.5.22 23.5.22 27.5.22	Hoshiarpur, Jalandhar, Kapurthala, Nawanshahr, Sangrur	Sugarcane	*Chilo infuscatellus*, *Scirpophaga excerptalis*	-	2-3% dead hearts

2.	1.6.22 10.6.22 15.6.22 22.6.22 28.6.22	Jalandhar, Gurdaspur, Sangrur, Patiala Kapurthala	Sugarcane	*Chilo infuscatellus*, *Scirpophaga excerptalis*	Chlorantraniliprole 0.4G @ 25 kg/ha	5-7% dead hearts
3.	4.7.22 11.7.22 15.7.22 18.7.22 25.7.22 29.7.22	Amritsar, Gurdaspur, Hoshiarpur Ropar, Bathinda, Muktsar	Sugarcane	*Chilo auricilius*	-	3-4%
			Maize	*Chilo partellus*, *Spodoptera frugiperda*	Chlorantraniliprole 18.5 SC @ 75 ml/ha	3-4% dead hearts and 10 % FAW damage
			Cotton	*Bemisia tabaci*, *Pectinophora gossypiella*	Azadirachtin 1500 ppm @ 2.5 litre/ha, Fenpropathrin 10EC @ 750 ml/ha	3-5 whitefly adults/ leaf 4-5% PBW damage
4.	5.8.22 8.8.22 12.8.22 22.8.22 26.8.22 29.8.22	Amritsar, Ferozepur, Patiala, Jalandhar, Bathinda, Mansa, Muktsar Sangrur	Sugarcane	*Chilo auricilius*	-	3-4%
			Maize	*Spodoptera frugiperda*	Chlorantraniliprole 18.5 SC @ 75 ml/ha	20 % FAW damage
			Cotton	*Bemisia tabaci* *Pectinophora gossypiella*	Flonicamid 50WG @ 200 g/ha, Fenpropathrin 10EC @ 750 ml/ha	6-8 whitefly adults/ leaf 0-5% PBW damage
			Rice	*Scirpophaga incertulas*, *Cnaphalocrocis medinalis*	Flubendiamide 480 SC @ 50 ml/ha	2-3% dead hearts & 5-6 % folded leaves
5.	2.9.22 5.9.22 9.9.22 12.9.22 19.9.22 28.9.22	Hoshiarpur, Jalandhar, Pathankot Bathinda, Mansa, Muktsar Patiala	Sugarcane	*Chilo auricilius*	-	4-5%
			Cotton	*Bemisia tabaci*, *Pectinophora gossypiella*	Flonicamid 50WG @ 200 g/ha	3-5 whitefly adults/ leaf 0-15 % PBW damage
			Rice	*Nilaparvata lugens*, *Scirpophaga incertulas*	Dinotefuron 20 SG @ 200 g/ha, Pymetrozine 50 WG @ 300 g/ha	3-5 hoppers/ hill 4-6% white ears
6.	4.10.22 7.10.22 12.10.22 18.10.22	Amritsar, Jalandhar, Ludhiana, Sangrur, Fazilka, Muktsar	Sugarcane	*Chilo auricilius*	-	3-4%
			Cotton	*Bemisia tabaci*	-	2-3 whitefly adults/ leaf
			Rice	*Nilaparvata lugens*	-	2-3 hoppers/ hill
7.	1.2.23 6.2.23 15.2.23 24.2.23	Amritsar, Kapurthala, Ferozepur, Mansa, Sangrur	Wheat	*Sitobion* sp., *Lipaphis erysimi*	-	4-6 aphids/ earhead
			Mustard	*Lipaphis erysimi*	-	8-10 aphids/ terminal shoot

*No pest incidence was observed in April, November, December 2022 & January 2023

II. 1. 13. Dr. YSRHU, Ambajipeta

Table 16. Surveillance for pest outbreak and alien invasive pests

S. No.	Date of survey	Location	Crop	Pests/Diseases incidence	Chemical pesticides if any used	Infestation (%) Number of black headed caterpillar larvae/ 4leaflets
1.	April 2022	Makarampuram, Pedakojjiriya, Jadupudi, Srikakulam district, AP	Coconut	Coconut black headed caterpillar, *Opisina arenosella*	Nil	2.45±0.72
	May 2022	Makarampuram, Pedakojjiriya, Jadupudi, Kaviti, Kanchili Srikakulam district, AP				1.93±0.36
	June 2022	Makarmpuram, Jadupudi Srikakulam district, AP				1.25±0.52
2.	March 2022	Pedavegi, Bhimadolu, Chintalapudi, Lingapalem and Musunuru mandals of Eluru district, AP	Coconut	Leaf blight of coconut- *Lasiodiplodia theobromae*	Nil	5-12% incidence

II. 1. 14. AAU, Anand

Table 17. Survey and surveillance for pest outbreak and alien invasive pests

S. No.	Date of Survey	Location	Crop	Pests/Diseases incidence	Infestation (%)
1	03/03/22	Medicinal and Aromatic Plants Research Farm, AAU Campus, Anand	Dodi	Psylla	11-12 %
2	08/03/22	Plant Pathology Farm, AAU Campus, Anand	Okra	Jassid, White fly and Shoot and Fruit borer/ YMV	4-5%, 6-7% and 4-5 %/ **1-2 %**
			Ashwagandha	*H. armigera*/ Anthracnose	7-8 %/ **6-7%**
3	15/03/22	Agronomy farm, AAU Campus, Anand	Lucerne	Aphid and *Spodoptera litura*	7-8 % and 8-9%
4	23/03/22	Plant Pathology Farm, AAU Campus, Anand	Maize	*S. frugiperda*/ Leaf blight	8-10%/ **4-5 %**
5	28/03/22	Horticulture farm, AAU Campus, Anand	Mango	Mango hopper, Leaf webber/ Mango Malformation	8-12 % and 2-4 %/ **2-3 %**
			Citrus	Psylla/ Die back	7-8 %/ **2-3%**

6	30/03/22	Entomology Farm, AAU Campus, Anand	Fennel	Aphid/ Powdery mildew	10-13 %/ **1-3 %**
7	07/04/22	Horticulture Farm, AAU campus, Anand	Mango	Mango hopper and Leaf webber Mango malformation	5-7 % and 2-4 %/ **1-2 %**
8	20/04/22	Forage Farm, AAU campus, Anand	Sorghum	Stem Borer and Painted bug	5-7 % and 1-3 %
9	25/04/22	Agronomy Farm, AAU campus, Anand	Sesame	False Chinch bug, Whitefly and Jassid/ Phyllody	1-2 %, 5-7 % and 2-4 %/ **1-2 %**
10	10/05/22	Main Vegetable Research Station Farm, AAU Campus, Anand	Cucumber	Leaf miner/ Mosaic	8-10%/ **10-12%**
11	25/05/22	Farmer's field, Navli	Brinjal	White fly, Jassid and Shoot and Fruit borer/ Little leaf of brinjal	8-9 %, 4-5 % and 6-7 %/ **6-7%**
			Cabbage	Painted bug	8-10 %
12	17/06/22	Entomology Farm, AAU Campus Anand	Bottle gourd	Fruit fly Leaf miner	10-12 % 6-7%
13	20/06/22	Agronomy Farm, AAU Campus Anand	Maize	*S. frugiperda*/ Leaf blight	8-10 %/ **1-2%**
14	22/07/22	Forage Research Station, AAU Campus, Anand	Maize	*S. frugiperda*	4-5%
			Sorghum	Stem borer and Ash Weevil	4-5% 2-3%
15	25/07/22	Main Vegetable Research Station Farm, AAU Campus, Anand	Ridge Gourd	Leaf miner	1-2 %
			Okra	Jassid and *S. litura*	1-2 % 2-3 %
16	20/08/22	Entomology Farm, AAU Campus, Anand	Maize	*S. frugiperda*, Stem borer and Aphid/ Leaf blight	18-20 %, 4-5 %. 2-3 %/ **10-15 %**
17	25/08/22	Tarapur, Dist. Anand	Paddy	Leaf folder	8-10 %
18	25/08/22	Budhej Ta. Tarapur, Dist. Anand	Paddy	Leaf folder	5-7 %
19	26/08/22	Bechari Ta. Umreth, Dist. Anand	Paddy	Leaf folder	7-8 %
20	30/08/22	Biological Control Research Farm, AAU Campus, Anand	Soybean	Whitefly/ Mosaic	8-10 %/ **8-10 %**

21	19/09/22	Forage Research Station, AAU, Anand	Maize	Fall Armyworm and Aphid/ Leaf blight	10-12% and 4-5%/ **10-15 %**
			Sorghum	Fall Armyworm	5-6%
22	03/10/22	Biological Control Research Farm, AAU Campus, Anand	Greengram	Aphid	8-9 %
23	21/10/22	Farmer's Field, Navli	Brinjal	Sucking Complex (Jassid and Whitefly) and Shoot and Fruit borer Little leaf of brinjal	4-5%, Sucking Complex and 6-8 % **3-4 %**
			Cotton	Sucking Complex (Aphid, Jassid, and Whitefly	8-10 %
24	21/10/22	Farmer's field, Kasumbad	Cotton	Sucking Complex (Aphid, Jassid, Whitefly and Mealybug)	18-20 %
			Cotton	Sucking Complex (Aphid, Jassid, and Whitefly	5-8 %
25	7/11/22	Biological Control Farm Farm, AAU Campus, Anand	Brinjal	Shoot and Fruit borer and Sucking Complex (Jassid and Whitefly)	8-10 %
			Tomato	*H. armigera* and whitefly	4-5 % and 5-6 %
			Green gram	Blister beetles	8-10%
26	18/11/22	Agronomy Farm, AAU Campus, Anand	Castor	Semilooper and Hairy caterpillar	7-8% and 3-4%
27	22/11/22	Horticulture farm, AAU Campus, Anand	Radish	Mustard saw fly	6-7%
28	30/11/22	Agriculture and Horti-culture Research Station, AAU, Khambholaj	Chilli	Black thrips and *Scirtothrips dorsalis*	6-7% and 4-5%
29	6/12/22	Agronomy Farm, AAU Campus, Anand	Castor	Hairy caterpillar	8-10%
30	12/12/22	Agriculture and Horti-culture Research Station, AAU, Khambholaj	Chilli	Black thrips	8-10%
31	17/12/22	Pathology Farm, AAU Campus, Anand	Cotton	Aphid, Jassid, Whitefly and *H. armigera*	8-10% Sucking pests and 7-8%
			Tomato	White fly and *H. armigera*	7-8% and 7-8%

32	27/12/22	Horticulture farm, AAU Campus, Anand	Radish	Mustard saw fly and Aphid	8-10% and 4-5%
33	04/01/23	Agriculture and Horticulture Research Station, AAU, Khambholaj	Chilli	Black thrips	8-10%
34	18/01/23	Biological Control Research Farm, AAU Campus, Anand	Coriander	Aphid	6-7%
35	18/01/23	Horticulture farm, AAU Campus, Anand	Radish	Aphid	8-10%
36	24/01/23	Medicinal and Aromatic Plants Research Farm, AAU Campus, Anand	Cress	Mustard saw fly	3-4%
37	07/02/23	Biological Control Research Farm, AAU Campus, Anand	Coriander	Aphid	8-10%
			Brinjal	Shoot and fruit borer	7-8%
38	14/02/23	Medicinal and Aromatic Plants Research Farm, AAU Campus, Anand	Cress	Mustard saw fly and Aphid	8-10% and 4-5%
39	14/02/23	Pathology Farm, AAU Campus, Anand	Onion	Thrips	7-8%
			Cotton	Jassid, Whitefly and *H. armigera*	8-10% and 8-10%

Results:

Survey was conducted in various locations of Anand district and other districts of Gujarat. During the survey, invasive thrips, *Thrips parvispinus* was observed in chilli crop.

II. 1. 15. AAU, Jorhat

Table 18. Insect pests observed in survey period

S. No.	Date of survey	Location	Crop	Pests/Diseases incidence	Chemical pesticides if any used	Infestation (%)
1	06.07.2022	AAU, campus	Boro rice, Bhut Jolokia	*Helicoverpa armigera* and chilli leaf folder	Neem oil 300ppm 500/L	Moderate
2	10.07.2022	Umrangsu, Dima Hasao	Arecanut	Spotted grass hopper *Aularchus miliaris*	Chlorpyriphos 20EC @ 2ml/L	80%
3	28.07.2022	Jorhat	Okra, Assam lemon	Leaf roller and mealy bug	Nil	Low
4	15.08.2022	Dangdhora, Golaghat	Rice	Leaf folder and stem borer of rice	Nil	Low
5	03.09.2022	Barauti Gaon, Sibasagar	Ridge gourd, Bhut Joloki	Fruit fly and mealy bug	Pheromone trap and Neem oil 15000ppm @2ml/L	Moderate

6	23.09.2022	Gohain gaon, Sibasagar	Pumpkin	Viral disease	-	Moderate
7	02.10.2022	Bahphola, Jorhat	Brinjal & cauli-flower	Brinjal fruit and shoot borer, *Pieris brassicae*	Neem oil 15000ppm @2ml/L	Moderate
8	29.10.2022	Kaasogoral, Jorhat	Tea	Termite	Chlorpyriphos 20EC @ 2ml/L	75%
9	15.11.2022	Baganpara, Baksa	Apple ber and dragon fruit	Fruit fly and mealy bug	Pheromone trap and Neem oil 15000ppm @2ml/L	Moderate
10	29.11.2022	Rice	Charaideo	Swarming caterpillar	Chlorantranilip-role 18 SC @ 0.3 ml /L followed by Lambda Cyhalo-thrin EC 1-5ml/L	70%
11	4.12.2022	Coconut	AAU, campus	Bondar's nesting white-fly & Rugose spiraling whitefly	Neem oil 15000ppm @2ml/L	Low
12	10.12.2022	Diphu	Cowpea	Aphid	*Lecanicillium lecanii* @ 5ml/L	Moderate
13	22.12.2022	Mohorisuu, Majuli	Chilli, Tomato, Brinjal	Fruit borer, Brinjal fruit and shoot borer, Chilly leaf curl virus	Neem oil 15000ppm @2ml/L	Moderate
14	21.02.2023	Dhemaji	Mustard	Swarming caterpillar	Chlorantranilip-role 18 SC @ 0.3 ml /L	Moderate
15	02.02.2023	ICR farm, AAU Jorhat	Maize	Fall army worm	Chlorantranilip-role 18 SC @ 0.3 ml /L	Moderate
16	15.02.2023	Experimental plot, Depart-ment of Agron-omy	Maize	Fall army worm	Chlorantranilip-role 18 SC @ 0.3 ml /L	Moderate
17	20.03.2023	Shyam Gaon, Sibsagar	Cowpea, Rice	Aphid, Fruit fly, Hispa in boro rice	Neem oil 15000ppm @2ml/L	Moderate

Fig 9. Bondar's nesting whitefly

Rugose spiralling whitefly

Spotted grass hopper *Aularchus miliaris*

II. 1.16. PJTSAU, Hyderabad

SURVEILLANCE FOR PEST OUTBREAK AND ALIEN PESTS

The trial involved surveys of Mahbubnagar, Rangareddy and Nalgonda districts of Telangana in both Kharif and rabi seasons of 2022-23. 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. 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.

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 20*22-23, 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 *P. absoluta.* Fusarial wilt was noticed in chick pea, chillies and colocasia crops.

II. 1.17. CAU, Pasighat

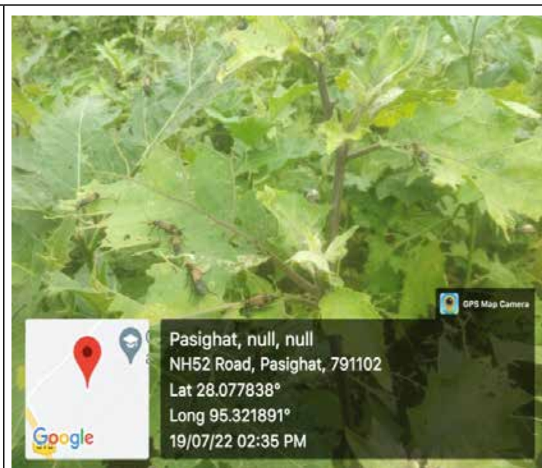
Table 19. Surveillance for Pest outbreak and alien invasive pests

S. No.	Date of survey	Location	Crop	Pests/ Diseases incidence	Chemical pesticides if any used	Infestation (%)
1	22/05/2022	CHF Pasighat, East Siang district, Arunachal Pradesh	Litchi	Ash weevil *Myllocerus sp*	Profenophos+Cypermthrin@2ml/l water Neem oil 1500 ppm@2ml/l water	Moderate
2	19/07/2022	CHF Pasighat, East Siang district, Arunachal Pradesh	Bitter brinjal	Blister beetle	Nil	Severe

3	13/07/2022	Pasighat, East Siang district, Arunachal Pradesh	Litchi	Erinose mite *Aceria litchi*	Nil	Severe
4	17/07/2022	Riga village, Siang district, Arunachal Pradesh	Large cardamom	Root grub	Nil	Moderate

Fig. 10 Different Pests recorded during the survey period

Ash weevil (*Myllocerus* sp.) on Litchi



Blister beetle on Bitter brinjal

Litchi erinose mite in Pasighat

Root grubs and Chirkey incidence on Large Cardamom at Riga, Siang, AR

Colocasia leaf beetles incidence at Hunli, Lower Dibang Valley on 30/07/2022	**Foorkey incidence on Large Cardamom at Hunli, Lower Dibang Valley on 31/07/2022**
	
Pink stem borer on Ragi at Monigong, ShiYomi on 13/08/2022	**Scales (*Pinnaspis buxi*) on Bush pepper on 07/12/2022**
	
***Aphis craccivora* on Faba bean at Pasighat on 13/12/2022**	**Colocasia Mealy bug: *Formicoccus polysperes* at Chidu village, LDV on 03/12/2022**

Besides these we have also documented the incidence of following pests Table 20.

Pest's Name	Host crop	Location	Severity status
Aphis gossypii	Brinjal	Riga, Siang	Moderate
Toxoptera citricidus	Khasi Mandarin	Riga, Siang	Low
Rhopalosiphum maidis	Miaze	Riga, Siang	Moderate
Ceratovacuna perglandulosa	Broom plant	Monigong, Shiyomi	Low
Phenacoccus parvus	Brinjal	CHF, Pasighat	Low

II. 1.18. SKUAST – Jammu

Table 21. Crop Pest Outbreak from April, 2022 to March, 2023

S. No.	Month	Date	Locations	Crop	Problems noticed & Level of incidence
1.	April	16/04/2022	Vill. - Sarore District: Samba	Cucurbits	Red Pumpkin Beetle- Moderate Bacterial blight Per cent disease incidence: 30%
2.	May	2/05/2022	Vill. – Patli Morh, Badhoi District: Samba	Shade plants, Ornamental	Mealy bug: 30 – 40% plants affected

3.	June	15/06/2022	Vill. - Dhiansar District: Samba	Guava	Mealy bug: Moderate to Severe
4.	July	17/07/2022 17/07/2021	Vill. – Sarore District: Samba Vill.-Patli Morh District: Samba	Cucumber Chilli	Mites and Aphids: Moderate Chilli wilt Per cent disease incidence: – 20%
5.	August	25/08/2022 25/08/2022	Vill. – Bishnah Vijaypur, District: Samba Vill. – Bishnah District: Samba	Rice Turmeric, Bridge gourd, Bitter gourd	Stunting and yellowing in rice field Per cent disease incidence: – 20-30% Rice blast disease also observed Per cent disease incidence: – 20% Hairy caterpillar infection Moderate
6.	September	21/09/2022	Vill. –Kulwal District: Samba	Spinach	Leaf spot on leaves Per cent disease incidence: – 20%
7.	October	18/10/2022	Vill. - Sarore District: Samba	Cucumber	Yellow mosaic Per cent disease incidence:- 30 - 40%
8.	November	19/11/2022	Vill.-Sarore District: Samba	Mango	Mealy bug – Moderate to Severe
9.	December	18/12/2022	Vill. – Sangwal, District: Samba	Guava, Mango	Mealybug – Moderate Fruitfly – Moderate Gall formation - Moderate
10.	January	Nil			
11.	February	18/02/2023	Vill.– Channi Manhassan, District: Samba Vill. – Ranjhari, Raya District: Samba	Cucumber Mango	Alternaria Leaf Blight - Per cent disease incidence: 25-30% Anthracnose and leaf blight – Per cent disease incidence: 30%
12.	March	09/03/2023	Vill. – Patli Morh, District: Samba	Trees	Mealy bug-Moderate

II. 1.19. OUAT, Bhubaneshwar

Table 22. Surveillance of insect pests in different crops

Month and year	Crop	Pest	Level of infestation	Chemical pesticides if any used
July 2021	Rice	Yellow stem borer (*Scirpophaga incertulas*)	Mild	Nil
August 2021	Rice	Yellow stem borer (*Scirpophaga incertulas*) Leaf folder (*C. medinalis*)	Moderate Moderate	Chlorantraniliprole 18.5% SC 200ml/ha
September 2021	Maize	Fall armyworm (*Spodoptera frugiperda*)	Low to Medium	Nil
October 2021	Rice	Yellow stem borer (*Scirpophaga incertulas*)	moderate	Chlorantraniliprole 18.5% SC 200ml/ha
November 2021	Maize	Fall armyworm (*Spodoptera frugiperda*)	Mild	Nil

December 2021	Mustard	Mustard aphid (*Lipaphis erysimi*)	Mild to Moderate	Nil
January 2022	Mustard	Mustard aphid (*Lipaphis erysimi*)	Moderate	Dimethoate 30 EC 625 ml/ha
February 2022	Brinjal	Brinjal fruit and shoot borer (*Leucinodes orbonalis*)	Moderate	Lambda-cyhalothrin 5% EC 300ml /ha
March 2022	Brinjal	Brinjal fruit and shoot borer (*Leucinodes orbonalis*)	Moderate	Lambda-cyhalothrin 5% EC 300ml /ha

II. 1.20. MPUAT, Udaipur

Surveillance for Pest Outbreak and Alien Invasive Pests

The extensive survey was conducted to record the present biodiversity of insects from different locations of Southern Rajasthan *viz.,* Udaipur, Chittorgarh and Rajsamand districts during *Kharif* and *Rabi* 2022. The diversity of insect pests and their natural enemies were recorded on different sown crops such as maize, soybean, pulses (blackgram, greengram and cowpea), and vegetables (tomato, brinjal, bhindi etc.) (Table 23).

Table 23. List of crop wise associated insect pests

S. No.	Crop	Common name	Insect	Family	Order
1.	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
2.	Vegetables (Tomato, Brinjal, Bhindi)	Fruit borer	*Helicoverpa armigera*	Noctuidae	Lepidoptera
		Brinjal shoot and fruit borer	*Leucinodes orbonalis*	Crambidae	Lepidoptera
		Tomato Pin Worm	*Phthorimaea absoluta*	Gelechidae	Lepidoptera
		Ash Weevil	*Myllocerus subfasciatus*	Curculionidae	Coleoptera
		Jassid	*Empoasca kerri*	Cicadellidae	Hemiptera
		Whitefly	*Bemisia tabaci*	Aleyrodidae	Hemiptera
		Aphid	*Aphis craccivora*	Aphididae	Hemiptera
3.	Soybean	Girdle beetle	*Oberea brevis*	Cerambycidae	Coleoptera
		Tobacco caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera
4.	Pulses (blackgram, greengram, cowpea)	Whitefly	*Bemisia tabaci*	Aleyrodidae	Hemiptera
		Jassid	*Empoasca kerri*	Cicadellidae	Hemiptera
		Tobacco caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera
		Aphid	*Aphis craccivora*	Aphididae	Hemiptera

Fig 11. Different Pests recorded during the survey period

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

Surveys were conducted to record the incidence of fall armyworm, *S. frugiperda* from June, 2022 to March, 2023. The survey indicated that the incidence of fall armyworm was noticed to be low to moderate in different districts of Southern Rajasthan with an average incidence range of 5-10 per cent (Table 24.).

Fig 12. Incidence of Fall armyworm

Table 24. Monitoring of *S. frugiperda* by pheromone traps at RCA Farm

Date of installation of pheromone trap	Number of traps/acre	No. of adults trapped (week)	Trap-1	Trap-2	Trap-3	Trap-4	Total trapped adults
01/06/2022	05	I	04	03	05	05	17
		II	05	06	10	09	30
		III	02	03	04	04	12
		IV	00	03	02	02	07
		V	02	07	15	03	27
		VI	03	05	04	03	15
02/11/2022	05	I	00	01	02	04	07
		II	03	01	07	02	13
		III	04	08	05	07	24
		IV	04	06	07	09	26
		V	01	04	07	04	16
		VI	02	05	08	03	18
		VII	01	08	10	03	22
		VIII	03	09	05	03	20
		IX	01	07	00	07	17
		X	02	05	04	03	14
		XI	00	01	00	00	00

II. 1.21. TNAU, COIMBATORE

Survey, surveillance and monitoring of rugose spiralling white fly and their natural enemies on coconut

Table 25. Roving survey - Incidence of Rugose spiralling whitefly (RSW) and Bondars nesting whitefly (BNW) and their natural enemies on coconut

S. No.	Date of survey	Village/District	GPS Coordinates	Population of whitefly		Natural enemies	
				Nos. of RSW/ leaflet	Nos. of BNW/ leaflet	*Encarsia* sp parasitisation (%)	*Apertochrysa astur* Nos./leaflet
1.	13.04.2022	K.G Valasu/Erode	11.1287°N,77.6344°E	5	8	20	1
2.	11.05.2022	Nagaranai/Erode	11.4185°N,77.2475°E	2	0	10	1+spider
3	11.05.2022	Kothukadu/Erode	11.4546°N,77.2553°E	5	3	10	1
4.	27.05.2022	Kariyenchettipalayam/Coimbatore	10.5687°N,77.0085°E	10	5	20	2
5.	27.05.2022	Uppiliyur Piruvu/Coimbatore	10.5723°N,77.0089°E	6	2	20	2
6.	27.05.2022	Samathur/ Coimbatore	10.6188°N,77.0141°E	3	6	35	1+spider
7.	27.05.2022	Kottampatti/ Combatore	10.6218°N,77.0144°E	2	3	25	1
8.	27.05.2022	Suleeswaranpatti/ Coimbatore	10.6355°N,77.0072°E	5	2	20	1
9.	27.05.2022	Periyapodhu/ Coimbatore	10.6538°N,77.0082°E	4	2	25	1

10.	28.05.2022	Kenjanur/ Erode	11.4986°N,77.2045°E	2	0	0	Spider
11.	03.06.2022	Indiampalayam/ Erode	11.4362°N,77.2528°E	4	1	10	1
12.	14.06.2022	Matthampalayam/ Coimbatore	11.1935°N,76.9719°E	5	1	20	1
13.	18.06.2022	Nagaranai/Erode	11.4185°N,77.2475°E	6	2	40	1
14.	18.06.2022	Sundakkapalayam/Erode	11.4355°N,77.2481°E	3	0	25	2
15.	22.06.2022	Ariyappampalayam/ Erode	11.4499°N,77.2420°E	8	0	20	Spider
16.	22.06.2022	Ukkaram/Erode	11.4455°N,77.2332°E	6	3	35	1
17.	25.06.2022	Kariyenchettipalayam/ Coimbatore	10.5687°N,77.0085°E	5	9	20	1
18.	08.07.2022	Paduvampalli/ Coimbatore	11.1595°N,77.1198°E	8	4	40	1
19.	08.07.2022	Chennappachettipudhur/ Coimbatore	11.1592°N,77.1197°E	2	2	25	2
20.	08.07.2022	Rayarpalayam/ Coimbatore	11.1717°N,77.1108°E	14	8	65	1
21.	08.07.2022	Alangium/ Tiruppur	10.6808°N,77.5101°E	6	3	40	2
22.	08.07.2022	Dhalavoipattinam/ Tiruppur	10.6828°N,77.5109°E	4	2	40	1
23.	27.07.2022	Mathireddypalayam/,Coimbatore	11.2551°N,77.1377°E	6	9	25	2
24.	27.07.2022	Pudhupalayam/ Coimbatore	11.2561°N,77.1362°E	5	12	30	1
25.	27.07.2022	Annur/ Coimbatore	11.2561°N,77.1362°E	3	10	25	1
26.	30.07.2022	Indiampalayam/Erode	11.4363 °N,77.2524°E	8	12	40	2
27.	30.07.2022	Nagaranai/Erode	11.4185°N,77.2475°E	4	3	20	1+spider
28.	30.07.2022	Kothukadu/Erode	11.4546°N,77.2553°E	5	3	25	1
29.	30.07.2022	Kenjanur/ Erode	11.4986°N,77.2045°E	3	6	15	1
30.	02.08.2022	Alangium/ Tiruppur	10.6808°N,77.5101°E	19	6	50	1
31.	02.08.2022	Dhalavoipattinam/ Tiruppur	10.6828°N,77.5109°E	12	4	50	2+spider
32.	26.08.2022	Nagaranai/Erode	11.4185°N,77.2475°E	4	3	25	1
33.	06.09.2022	Kariyenchettipalayam/ Coimbatore	10.5687°N,77.0085°E	6	15	40	2
34.	06.09.2022	Uppiliyur pirivu/Coimbatore	10.5329°N, 77.0190°E	4	3	45	1
35.	26.11.2022	Vettaikaranpudur/ Coimbatore	10.5596°N; 76.8853°E	6	8	30	1
36.	26.11.2022	Saralaipathy/ Coimbatore	10.5442°N; 76.9023°E	14	9	35	1
37.	28.11.2022	Bhavanisagar/Erode	11.4792°N; 77.1342°E	4	2	20	2
38.	28.11.2022	Kavilipalayam/Erode	11.3809°N; 77.2182°E	12	5	50	1
39.	01.12.2022	Nagaranai/Erode	11.4185°N,77.2475°E	3	3	40	2
40.	02.12.2022	Vettaikaranpudur/Ciombatore	10.5596°N; 76.8853°E	4	8	30	1
41.	02.12.2022	Saralaipathy/Coimbatore	10.5442°N; 76.9023°E	10	5	45	1

42.	02.12.2022	Marchinaickenpalayam Coimbatore	10.6055 N; 76.9142 E	2	2	60	2
43.	02.12.2022	Chinnappampalayam Coimbatore	10.6017°N, 76.9201°E	1	2	45	1
44.	02.12.2022	Selamanur/Coimbatore	10.9929°N, 76.7915°E	8	13	25	2
45.	06.12.2022	Madhampatti/ Coimbatore	10.9914°N,76.8419 °E	4	15	30	1+spider
46.	06.12.2022	Kaliyannanpudur/ Coimbatore	10.9973°N,76.8259 °E	5	8	45	1
47.	07.12.2022	Somavarapatti/Coimbatore	10.6701°N,77.1969 °E	4	12	50	2
48.	06.12.2022	Kongalnagaram/Coimbatore	10. 4033°N,77.1127°E	7	15	45	1
49.	21.12.2022	Chinnappampalayam/Coimbatore	10.6017°N, 76.9201°E	1	4	50	2+spider
50.	21.12.2022	Vettaikaranpudur/Coimbatore	10.5596°N; 76.8853°E	6	8	45	1
51.	21.12.2022	Saralaipathy/Coimbatore	10.5442°N; 76.9023°E	2	6	55	2
52.	21.12.2022	Kariyenchettipalayam/ Coimbatore	10.5687°N,77.0085°E	4	16	30	2
53.	28.12.2022	Viraliyur/Coimbatore	10.9973°N,76.8259 °E	3	6	50	1
54.	28.12.2022	Narasipuram/Coimbatore	10.9880°N, 76.7740°E	5	8	45	1
55.	03.01.2023	Somavarpatti/Coimbatore	10.6701°N,77.1969 °E	5	14	30	2
56.	07.01.2023	Pungampalli/Erode	11.3923°N; 77.1775°E	6	13	15	1
57.	13.01.2023	Kaliannanpudur/Coimbatore	10.9973°N,76.8259 °E	4	10	20	2
58.	01.02.2023	Saralaipathy/Coimbatore	10.5442°N; 76.9023°E	4	11	45	1
59.	01.02.2023	Kariyenchettipalayam/Coimbatore	10.5687°N,77.0085°E	8	15	45	2+spider
60.	08.02.2023	Devarayapuram/Coimbatore	10.5951°N,76.4857°E	5	12	35	1
61.	08.02.2023	Kondaiyampalayam/ Coimbatore	10.9745°N,76.8629 °E	8	15	20	1
62.	16.02.2023	Somavarapatti/ Coimbatore	10.6701°N,77.1969 °E	6	10	35	3
63.	17.02.2023	Pullagoundenpudur/ Coimbatore	10.9945°N,76.7992 °E	7	13	30	1
64.	21.02.2023	K.G. Valasu/ Erode	11. 1287°N,77.6344°E	3	14	25	2
65.	23.02.2023	Kulathuppalayam/ Coimbatore	10. 9975°N,76.8462°E	4	8	40	1
66.	23.02.2023	Dhaliyur/Coimbatore	10. 9745°N,76.8629°E	3	5	25	1
67.	23.02.2023	Kongalnagaram/ Coimbatore	10. 4033°N,77.1127°E	2	14	20	2
68.	01.03.2023	Kaliannanpudur/ Coimbatore	10.9973°N,76.8259 °E	4	6	30	1
69.	04.03.2023	Desipalayam/Erode	11.3927°N, 77.1766°E	7	15	45	1

70.	08.03.2023	Pungampalli/Erode	11.3920°N, 77.1774°E	2	8	25	3
71.	08.03.2023	Shenbagapudur/Erode	11.4676°N, 77.2228°E	1	6	10	2+spider
72.	08.03.2023	Indiampalayam/Erode	11.4424°N, 77.2525°E	17	5	30	2
73.	08.03.2023	Karappadi/Erode	11.4334°N, 77.3301°E	12	18	45	1
74.	08.03.2023	Pariyur/Erode	11.4769°N, 77.4577°E	2	6	30	3
75.	08.03.2023	Moongilpatti/Erode	11.5025°N, 77.5452°E	3	6	15	2
76.	08.03.2023	Thalavaipettai/Erode	11.4648°N, 77.6249°E	12	5	30	2
77.	08.03.2023	Savundappur/Erode	11.5239°N, 77.5126°E	13	18	50	3
78.	16.03.2023	Paduvampalli/ Coimbatore	11.1709°N, 77.1154°E	2	9	30	2
79.	16.03.2023	Rayarpalayam/ Coimbatore	11.1700°N, 77.1124°E	13	8	45	6
80.	16.03.2023	Sangunaickenpalayam/Coim-batore	11.1854°N, 77.1211°E	4	14	40	4
81.	16.03.2023	Andigoundanur/Tirupur	10.5209°N,77.2764°E	1	8	40	1
82.	23.03.2023	Thatathiruram/ Cuddalore	11.5802°N,78.8614°E	8	1	35	1
83.	23.03.2023	Kandappankurichi/ Cuddalore	11.5288°N,79.2463°E	7	1	40	1
84.	29.03.2022	Srirangam/ Tiruchirapalli	10.8613°N,78.6797°E	21	16	40	4

Survey to monitor the incidence of coconut insect pests

Surveys were conducted to assess the infestation of Rugose spiralling whitefly (RSW) *Aleurodicus rugioperculatus* and Bondars Nesting Whitefly (BNW) *Paraleyrodes bondari* on coconut in various Districts in Tamil Nadu *viz.,* Coimbatore, Tirupur, Erode, Cuddalore and Trichy. The population of RSW ranged between 1.00 and 21.00/leaflet in various Districts in Tamil Nadu. The parasitisation by *Encarsia guadeloupae* ranged between 10.00 and 60.00 per cent on coconut gardens and a predator *Apertochrysa astur* was seen in all the coconut gardens. The maximum population of BNW (18.00/leaflet) was seen in Karapadi village in Erode district (Table 25.). Besides *E. guadeloupae* and *A. astur,* many predators *viz., Cybocephalus* spp., *Chilocorus nigrita*, praying mantis, dragonflies and spiders (*Argiopes* sp) were also observed in coconut gardens. In fixed plot survey, the population of RSW was maximum during second fortnight of August,2022 while it was minimum during first fortnight of January,2022. BNW population ranged between 9.0 and 34.0/10leaflets. Parasitisation by *Encarsia* sp was 50.00 per cent during first fortnight of September, 2021. Maximum of 4 numbers of *A.astur* grubs/leaflet were observed during second fortnight of April, 2023(Table 26.).

Table 26. Fixed plot survey for coconut RSW, BNW and its natural enemies

Location – Coconut nursery, TNAU Variety – ALR 3

Month	Fortnight	RSW population		BNW population		Natural enemies	
		No. of Colonies / 10 leaflets	No. of Adults / 10 leaflets	No. of Colonies / 10 leaflets	No. of Adults / 10 leaflets	*Encarsia sp.*, parasitization (%)	*Apertochrysa astur* (No. grubs / 10 leaflets)
January, 2022	13.01.2022	5	6	22	27	30	2
	30.01.2022	9	12	19	24	40	1
February, 2022	15.02.2022	10	16	21	19	45	1
	28.02.2022	12	20	18	21	40	2
March, 2022	10.03.2022	16	27	14	13	50	1
	29.03.2022	8	11	6	4	45	2
April, 2022	15.04.2022	19	32	15	16	50	2
	29.04.2022	12	17	11	9	35	4
May, 2022	12.05.2022	15	22	12	15	40	2
	26.05.2022	20	29	16	19	45	1
June, 2022	02.06.2022	13	18	14	16	30	1
	17.06.2022	11	24	13	23	50	1
July, 2022	02.07.2022	14	21	11	15	45	2
	18.07.2022	16	20	10	12	35	1
August, 2022	11.08.2022	25	39	9	15	40	2
	26.08.2022	28	44	13	19	45	2
September, 2022	01.09.2022	18	24	10	16	50	1
	15.09.2022	16	23	12	21	40	2
October, 2022	05.10.2022	14	21	13	26	30	1
	22.10.2022	12	18	15	25	25	-
November, 2022	07.11.2022	10	16	18	28	35	1
	22.11.2022	9	15	17	34	25	1
December, 2022	05.12.2022	7	13	15	26	30	-
	23.12.2022	6	9	13	22	35	1
January, 2023	06.01.2023	8	14	11	17	20	1
	23.01.2023	6	11	13	21	25	1
February, 2023	07.02.2023	10	9	15	19	40	-
	22.02.2023	7	7	10	12	20	1
March, 2023	10.03.2023	5	3	12	10	15	-
	27.03.2023	8	10	15	21	20	2

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

The infestation of *Paracoccus marginatus* was noted in crops like papaya, tapioca, mulberry, cocoa and guava. The incidence of papaya mealybug was observed in Coimbatore, Erode and Tiruppur districts. Infestation of papaya mealy bug ranged between 0.4 and 14.2 per cent in papaya. Natural enemies of papaya mealy bug *viz., Acerophagus papayae*, *Spalgis epius* and *Cryptolaemus montrouzieri* were recorded (Table 27).

Table 27. Roving survey – Incidence of Papaya Mealybug and its natural enemies

S.No	Date of survey	Village/District	GPS coordinates	Age of the crop (months)	*Paracoccus marginatus* Incidence (% infested trees)	Natural enemies/5 leaflets		
						Acerophagus papayae	*Apertochrysa astur*	*Cryptolaemus sp*
1.	21.03.2023	Senthampalayam/ Coimbatore	11.1372°N,77.1372°E	08	14.2	11.6	1.0	2.2
2.	16.03.2023	Andigoundanur/ Tirupur	10.5209°N,77.2764°E	08	0.4	9	-	4
3.	24.03.2023	Keetapalayam/ Tiruppur	11.0656°N,77.6909°E	08	4.8	4.6	1.2	1.0
4.	28.03.2023	Punjaithuraiyampalayam/ Erode	11.5067°N,77.3996°E	08	13	12.2	1.6	1.2
5.	30.03.2023	Perumapalayam/ Erode	11.4770°N,77.6243°E	15	8.2	3.6	-	1.0

Outbreak of coconut black headed caterpillar

During July, 2022, there was an outbreak of coconut black headed caterpillar in Sulur (Coimbatore Dt.) and Dharapuram (Tirupur Dt.). Awareness campaign cum field demonstration for the release of Braconid for the management of coconut black headed caterpillar was done at Dharapuram.

III. Biological control of plant disease using antagonistic organisms

Biological Control of Cereal Diseases

III. 1. Biological Control of Rice Diseases

GBPUAT

III. 1.1. Large scale demonstration of Pant Bioagent (PBAT-3) for the management of rice sheath blight (GBPUAT, Pantnagar)

Crop: Rice (var. local/hybrid)

Location: Farmers fields of District Udham Singh Nagar, Nainital District, Uttarakhand.

Area: 470 ha

Treatments

T1= Biocontrol (microbial) Package

T1: PBAT -3 formulation

- 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/ L for about 30 minutes.
- Two sprays of PBAT 3 @ 10 g/ L on standing crop (Tillering phase) at 10-12 days intervals

T2 = Farmers Practice

Carbendazim 2g/L drenching and spraying

Observations

- Disease incidence (Sheath blight)
- Grain yield of crop (kg/ha)

- Cost-benefit ratio.
- Large scale field demonstrations of bio-control were conducted at the end of 458 farmers of 65 villages of District Nainital and U S Nagar, covering an area of 470 ha. The farmer's acreage ranged was from 0.5-10.0 ha. Thirtyfive quintals PBAT-3 (*Trichoderma harzianum* Th14 + *Pseudomonas fluorescens* Pf 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. Pheromone traps with lure(*Scirpophaga incertulas*) were placed @ 20/ha to control rice stem borer.

Table 28. Occurrence of rice diseases at farmer's field

Disease	Causal Organism	PBAT-3	Conventional Practices
		Disease incidence (%)	Disease incidence (%)
Sheath blight	*Rhizoctonia solani*	12	10

An average yield of 65.0 q/ha was recorded by the farmers adopting bio-control technologies along with need based organic practices as compared to an yield of 65.5 q/ha by the farmers adopting conventional practices for the management of insect pests and diseases.

Table 29. Cost-benefit ratio with biocontrol practices and with conventional practices

Management Practices	Cost of production per ha	Yield	Selling price	Total selling price	Net Profit	Cost benefit ratio
	(Rs.)	(q/ha)	(Rs./q)	(Rs.)	(Rs.)	
Biocontrol Practices	42,600.00	65.0	2040.00	132600.00	90000.00	**1: 2.11**
Conventional practices	43,200.00	65.5	2040.00	133620.00	90420.00	**1: 2.09**


Fig 13. View of large scale field demonstration of Biocontrol technologies in Rice

III. 1.2. Development of biointensive IPM package and practices for pest management in basmati rice (Pusa basmati 1121)

Crop: Rice

Disease: Sheath Blight and Brown spot of Rice

Achievements: Maximum root length (20.16 cm) and shoot length (52.83 cm) were recorded in BIPM practices. This was at par with farmer's practice, the root and shoot lengths were observed 19.13 cm and 49.46 cm. Two diseases **viz.,** Sheath blight and Brown spot were observed in the experimental field during the cropping season. The lowest incidence of Sheath blight (*Rhizoctonia solani*) (14.25%) was observed in BIPM practices, which was at par with farmer's practice (15.62%) maximum disease incidence was found in untreated control (29.50%). In BIPM practices, sheath blight disease reduction was 51.69% while in farmer's practice it was 47.05%. Incidence of Brown spot (*Drechslera oryzae*) infected panicle/hill (11.00%) was recorded in BIPM practices was statistically at par with farmer's practice (13.00%). In BIPM practices, Brown spot disease reduction was 44.04% while in farmer's practice it was 33.87%. Maximum yield of rice was observed in BIPM (31.62 q/ha) which is statistically at par with farmers practice (29.62 q/ha) with cost benefit ratio of 1:2.33 in case of BIPM practices.

Fig 14. View of BIPM field demonstration of Biocontrol technologies in Rice field

Table 30. Effect of BIPM practices on the incidence of major diseases in rice

Treatment	Root length (cm)	Shoot length (cm)	Sheath Blight		Brown Spot		Yield (q/ha)	Percentage yield increase over control (%)	Cost benefit ratio
			Disease Incidence (%)	Disease Reduction (%)	Infected Panicles/hill (%)	Disease Reduction (%)			
BIPM	20.16 (26.67)	52.83 (46.62)	14.25 (22.17)	51.69	11.00 (19.23)	44.04	31.62 (34.21)	22.79	1:2.33
Farmer's practice	19.13 (25.93)	49.46 (44.69)	15.62 (23.27)	47.05	13.00 (21.12)	33.87	29.62 (32.97)	15.02	1:2.00
Untreated Control	15.60 (23.25)	39.50 (38.39)	29.50 (33.28)	-	19.66 (26.31)	-	25.75 (30.48)	-	-

CV	6.17	4.61	6.22		7.76		4.23		-
CD (0.05)	2.56	4.94	2.15		2.56		2.17		
SEm±	1.27	4.76	1.54		1.27		1.57		

PAU, Ludhiana

III. 1.3. Evaluation of antagonistic microbes against brown spot, blast and sheath blight of rice

Location : PAU, Ludhiana

Variety : PR 121

Date of sowing : 24.5.2022

Date of transplanting : 24 6.2022

Treatments : Three

T1: Foliar sprays of *Pseudomonas fluorescens* NBAIR PFDWD @ 10 gm/ liter on standing crop at 10 days interval i.e. 50, 60 and 70 days after transplanting (DAT).

T2: Two sprays with recommended fungicide Amistar Top 325 SC (azoxystrobin + difenoconazole) @ 200 ml/ acre starting with the initiation of disease

T3: Water sprayed control

Plot size : **50 m^2 each**

Replications : **6**

Observations recorded :

Disease severity based of SES 0-9 scale; IRRI recorded from 25 plants selected at random from each replicated plot.

Due to late receipt of bio-control formulation, the seed and seedling dip treatment could not be undertaken and only foliar sprays were given in the trial. The sheath blight incidence and severity in *Pseudomonas fluorescens* NBAIR PFDWD sprayed plots was statistically at par with the untreated control (Table 31.). The incidence in plots treated with *Pseudomonas fluorescens* was 75.33 per cent, with a severity of 30.33 per cent. These figures were statistically at par with control, where incidence and severity was 76.66 and 33.83 per cent, respectively. However, sprays of recommended fungicide Amistar Top 325 SC (azoxystrobin + difenoconazole) was found highly effective in managing the disease, where incidence of 28.00 per cent and average severity of 8.33 per cent, was recorded. Grain yield recorded after harvesting was 65.11q/ha in *Pseudomonas fluorescens* NBAIR PFDWD treatment and was as par with untreated control. However, chemical control recorded significantly better yield (74.0q/ha).

Table 31. Evaluation of bio-control agent *Pseudomonas fluorescens* NBAIR PFDWD against sheath blight of rice during 2022

Treatment	Disease incidence (%)	Sheath blight severity (%)	Grain yield (q/ha)
Pseudomonas fluorescens NBAIR PFDWD	75.33	30.33 (33.36)	65.7
Amistar Top 325 SC (azoxystrobin + difenoconazole)	28.00	8.33 (16.39)	73.5

Untreated control	76.66	33.83 (35.44)	64.3
LSD (*P=0.05*)	10.75	(2.88)	
CV %	13.93	15.44	3.39

*Figures in parentheses are arc sine transformed values

III. 1.4. Large scale demonstration of Pant Bioagent (PBAT-3) for the management of rice sheath blight

Treatments:

T1: Seed bio-priming with Pant Bioagent formulation, PBAT-3 (*T. harzianum* Th14 + *Pseudomonas fluorescens* Psf 173) @ 10g/kg of seeds + seedling dip with PBAT 3@ 10 g/ L for about 30 minutes + two sprays of PBAT 3 @ 10 g/ L on standing crop (tillering phase) at 10-12 days intervals

T2: POP Recommendation - 200 ml Amistar Top 325 SC (azoxystrobin + difenoconazole) or 80 g Nativo 75 WG (trifloxystrobin+tebuconazole)

The trial was finalized and assigned to PAU late in October month and season was already over. The experiment will be conducted in *Kharif*, 2023

AAU, Anand

III. 1.5. Evaluation of antagonistic microbes against brown spot, blast and sheath blight of rice

Table 32. Evaluation of antagonistic microbes against blast and sheath blight of rice during 2022-23

Treatments	Blast PDI (%)	Disease reduction over control (%)	Sheath blight PDI (%)	Disease reduction over control (%)
T_1-*Pseudomonas fluoresens* NBAIR PF-DWD(Seed treatment @10 g/litre +Seedling root dip @ 10 gm / litre+ Foliar spray @ 10 g/litre on standing crop at 10 days interval, *i.e.* 40, 50, 60 and 70 days after transplanting (DAT)	23.29*[b] (15.63)	39.21	16.09[b] (7.68)	49.27
T_2-POP Recommendation(Application of Tebuconazole 50%+ Trifloxystrobin 25 % (75% WG) 1g/L	17.98[a] (9.53)	62.93	12.71[a] (4.84)	68.03
T_3-Untreated control	30.47[c] (25.71)	-	22.90[c] (15.14)	-
S. Em.± (T)	1.05	-	0.82	-
C.D. at 5% T	3.23	-	2.53	-
C. V. (%)	11.59	-	12.58	-

Note: *Figures outside the parentheses are arcsine transformed values, those inside are retransformed values
PDI: Percent Disease Intensity

Table 33. Evaluation of antagonistic microbes on different plant growth parameters and yield in rice during 2022-23

Treatments	Shoot length (cm)	Root length (cm)	Yield (q/ha)	Yield increase over control (%)	B:C Ratio
T_1-*Pseudomonas fluorescens* NBAIR PFDWD (Seed treatment @10 g/litre +Seedling root dip @ 10 gm / litre+ Foliar spray @ 10 g/litre on standing crop at 10 days interval, *i.e.* 40, 50, 60 and 70 days after transplanting (DAT)	59.25a	6.96b	47.29b	72.40	6.2
T_2-POP Recommendation(Application of Tebuconazole 50%+ Trifloxystrobin 25 % (75% WG) 1g/L	71.11a	10.04a	58.57a	113.53	8.2
T_3-Untreated control	46.79b	5.79b	27.43c	-	4.1
S. Em.± (T)	3.50	0.34	2.26	-	-
C.D. at 5% T	12.12	1.19	6.97	-	-
CV (%)	11.50	14.38	13.48	-	-

Results:

The per cent disease index (PDI) as well as the growth parameters of individual treatments are presented in the Table 32 and 33. The treatment T_2 -POP Recommendation Tebuconazole 50%+ Trifloxystrobin 25 % recorded the lowest blast per cent disease intensity (9.53%) as compared to treatment T_1 *Pseudomonas fluorescens* NBAIR PFDWD (Seed treatment +Seedling root dip + Foliar spray) (15.63%). Further, treatment T_2- POP Recommendation Tebuconazole 50%+ Trifloxystrobin 25 % recorded lowest sheath blight per cent disease intensity (4.84%) as compared to treatment T_1 *Pseudomonas fluorescens* NBAIR PFDWD (Seed treatment +Seedling root dip + Foliar spray) (7.68%). The treatment T_2 -POP Recommendation Tebuconazole 50%+ Trifloxystrobin 25 % showed the highest percent disease reduction over control in case of blast (62.93%) and sheath blight (68.03%) in rice.

Similarly, the observations of growth parameters revealed treatment T_2 and T_1 found to be the most promising due to the increased shoot and root growth. The data of grain yield showed the highest yield (58.57 q/ha) in the treatment T_2 -POP Recommendation Tebuconazole 50%+ Trifloxystrobin 25 % as compared to treatment T_1 *Pseudomonas fluorescens* NBAIR PFDWD (Seed treatment + Seedling root dip + Foliar spray) (47.29 q/ha). The highest (113.53%) increase in yield over untreated control was obtained in the treatment T_2 -POP Recommendation Tebuconazole 50%+ Trifloxystrobin 25 %.

AAU, Jorhat

III. 1.6. Biological control of plant disease

(i) Evaluation of antagonistic microbes against brown spot, blast and sheath blight of rice (Centres: ICAR-NRRI Cuttack; AAU Anand; AAU Jorhat; PAU Ludhiana; UAS Raichur):

Experiment will be start from Sali rice, 2023

NRRI, Cuttack

The field experiment was conducted at ICAR-NRRI to test the efficacy bio-agents against sheath blight, brown spot and blast diseases of rice in comparison with POP recommendation. The strain NBAIR-PFDWD (*Pseudomonas fluorescens*) was effectively reduced the rice diseases *viz*., sheath blight, brown spot and blast by 55.77%, 63.04% and 61.94% respectively in kharif 2022. The percent disease reduction over the control was highest for chemical fungicide against sheath blight (80.92%), brown spot (85.39%) and blast (79.49%). The highest grain yield/plot (14.74 kg/plot) was recorded in chemical treatment followed by plants treated with NBAIR-PFDWD which had the 13.13 kg/plot (Table 34.). In case of Rabi season (2023), among the bioagents, *Bacillus amyloliquefaciens* NRRI- BS5 treatment recorded the lowest PDI of sheath blight (11.12%), brown spot (7.03%) and blast (3.96%) followed by NBAIR-PFDWD (*P. flourescens*) which recorded the PDI of 12.85%, 8.44%, 4.48% for sheath blight, brown spot and blast respectively. The highest disease index/incidence was observed in untreated control plot. The maximum yield/plot (14.45 kg/plot) was recorded in chemical treatment followed by plants treated with *Bcillus amyloliquefaciens* NRRI- BS5 (13.46 kg/plot) and NBAIR-PFDWD which had the 12.74 kg/plot (Table 35.).

Table 34. Evaluation of antagonistic microbes against brown spot, blast and sheath blight of rice during Kharif 2022

Treatments	Plant height (cm)	Root length (cm)	Sheath blight		Brown spot		Blast		Yield (kg/plot)	Percentage yield increase over control (%)
			PDI (Percent disease incidence)	Disease reduction over control (%)	PDI (Percent disease index)	Disease reduction over control (%)	PDI (Percent disease index)	Disease reduction over control (%)		
T1: *Pseudomonas fluoresens* NBAIR PFDWD	100.80	18.81	19.20	55.77	11.08	63.04	8.35	61.94	13.13	21.40
T3:POP Recommendation (Tebuconazole 50%+ Trifloxystrobin 25 % (75% WG)	98.20	17.84	8.28	80.92	4.38	85.39	4.50	79.49	14.74	29.98
T3:Untreated control	93.60	15.15	43.41		29.98		21.94		10.32	
S.Em	0.36	0.35	0.86		0.54		0.40		0.54	
CD (0.05%)	1.18	1.17	2.86		1.78		1.33		1.79	

Table 35. Evaluation of antagonistic microbes against brown spot, blast and sheath blight of rice during Rabi 2023

Treatments	Plant height (cm)	Root length (cm)	Sheath blight		Brown spot		Blast		Yield (kg/plot)	Percentage yield increase over control (%)
			PDI (Percent disease incidence)	Disease reduction over control (%)	PDI (Percent disease index)	Disease reduction over control (%)	PDI (Percent disease index)	Disease reduction over control (%)		
T1: *Pseudomonas fluoresens* NBAIR PFDWD	102.4	18.18	12.85	54.35	8.44	61.49	4.48	58.86	12.74	15.22

T2: *Bacillus amylo-liquefaciens* NRRI-BS5	104.8	18.90	11.12	60.49	7.03	67.92	3.96	63.64	13.46	19.76
T3:POP Recom-mendation (Tebu-conazole 50%+ Trifloxystrobin 25 % (75% WG)	98.8	17.25	5.16	81.66	4.20	80.84	2.72	75.02	14.45	25.25
T4:Untreated control	92.4	14.81	28.15		21.92		10.89		10.80	
SEm	0.42	0.38	0.57		0.46		0.36		0.35	
CD (0.05%)	1.32	1.18	1.78		1.44		1.11		1.09	

TNAU

Evaluation of *Bacillus subtilis* TNAU BS1 against major diseases of rice (Blast, brown spot, Bacterial leaf blight) (TNAU Coimbatore)

Table 36. Effect of bio agents against major diseases of rice

Treatments	Blast*	Brown spot*	BLB*	False Smut*	Yield Kg/ ha**
T1: *Bacillus subtilis* TNAU BS1(Seed treatment (10g/kg) + soil application @ 5 kg/ha+ Foliar spray @10 g/kg)	12.56 (20.58)^{a}	14.63 (22.38)^{a}	6.52 (14.70)^{a}	6.81 (15.07)^{a}	3728 (61.04)^{a}
T2: *Bacillus subtilis* NBAIR BS1(Seed treatment (10g/kg) + soil application @ 5 kg/ha+ Foliar spray @10 g/kg)	13.47 (21.41)^{ab}	15.72 (23.18)^{a}	7.27 (15.51)^{ab}	7.43 (15.51)^{a}	3482 (58.98)^{a}
T3: *Pseudomonas fluorescens* NBAIR - PFDWD (Seed treatment (10g/kg) + soil application @ 5 kg/ ha+ Foliar spray @10 g/kg)	15.66 (23.20)^{ab}	13.24 (21.23)^{a}	10.33 (18.58)^{bc}	7.85 (17.22)^{ab}	3396 (58.22)^{a}
T4: Azoxystrobin @ 0.1% 1ml/l	17.33 (24.54)^{b}	20.19 (26.65)^{b}	9.54 (17.92)^{abc}	8.22 (16.61)^{a}	3517 (59.25)^{a}
T5: Control	24.48 (29.61)^{c}	28.37 (31.97)^{c}	12.62 (20.72)^{c}	12.75 (20.88)^{b}	2564 (50.59)^{b}
CD (*P* = 0.05)	3.757	3.121	3.740	3.736	3.782
SEd	1.789	1.486	1.781	1.779	1.801

Figures in parentheses are arcsine transformed values* and square root transformed values**
In a column means followed by same letter(s) are not significantly different (*P*=0.05) by LSD
Values are mean of four replications.

A field trial was conducted to evaluate the effect of *Bacillus subtilis* (TNAU strain) on major diseases of rice. Results revealed that T1 -*Bacillus subtilis* TNAU BS1 (Seed treatment (10g/kg) + soil application @ 5 kg/ ha+ Foliar spray @10 g/kg), T2-*Bacillus subtilis* NBAIR BS1 (Seed treatment (10g/kg) + soil application @ 5 kg/ha+ Foliar spray @10 g/kg) and T3 – *Pseudomonas fluorescens* NBAIR-PFDWD (Seed treatment (10g/kg) and soil application @ 5 kg/ha+ Foliar spray @10 g/kg) were equally effective against blast and brown spot and the incidence of blast and brown spot diseases of these three treatments were significantly higher than the control. BLB and false smut incidences were on par in all the treatments (Table 36.). Yield in T1 -*Bacillus subtilis* TNAU BS1 (3728 Kg/ha), T2-*Bacillus subtilis* NBAIR (3482 Kg/ha), and T3 – *Pseudomonas fluorescens* NBAIR-PFDWD (3396 Kg/ha) were on par with the yield in T4-Azoxystrobin (1ml/lit) (3517 Kg/ha).

III. 2. Biological Control of Pulse Diseases

Biological Control of Chickpea Diseases

GBPUAT

III. 2.1. Development of biointensive IPM package and practices for pest management in pulse (chickpea)
Crop: Chickpea

Disease: *Fusarium* wilt

Achievements: In BIPM practice on chickpea observed root length (19.74 cm) and shoot length (41.33 cm) which is on par to farmers practice, root length (18.12 cm) and shoot length (39.21 cm). Maximum seed germination of 84.33 per cent was observed in BIPM practices which is on par with farmer's practice (82.00%) and least germination per cent was observed in untreated control (68.00%). The highest plant stand/m^2 at 60 DAS of chickpea was recorded in BIPM practice (14.80) which is on par with farmer's practice (13.00) while significantly lower in untreated control (11.40).

Table 37. Effect of BIPM practices on seed germination and incidence of wilt disease in Chickpea

Treatments	Germination Percentage (%)	Root length (cm)	Shoot length (cm)	Plant stand/ m^2@ 60 DAS
BIPM	84.33 (66.70)	19.74 (26.38)	41.33 (40.00)	14.80 (22.61)
Farmer's practice (Conventional)	82.00 (64.90)	18.12 (25.18)	39.21 (38.77)	13.00 (21.28)
Control	68.00 (55.55)	14.63 (22.48)	35.16 (36.36)	11.40 (19.71)
CV	1.78	7.03	3.26	10.21
CD (0.05)	3.16	2.78	2.85	1.95
SEm±	1.94	1.51	1.58	1.8

*Note: Data in parenthesis are angular transformed values

Fig 15. Field view of BIPM on Chickpea

PAU, Ludhiana

III. 2.2. Biological suppression of chickpea pod borer *Helicoverpa armigera* and soil borne diseases of chickpea (*Fusarium* wilt, Dry root rot and Collar rot)

The experiment is being conducted at Entomological Research Farm, PAU, Ludhiana on chickpea variety PBG 7. The chickpea crop was sown on 10.11.2022. As the details of the experiment were decided in the workshop in October, the treatments against the diseases were not applied (no seed treatment). The treatments against pod borer *Helicoverpa armigera* were applied. There are four replications for each treatment.

Treatments details

T1: *Bacillus thuringiensis* NIBSM Bt 18 1% @ 10ml/ L water

T2: *Bacillus thuringiensis* var. *kurstaki* 0.5WP (DOR Bt-1) @ 2.0 kg/ha (PAU POP)

T3: Chemical control: chlorantraniliprole 18.5 SC @ 125 ml/ ha (PAU POP)

T4: Untreated control

Two sprays of above-mentioned biopesticides/ insecticide were done; first at pod initiation and second 15 days thereafter. The observations of pod damage, number of larvae, natural enemies etc. are being recorded.

Photo 16. Chickpea crop at Entomological Research Farm

III. 3. Biological Control of Cowpea Diseases

KAU, Kumarakom

III. 2.3. Demonstration of the bioefficacy of *Trichoderma asperellum* KAU strain application for the management *Fusarium* wilt in cowpea

Variety: Vellayani Jyothika

Plot size :1 acre

Treatments:

T1: Seed treatment with *Trichoderma asperellum* KAU strain followed by its basal application

T2: POP Recommendation (Seed treatment with Carbendazim 50 WP followed by soil drenching)

Method of application of Treatments:

- Talc based formulation of *T. asperellum* (2×10^6 c.f.u./g) will be applied as seed treatment @20 g/kg of seed.
- Basal application: *T. asperellum* multiplied in cowdung + neemcake (9:1 ratio) @ 250 g /plant at the time of planting followed by soil drenching of itsb talc-based formulation @20 g/L at 20,40 and 60 DAS

- Chemical check-Seed treatment with carbendazim @ 2g kg^{-1} followed by soil drenching with 0.2 per cent solution at 15 DAS

Observations:

- Disease incidence (%) at 30, 45, 60 DAS
- Shoot and root growth (in cm)
- Yield (kg/ha) and C:B ratio

The trial is going on at RARS farm and farmers fields's (2 locations). In order to reduce the pests incidence in the field, maize seeds were sown in the borders two weeks prior to cowpea planting and marigold plants were raised in between the cowpea plants. The cow pea seedlings (var. Vellayani Jyothika) raised in pot trays after seed treatment with *T. asperellum*/carbendazim were transplanted to field and are being monitored for the incidence of the disease (Fusarium wilt)

III. 2.4. KAU, Vellayani

Experiment II: Demonstration of the bioefficacy of *Trichoderma asperullum* KAU strain application for the management *Fusarium* wilt in cowpea

The experiment was carried out during November 2022 to February 2023 at Valiyarathala, under Malayinkeezhu Krishi bhavan in an area of 50 cents (0.2 ha) using hybrid cowpea variety Polo. Experiment was laid out in RBD with 2 treatments replicated 14 times. Unit plot size was 40 m^2. Treatments evaluated were Talc based formulation of the *Trichoderma asperullum* KAU strain 2×10^6 spores mL^{-1} @ 20 g $kg^{-1}$of seed + basal application (multiplied in cowdung + neemcake 9:1 ratio) @ 250 g /plant and soil drenching @ 20 g/L at 20,40 and 60 DAS and Seed treatment with carbendazim @ 2g kg^{-1} of seed followed by soil drenching @ 0.2 per cent at 15 DAS.

Table 38. Efficacy of microbial agents in managing *Fusarium* wilt of cowpea

Treatments	Disease incidence (%)		
	30 DAS	45 DAS	60 DAS
Talc based formulation of the *Trichoderma asperullum* KAU strain 2×10^6 spores @ 20 g $kg^{-1}$of seed + basal application (multiplied in cowdung + neem-cake 9:1 ratio) @ 250 g /plant and soil drenching @20 g/L	0	0.35	1.89
Seed treatment with carbendazim @ 2g kg^{-1} of seed followed by soil drenching @ 0.2 per cent	0.08	0.41	2.44

Table 39. Yield of plots treated with microbial agents to manage *Fusarium* wilt in cowpea

Treatments	Yield (kg)
Talc based formulation of the *Trichoderma asperullum* KAU strain 2×10^6 spores @ 20 g $kg^{-1}$of seed + basal application (multiplied in cowdung + neemcake 9:1 ratio) @ 250 g /plant and soil drenching @20 g/L	34.79
Seed treatment with carbendazim @ 2g kg^{-1} of seed followed by soil drenching @ 0.2 per cent	33.40
CD (0.05%)	**NS**
CV	39.08

In general, the incidence of fusarium wilt was low during this season, as with the case of previous season when he same variety Polo was grown. The variety Polo seems to be tolerant to fusarium wilt. The percentage incidence was less than 2 % in biocontrol treatment with *T.asperellum* and it was less than 3 in Carbendazim treatment

III. 4. Biological Control of Pea Diseases

GBPUAT

III. 3.1. Demonstration of the bioefficacy of *Trichoderma asperellum* (Solan isolate) for the management of Fusarium wilt

Crop: Pea

Location: Farmers fields of District Nainital of Uttarakhand.

Area: 0.5 ha

Treatments

T1= Biocontrol (microbial) Package

Talc based formulation of the *Trichoderma asperellum* UHFTa1 2×10^6 spores /g seed treatment @ 20 g $kg^{-1}$of seed + basal application (multiplied in cowdung + neemcake 9:1 ratio) @ 50 g /plant and soil drenching @20 g/L at 20,40 and 60 DAS.

T2 = Farmers Practice
Seed treatment with carbendazim @ 1g kg^{-1} of seed followed by soil drenching @ 0.2 per cent at 15 DAS
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 03 different farmers of district Nainital covering an area of 0.5 ha.

Table 40. Occurrence of pea diseases at farmer's field

Disease	Causal Organism	*Trichoderma asperellum* UHFTa1	Conventional Practices
		Disease incidence (%)	Disease incidence (%)
Fusarium wilt	*Fusarium* spp.	15	13

An average yield of 78.0 q/ha was recorded by the farmers adopting bio-control technologies along with need based organic practices as compared to an yield of 80.0 q/ha by the farmers adopting conventional practices.

Table 41. Cost-benefit ratio with biocontrol practices and with conventional practices

Management Practices	Cost of production per ha	Yield	Selling price	Total selling price	Net Profit	Cost benefit ratio
	(Rs.)	(q/ha)	(Rs./q)	(Rs.)	(Rs.)	
Biocontrol Practices	72000.00	78.0	2500.00	195000.00	123000.00	**1: 1.70**
Conventional practices	75000.00	80.0	2500.00	200000.00	125000.00	**1: 1.66**


Fig 17. View of large scale field demonstration of Biocontrol technologies in Pea

III. 3.2. Large scale demonstration of Pant Bioagent (PBAT-3) for the management of fusarial wilt of pea

Crop: Pea (Pant sabji matar-3/ Arkel)

Location: Farmers fields of District Nainital of Uttarakhand.

Area: 30 ha

Treatments

T1= Biocontrol (microbial) Package

Seed bio-priming through Pant Bioagent formulation, PBAT-3 (*T.harzianum* Th14 *Pseudomonas fluorescens* Pf 173) @ 10g/kg of seeds+Soil application of PBAT @5 kg/ha +Spray of PBAT 3 @ 10 g/L on standing crop at 10-12 days intervals.

T2 = Farmers Practice

Carbaendazim Seed treatment @1g/kg and drenching @1g/ L

Observations:

- Disease incidence (wilt)
- Pod yield of crop (q/ha)
- Cost-benefit ratio.

Large scale field demonstrations of bio-control technologies on pea were conducted at 88 different farmers of district Nainital and U S Nagar covering an area of30ha.Twelve quintals PBAT-3 (*Trichoderma harzianum*Th14 + *Pseudomonas fluorescens* Pf 173) was distributed to the farmers.

Table 42. Occurrence of pea Fusarium wilt diseases at farmer's field

Disease	Causal Organism	PBAT-3	Conventional Practices
		Disease incidence (%)	Disease incidence (%)
Fusarium wilt	*Fusarium* spp.	12	10

An average yield of 72.0 q/ha was recorded by the farmers adopting bio-control technologies along with need based organic practices as compared to an yield of 73.0 q/ha by the farmers adopting conventional practices.

Table 43. Cost-benefit ratio with biocontrol practices and with conventional practices

Management Practices	Cost of production per ha	Yield	Selling price	Total selling price	Net Profit	Cost benefit ratio
	(Rs.)	(q/ha)	(Rs./q)	(Rs.)	(Rs.)	
Biocontrol Practices	72000.00	72.0	2500.00	180000.00	108000.00	**1: 1.50**
Conventional practices	75000.00	73.0	2500.00	182500.00	107500.00	**1: 1.43**


Fig 18. View of farmers field of large scale field demonstration of Biocontrol technologies in Pea

Biological Control of Commercial Crops Diseases

III. 5. Biological Control of Sugarcane Diseases

SBI, Coimbatore

In order to select an efficient bioagent or consortia of bioagents against major fungal diseases viz., red rot, smut and wilt of sugarcane, three pot culture experiments were conducted with fungal and bacterial bioagents against all the 3 diseases. In which, bioagents were selected and included for all the three diseases, which include *Trichoderma* spp. (*Trichoderma asperellum* (T1), *T. atroviride* (T5), *T. harzianum* (T20) and *T. aureoviride* (T21) and two isolates of *Paenibacillus alvei* (AFG3 and VPT4). Efficacy of bioagents were tested by treating the single bud setts with liquid formulation of both fungal and bacterial bioagents individually and in combination against 3 diseases. To study the efficiency of biocontrol agents against primary source of inoculum, smut infected Co 97009 and wilt infected Co 775 were used, while for red rot, the susceptible variety CoC 671 and soil borne inoculum were used. All the 3 cultivars were subjected to mechanized sett treatment in the Sett Treatment Device at 150 mm Hg vacuum level for 15 min with various bioagents and planted in the pots with suitable infected/ inoculated and healthy control in 3 replications. In all the 3 experiments, efficacy of antagonists was observed in terms of improving germination, plant survival and improving plant growth. Among the bioagents, *P. alvei* isolates were found to be superior against smut and wilt and improving plant growth parameters, which was followed by *T. asperellum* and *T. harzianum.* However, for red rot management bacterial bioagents in combination with fungicide were found to be effective. Hence, 3 field experiments have been laid out at the institute field with effective isolate of *P. alvei* (AFG3) and *T. asperellum* individually and in combination by different delivery methods viz., sett treatment and soil application to study their efficacy against red rot, smut and wilt along with yield attributes.

Biological Control of Plantation Crops Diseases

III. 6. Biological Control of Cocoa Diseases

Dr. YSRHU, Ambajipeta

III. 6.1. Field evaluation of effective bio control agents against *Phytophthora* Pod rot in cocoa

Results

The experiment was carried out at Avidi village of Dr. BR Ambedkar Konaseema district during monsoon season with the onset of rains and the treatments have given at 45 days interval. Based on the experiment results it was found that after first round of treatment imposition there is a significant reduction in the mean disease incidence 28.57 in the treatment (T_1) Spraying of *Trichoderma reesei* (Accession No.NAIMCC-F-04174) @ 2 $\times 10^6$ cfu/ml) followed by copper oxychloride (3g/litre of water) (T_3) spraying is 24.56 and there is a increase in mean disease incidence in control (T_4) (36.50) followed by Soil application of 50g *T. reesei* along with 5 kg neemcake (T_2) (17.97).

After second round of treatment imposition at 45 days, it was found that there is a significant reduction in the mean disease incidence 24.40 in the treatment (T_1) Spraying of *Trichoderma reesei* (Accession No.) @ 2 $\times 10^6$ cfu/ml) followed by copper oxychloride (3g/litre of water) (T_3) spraying is 16.39 and there is a increase in mean disease incidence in control (T_4) (8.45).

Table 44. Field evaluation of effective bio control agents against *Phytophthora* Pod rot in cocoa

Name of the Treatment	Mean Disease incidence						
	Pre - treatment	45 Days after treatment	Mean Disease incidence reduction	Mean Disease incidence increase	90 days after treatment	Mean Disease incidencereduction	Mean disease incidence increase
T_1 - Spraying of *Trichoderma reesei* @ 2 $\times 10^6$ cfu/ml)	8.89 (17.04)*	6.35 (13.85)	28.57	-	4.80 (11.95)	24.40	-
T_2 -Soil application of 50g *T. reesei* along with 5 kg neemcake	12.57 (20.54)	14.83 (22.36)	-	17.97	13.83 (21.47)	6.74	-
T_3 - Spraying of copper oxychloride (3g/litre of water)	17.14 (24.32)	12.93 (20.84)	24.56	-	10.81 (18.77)	16.39	-
T_4 - Control (without any treatment)	13.00 (20.85)	17.75 (24.38)	-	36.50	19.25 (25.65)	-	8.45
SEM (±)	1.71	2.10	6.46		2.09		
CD (0.05%)	5.27	6.48					

*Figures in parentheses are arc sign transformed values

Biological Control of Spice Crops Diseases

III. 7. Biological Control of Ginger Diseases

CAU, Pasighat

III. 7.1. Evaluation of microbial antagonists for the management of ginger rhizome rot

Objective: To study the field efficacy of microbial antagonists for the management of ginger rhizome rot

Crop and Variety: Ginger, Nadiya

Spacing: 30×25 cm

Plot size: 2×2 m=4 m^2

Treatments: 04

Replications: 05

Design: RBD

Season: 2022

Location: Biocontrol field, CHF, Pasighat

Treatment details

T_1: Powder formulation of *Trichoderma harzianum* AAU-MC2: Rhizome treatment (@ 20 g kg-1+basal application (multiplied in cow dung + neem cake 9:1 ratio) @ 100 g /plant and soil drenching @ 20 g/L at 10, 20 and 40 DAP

T_2: Copper hydroxide soil drenching @ 2g/L water

T_3: Untreated Control

Methodology and Observations:

Disease incidence during cropping stage

Disease incidence after harvest

Yield data (Kg/ha)

The data was statistically analyzed using suitable transformation.

Table 45. Field efficacy of microbial antagonists for the management of ginger rhizome rot

Treatments	Disease incidence during cropping stage (%)	Disease incidence after harvest (%)	Yield data (t/ha)
T_{1} - Formulation of *Trichoderma harzianum* AAU-MC2: Rhizome treatment (@ 20 g kg-1+basal application (multiplied in cow dung + neem cake 9:1 ratio) @ 100 g /plant and soil drenching @20 g/L at 10, 20 and 40 DAP	18.70 (25.44)	6.72 (14.99)	16.50 (4.12)**
T_{2} - Copper hydroxide soil drenching @2g/L water	18.23 (25.25)*	6.27 (14.32)	16.30 (4.10)
T_{3} - Untreated Control	37.08 (37.49)	10.92 (19.20)	10.25 (3.28)
S.Em ±	0.74	0.94	0.04
C.D. at 5 %	2.29	2.91	0.13

*Figures in the parenthesis are Arc sine transformed values

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

Results:

The results revealed that both bio-pesticide *i.e., Trichoderma harzianum* (AAU-MC2 strain) and chemical fungicide (Copper hydroxide soil drenching) were found statistically on par treatments in comparison to untreated control *viz.,* Disease incidence during cropping stage (18.23 % in T_1 v/s 18.70 % in T_2), disease incidence after harvest (6.72 % in T_1 v/s 6.27 % in T_2) and rhizome yield (16.50 in T_1 v/s 16.30 in T_2). However, untreated control was observed as inferior over remaining treatments in the disease incidence and thus least rhizome yields. These results supported the possibility of using native strains of *T. harzianum* for biointensive disease management of ginger rhizome rot.

Experimental plot view

Rhizome rot incidence during cropping

Rhizome treatment before planting

Soil drenching in field

Fig 19. Management of ginger rhizome rot result

Biological Control of Vegetable Diseases

III. 8. Biological Control of Tomato Diseases

UBKV

III. 8.1. Evaluation of Fluorescent Pseudomonads isolates against Tomato Wilt

The experiment was conducted at U.B.K.V. Research Farm in plot size 3m x 1 m with 3 replications. From the table no 46. it was found that highest shoot length was recorded by pf isolate no 10 (34.32 cm), highest root length found by isolate no 29 (13.80 cm). Highest shoot dry weight recorded by isolate no 22 (0.3694). Highest root dry weight recorded by isolate no 29 (0.0280 gm). Lowest wilt% recorded by isolate no 8 (0%), 10(0%), 29 (0%). Highest yield was recorded by isolate no 29 (34.33 t/ha) followed by isolate no 8 (33.50 t/ha).

Table 46. Evaluation of Fluorescent Pseudomonads isolates against Tomato Wilt

Pf isolate No	Shoot length (cm)	Root length (cm)	Shoot dry weight (gm)	Root dry weight (gm)	Wilt (%)	Yield (t/ha)
8	33.04	11.64	0.2910	0.0764	00	33.50
10	34.32	11.56	0.3324	0.0636	00	28.88
22	31.36	11.18	0.3694	0.0506	25	28.11
24	30.34	13.46	0.3374	0.0586	20	29.80
29	25.52	13.80	0.2776	0.0984	00	34.33
CONTROL	16.36	6.92	0.0960	0.0280	65	21.30
CD at 5%	NS	3.45	0.12	0.020	4.25	3.99

IV. Biological Control of Crop Pests

CEREALS

IV. 1. Biological Control of Rice Pests

IIRR

IV. 1.1. Large scale bio-intensive pest management on rice (ICAR-IIRR, Hyderabad)

The demonstrations were taken up in Dwarakanagar,Nalgonda district, and Rudraram, Shabad Mandal, Rangareddy, Telangana. Inputs such as DRR Dhan 48 seeds, Phosphorous solubilising Bacteria, seed bioprimers such as Telangana with 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 in Nalgonda. The farmer chose to grow Bhendi, green gram and black gram on the bunds. The package of practices in the BIPM modules included addition of FYM in nursery and main field and need based application of pesticides. The incidence of insect pests was low during this season with only Leaf folder damage. Application of an insecticide was taken up uniformly in all treatments to prevent BPH which is the key pest in these regions. Increase in spider population (20-35%) was observed. The BIPM module with seed bio-primed with *Trichoderma asperellum* Strain TAIK1 performed well. In farmer's own words the plants in all BIPM modules looked strong and healthy which instigated him to go for *growmor* fertilizer application in the farmers practice field where he observed plants to be a little weak. Overall though higher yields were observed in Farmers Practice field, the BIPM module with *Trichoderma asperellum* Strain TAIK1 also gave comparable yields (Table 47.). The benefit-cost ratio was also highest with this module (1.63).

Table 47. Pest and natural enemie's incidence at Dwarakanagar, Nalgonda, Telangana, *Kharif* 2022

Treatments	Leaffolder % damage	Spiders (No./ hills	Yield (kg/ ha)	B:C Ratio
T1- BIPM with *Trichoderma asperellum* Strain TAIK1	5.85	2.38	6180[a]	1.63
T2- BIPM with *Bacillus cabrialesii* BIK3	5.32	3.12	4900[b]	1.11
T3 - BIPM with *Pseudomonas fluorescens*	6.15	2.01	5020[b]	1.16
T4- Farmers practice	10.58	0.82	6500[a]	1.34
CD (0.05)	NS	1.12	1043.9	

The second location was grown totally organic with and without bund cropping at Rudraramvillage, Shabad Mandal, Rangareddy, Telangana. DRR DHAN 48 seeds and seedling of marigold were distributed. The good management practices gave the farmer a yield of 5100 kg /ha. Pest incidence was low to minimal.

IV. 1.2. Comparative efficacy of entomopathogenic fungi against sucking pests of rice, *Leptocorisa acuta* (Through AICRP Entomology programme, ICAR- IIRR)

During kharif 2022, the trial was taken up at nine locations *viz*., Brahmavar, Chatha, Coimbatore, Gangavati, Karjat, Mandya, Moncompu, Navasari and Raipur with a susceptible variety of the location. Three entomopathogens *viz*., *Lecanicillium saksenae* ($1x10^8$ spores/g) @ 5 g/l), *Beauveria bassiana* ($1x10^8$ spores/g) @ 5 g/l and *Metarhizium anisopliae* ($1x10^8$ spores/g) @ 5 g/l) were compared with Thiamethoxam 0.2 g/l and untreated Control. The five treatments were replicated four times in a randomized block design. Foliar sprays of various treatments were taken up at fortnightly intervals twice during the reproductive phase for ear head bugs or during active tillering phase for hopper pests. Observations on population of ear head bugs and hopper pests one day before and 7 and 15 days after each spray was recorded from 25 hills selected at random. Data on natural enemies in 10 hills or per plot was also recorded.

1. *Brahmavar*

The number of ear head bugs at seven days after first spray was significantly lower with *L. saksenae* treatment (4.00/ 25 hills) followed by *B. bassiana* (4.50) compared with 18.00 bugs in untreated control (Table 48.)**.** At 15 days after first spray, the least number of ear head bugs were observed in *L. saksenae* sprayed plots (2.00/ 25 hills). Seven days after second spray, all the treatments showed significantly lesser number of ear head bugs compared to control (16.50), the least being observed with *L. saksenae* (1.25/25 hills). *Metarhizium anisopliae* with a population of 11.00/25 hills was the least effective among the bioagents tested. Similar trend was observed 15 days after second spray. Overall, *L. saksenae* was the most effective treatment.

The number of mirid bugs did not differ significantly among the treatments. However, the highest number of mirids were observed in the control and *M. anisopliae* treated plots whereas the lowest number of mirids was found in thiamethoxam treatment. The number of spiders per plot was significantly higher in control (3.25). Among the other treatments *L. saksenae* recorded highest number of spiders per plot(2.00) while thiamethoxam treated plots did not register any spider count. The number of coccinellids was also significantly higher per plot in untreated control (2.25). Overall, the natural enemy count was significantly higher in control followed by *L. saksenae*, *B. bassiana* and *M. anisopliae* treatments.. The highest yield was observed with *L. saksenae* treatment (2166.25 kg/ha) followed by thiamethoxam (2131.25 kg/ha. The least yield was observed in the control plot with 1996.88 kg/ha.

2. *Chatha*

Observations were recorded on populations of stink bugs, white leafhopper, green leafhopper and gundhi bug. The population was low and did not differ among treatments. Population of natural enemies *viz*., spiders and coccinellids were also recorded and ranged from 1-2 individuals per plot in all treatments. The yield was significantly higher in the plots with *M anisopleae* treatment (3350 kg/ha) and the least was seen in untreated control (2887 kg/ha).

3. *Coimbatore*

The number of ear head bugs at seven days after first spray was significantly lower with *L. saksenae* treatment (5.00/ 25 hills) which was on par with thiamethoxam (4.75/25 hills) (Table 49.). Similar trend was observed at 15 days after first spray. At seven days and 15 days after second spray, *L. saksenae and* thiamethoxam gave significantly better control of ear head bugs (1.5-2.0/ 25 hills) while other treatments were on par. Overall, *L. saksenae* was the most effective treatment among the bioagents. The number of mirid bugs was highest in the control (12.00/plot) and *L. saksenae* treated plots (13.75/plot) whereas significantly lower number of mirids were found in thiamethoxam treatment (4.75/plot). The number of spiders ranged from 4.00 in thiamethoxam treatment to 11.00/plot in untreated control.

The yields were on par among treatments and ranged from 6649.13 to 6966.06 kg/ ha.

4. *Gangavathi*

The population of hoppers was on par in all treatments and significantly lower (5.03 to 9.41/ 25 hills) as compared to untreated control (14.53 and 18.35/ 25 hills) after the first spray (Table 50.). *L. saksenae* performed on par with thiamethoxam 7 days after second spray while both *L. saksenae* and *Beauveria bassiana* were as effective against hoppers as chemical control 15 days after second spray. The least effective bioagent against hoppers was *M anisopliae* (Table 50.).

The number of ear head bugs after first spray was significantly lower in all treatments as compared to untreated control, at 7 and 15 days after spraying. Similar trend was observed after second spray at 15 days after second spray, *L. saksenae and* thiamethoxam were on par (0.96-1.10/ 25 hills). The population of mirids, spiders and coccinellids were significantly lower in thiamethoxam treated plots (3.09, 1.06 and 0.62/ m^2 respectively) while they were on par in all other treatments including untreated control (11.99, 5.40 and 3.03/ m^2 respectively) indicating minimal or no impact on natural enemy population.

The yield was on par among treatments and ranged from 5845 to 7155 kg/ ha and significantly higher than untreated control (2570 kg/ ha) (Table 50.).

5. *Karjat*

The number of ear head bugs at five days after first spray was significantly lower with thiamethoxam and *L. saksenae* treatments (1.35 and 2.40/ 25 hills respectively) (Table 51.). At seven days after first spray, the least number of ear head bugs were observed in thiamethoxam and *L. saksenae* sprayed plots(0.25 and 1.30/ 25 hills). The other two bio-agents *B. bassiana* and *M. anisopliae* were ineffective in reducing pest population. After second spray, all the treatments showed significantly lesser number of ear head bugs compared to untreated control (1.5-2.70/ 25 hills), with no bugs observed in thiamethoxam treatment. Overall, *L. saksenae* was the most effective treatment among bioagents.

6. *Mandya*

At seven days after first spray significantly lower population of bugs were observed with all treatments (2.16-3.24/ 25 hills)) except *B. bassiana* (3.75/ 25 hills) and untreated control (Table 52.)**.** At 15 days after first spray, the least number of ear head bugs were observed in thiamethoxam sprayed plots (1.16/ 25 hills) followed by *L. saksenae* treated plots (1.92/25 hills). Similar trend was observed after second spray, wherein all the treatments showed significantly lesser number of ear head bugs compared to the control (2.48-2.53/25 hills). The least number of bugs was observed in chemical treatment followed by *L. saksenae* (Table 52.)

The number of natural enemies *viz*., spiders and coccinellids were lowest in thiamethoxam treatment (8.50 and 2.50 /plot respectively). All other treatments were on par with spiders ranging from 27.50 – 36.00/plot and coccinellids ranging from 13.75-15.00/ plot among the control and bioagent treated plots. The highest yield was observed with thiamethoxam treatment (7120 kg/ha) which was on par with *L. saksenae* and *M. anisopliae* (6153 and 5824 kg/ha respectively).

7. Moncompu

The population of leafhoppers ranged from 14.65-26.25/ 25 hills in untreated control. Population of green leafhoppers was on par (6.75 to 11.00/ 25 hills) in all treatments and significantly lower as compared to untreated control seven days after the first spray (Table 53.). On the other hand, 15 days after first and second spray thiamethoxam had significantly lower population (1.25 and 2.25/ 25 hills respectively) while the bioagent treated plots were on par, but superior to untreated control. *L. saksenae* was the second most effective treatment after thiamethoxam, with population ranging from 7.25- 11.00 / 25 hills (Table 53.).

Population of planthoppers was on par and significantly lower in thiamethoxam and *L. saksenae* treated plots seven days after (73.5 and 58.75/ 25 hills respectively) and fifteen days after (6.97 and 6.59/ 25 hills) spray (Table 53.). After second spray, thiamethoxam had significantly lower population (25.25 and 9.00/ 25 hills respectively) while the bioagent treated plots were on par but superior to untreated. *L. saksenae* was second most effective treatment with population ranging from 42.25 -87.25 / 25 hills after second spray (Table 53.).

The treatments did not vary significantly in reducing ear head bug population after first spray including the chemical thiamethoxam (Table 54.). Fifteen days after second spray, lower population (2.5/ 25 hills) was observed in *M anisopliae* treatment followed by thiamethoxam (4.5/ 25 hills). The highest yield was observed in thiamethoxam followed by *L. saksenae* treatment (Table 54.).

8. *Navsari*

The number of ear head bugs was significantly lower with thiamethoxam treatment (4.00 – 5.75/ 10 hills) after first and second spray. The three bioagents did not differ significantly in their effectiveness (Table 55.).

The population of natural enemies were highest in untreated control 9.75, 7.75 and 8.50 mirids, spiders and coccinellids per plot. Thiamethoxam registered lowest number of natural enemies. The three bioagent treatments were on par, with the highest population recorded in *L. saksenae* treatment with 9.25, 6.25 and 6.75 mirids, spiders and coccinellids per plot. The highest yield was observed in thiamethoxam treatment (5339 kg/ha) and least in untreated control (4488 kg/ha). The three bioagents treatments were on par with a yield range of 4789 – 4948 kg/ha (Table 55.).

9. *Raipur*

All treatments were significantly more effective than untreated control which recorded 4.25 – 6.00 ear head bugs per 25 hills. The number of ear head bugs were on par in all other treatments though the population of bugs was slightly lower in the bioagent treated plots. Among the bioagents the least population was observed in *L. saksenae*treated plots which reached1.5/ 25 hills fifteen days after second spray (Table 56.).

The highest population of natural enemies was observed in untreated control with 3.00, 3.25 and 2.5 ground beetles, spiders and coccinellids per plot respectively. The number of spiders and coccinellids in *L. saksenae* treatment was on par with untreated control. Thiamethoxam registered lowest number of natural enemies. The lowest yield was observed in the control plot with 6275 kg/ha, while all other were on par with a yield range of 6963 – 7138 kg/ha (Table 56.).

Across Locations

When analysed across locations, *L. saksenae* performed best among the three bioagents tested but slightly lesser than thiamethoxam treatment (Table 57.)

The results indicated *L. saksenae* to be the most effective of the three pathogens tested in seven locations with no detrimental impact on natural enemies.

Table 48. Effect of entomopathogens on sucking pests and their natural enemies at Brahmavar, EESP, *kharif* 2022

Treatment	No. of Ear head bugs / 25 hills						Natural enemies No./ plot			Yield (kg/ ha) *
	I spray			II spray			Mirid	Spi-der	Cocci-nellid	
	PC	7DAS	15DAS	21DAS/ PC						
Lecanicillium saksenae @ 1 x 10^7 cfu ml $^{-1}$ KAU 7714 (20 g talc formulation/ L)	13.25	4.00 (2.11)	2.00 (1.56)	3.50 (2.00)	1.25 (1.31)	1.00 (1.22)	0.75 (1.10)	2.00 (1.56)	0.75 (1.10)	2166.25
Beauveria bassiana @1 x 10^8 cfu ml^{-1} NBAIR Bb 5 (20 g talc formu-lation / L)	10.25	4.50 (2.20)	3.75 (2.06)	5.50 (2.45)	2.50 (1.70)	1.75 (1.49)	0.75 (1.10)	1.00 (1.18)	0.75 (1.10)	2084.38
Metarhizium anisopliae @ 1 x 10^8 cfu ml $^{-1}$ NBAIR Ma 4 (20 g talc formulation / L)	11.75	7.25 (2.73)	9.75 (3.20)	11.50 (3.46)	9.50 (3.16)	11.00 (3.39)	1.00 (1.22)	0.25 (0.84)	0.50 (0.97)	2028.13
Thiamethoxam	11.50	6.50 (2.68)	4.75 (2.29)	6.50 (2.64)	3.50 (2.00)	2.75 (1.80)	0.50 (0.97)	0.00 (0.71)	0.25 (0.84)	2131.25
Control	11.00	18.00 (4.34)	17.00 (4.18)	19.00 (4.42)	16.50 (4.12)	16.25 (4.09)	1.00 (1.22)	3.25 (1.92)	2.25 (1.65)	1996.88
SED		0.32	0.12	0.07	0.13	0.09		0.14	0.19	
CD (0.05)	NS	0.71	0.27	0.16	0.29	0.19	NS	0.30	0.41	NS

Figures in parenthesis are square root transformed values; PC- pre-count; DAS- days after spraying;

Table 49. Effect of entomopathogens on sucking pests and their natural enemies at Coimbatore, EESP, *kharif* 2022

Treatment	No. of Ear head bugs / 25 hills					Natural enemies No./ plot		Yield (kg/ha) *
	I SPRAY			II SPRAY		Mirid	Spider	
	PC	7DAS	15DAS	7DAS	15DAS			
Lecanicillium saksenae @ 1 x 10^7 cfu ml -1 KAU 7714 (20 g talc formulation/ L)	13.75 (3.74)	5.00 (2.33)	5.50 (2.44)	3.75 (2.05)	2.00 (1.56)	12.00 (3.53)	8.00 (2.90)	6966.06
Beauveria bassiana @1 x 10^8 cfu ml-1 NBAIR Bb 5 (20 g talc formulation / L)	18.25 (4.32)	10.25 (3.27)	9.75 (3.19)	5.50 (2.44)	3.25 (1.92)	9.50 (3.16)	7.25 (2.75)	6766.19
Metarhizium anisopliae @ 1 x 10^8 cfu ml -1 NBAIR Ma 4 (20 g talc formulation / L)	17.25 (4.20)	11.25 (3.42)	9.75 (3.19)	5.00 (2.32)	3.50 (1.98)	9.25 (3.11)	6.25 (2.56)	6708.88
Thiamethoxam	13.50 (3.69)	4.75 (2.27)	7.75 (2.86)	2.50 (1.70)	1.50 (1.40)	4.75 (2.27)	4.00 (2.08)	6962.31
Control	14.50 (3.84)	17.50 (4.23)	21.00 (4.63)	9.00 (3.07)	6.50 (2.64)	13.75 (3.76)	11.00 (3.38)	6649.13
SED		0.19	0.21	0.25	0.20	0.22	0.32	
CD (0.05)	NS	0.40	0.46	0.54	0.44	0.49	0.70	NS

Figures in parenthesis are square root transformed values; PC- pre-count; DAS- days after spraying;

Table 50. Effect of entomopathogens on sucking pests and their natural enemies at Gangavathi, EESP, *kharif* 2022

Treatment	No. of Ear head bugs / 25 hills					NO. of hoppers/ 25 hills						No. of natural enemies/ m^2		Coccinellid	Yield (kg/ ha)
	I SPRAY			II SPRAY		I SPRAY			II SPRAY						
	PC	7 DAS	15 DAS	7 DAS	15 DAS	PC	7 DAS	15 DAS	PC	7 DAS	15 DAS	Mirid	Spider		
Lecanicillium saksenae @ 1 x 10^7 cfu ml $^{-1}$ KAU 7714 (20 g talc formulation/ L)	3.88 (2.09)	3.31 (1.95)	2.62 (1.76)	2.01 (1.58)	1.10 (1.26)	11.20 (3.42)	8.70 (3.03)	8.09 (2.93)	8.97 (3.08)	5.81 (2.51)	1.50 (1.41)	10.58 (3.33)	4.68 (2.27)	2.89 (1.84)	7155 (84.56)
Beauveria bassiana @1 x 10^8 cfu ml^{-1} NBAIR Bb 5 (20 g talc formulation / L)	3.81 (2.07)	3.62 (2.03)	3.05 (1.88)	2.27 (1.66)	2.18 (1.64)	11.63 (3.48)	9.41 (3.15)	8.45 (2.99)	8.95 (3.07)	6.34 (2.61)	5.04 (2.35)	10.22 (3.27)	4.5 (2.24)	2.81 (1.82)	6065 (7.79)
Metarhizium anisopliae @ 1 x 10^8 cfu ml $^{-1}$ NBAIR Ma 4 (20 g talc formulation / L)	3.92 (2.10)	3.15 (1.91)	2.46 (1.72)	1.99 (1.58)	1.46 (1.40)	12.15 (3.56)	8.81 (3.05)	7.99 (2.91)	8.78 (3.05)	5.42 (2.43)	2.03 (1.59)	10.53 (3.32)	4.58 (2.25)	2.86 (1.83)	6935 (83.26)
Thiamethoxam	3.99 (2.12)	2.44 (1.71)	1.54 (1.43)	1.24 (1.32)	0.96 (1.21)	11.90 (3.52)	5.78 (2.50)	5.03 (2.35)	8.50 (3.00)	3.12 (1.90)	5.92 (2.52)	3.09 (1.88)	1.06 (1.25)	0.62 (1.06)	5845 (76.40)
Control	3.91 (2.10)	4.24 (2.18)	4.85 (2.31)	5.32 (2.41)	5.54 (2.46)	11.55 (3.47)	14.53 (3.87)	18.35 (4.34)	25.26 (5.07)	32.29 (5.73)	39.21 (6.30)	11.99 (3.54)	5.40 (2.43)	3.03 (1.88)	2570 (50.57)
SED		0.03	0.07	0.05	0.05		0.07	0.07	0.11	0.09	0.10	0.08	0.07	0.05	2.69
CD (0.05)	NS	0.07	0.15	0.10	0.11	NS	0.15	0.15	0.24	0.21	0.21	0.16	0.15	0.10	5.86

Table 51. Effect of entomopathogens on sucking pests at Karjat, EESP, *kharif* 2022

Treatment	No. of Ear head bugs / 25 hills				
	I SPRAY			II SPRAY	
	PC	5 DAS	7 DAS	3 DAS	5 DAS
Lecanicillium saksenae @ 1 x 10^7 cfu ml $^{-1}$ KAU 7714 (20 g talc formulation/ L)	9.45 (3.15)	2.40 (1.70)	1.30 (1.34)	0.65 (1.07)	0.45 (0.97)
Beauveria bassiana @1 x 10^8 cfu ml^{-1} NBAIR Bb 5 (20 g talc formulation / L)	11.10 (3.40)	4.30 (2.17)	3.35 (1.95)	1.60 (1.44)	1.05 (1.24)
Metarhizium anisopliae @ 1 x 10^8 cfu ml $^{-1}$ NBAIR Ma 4 (20 g talc formulation / L)	10.30 (3.28)	4.50 (2.22)	2.85 (1.83)	1.55 (1.43)	1.05 (1.24)
Thiamethoxam	10.90 (3.37)	1.35 (1.36)	0.25 (0.86)	0.00 (0.71)	0.00 (0.71)
Control	11.75 (3.50)	6.50 (2.63)	5.60 (2.45)	2.70 (1.78)	1.75 (1.49)
SED		0.19	0.17	0.12	0.10
CD (0.05)	NS	0.41	0.36	0.26	0.21

Figures in parenthesis are square root transformed values; PC- pre-count; DAS- days after spraying; *extrapolated

Table 52. Effect of entomopathogens on sucking pests and their natural enemies at Mandya, EESP, *kharif* 2022

Treatment	No. of Ear head bugs / 25 hills						Natural enemies No./ plot		Yield (kg/ ha) *
	I SPRAY			II SPRAY			Spider	Cocci-nellid	
	PC	7 DAS	15 DAS	21 DAS/ PC	7 DAS	15 DAS			
Lecanicillium saksenae @ 1 x 10^7 cfu ml $^{-1}$ KAU 7714 (20 g talc formulation/ L)	4.70 (2.28)	2.89 (1.84)	1.92 (1.55)	2.49 (1.73)	1.73 (1.49)	1.28 (1.33)	28.25 (5.29)	13.75 (3.63)	6153 (78.12)
Beauveria bassiana @1 x 10^8 cfu ml^{-1} NBAIR Bb 5 (20 g talc formulation / L)	3.97 (2.11)	3.75 (2.06)	3.27 (1.94)	4.22 (2.17)	3.86 (2.09)	3.45 (1.99)	27.50 (5.21)	16.50 (4.08)	4168 (64.21)
Metarhizium anisopliae @ 1 x 10^8 cfu ml $^{-1}$ NBAIR Ma 4 (20 g talc formulation / L)	3.82 (2.08)	3.24 (1.93)	2.68 (1.78)	3.04 (1.88)	2.24 (1.65)	2.07 (1.60)	31.75 (5.64)	14.75 (3.84)	5824 (76.16)
Thiamethoxam	4.23 (2.17)	2.16 (1.63)	1.16 (1.29)	1.87 (1.54)	1.05 (1.24)	0.82 (1.14)	8.50 (2.94)	2.50 (1.70)	7120 (84.32)
Control	3.32 (1.95)	3.96 (2.11)	4.63 (2.26)	5.31 (2.41)	5.68 (2.48)	5.90 (2.53)	36.00 (5.96)	15.00 (3.87)	2296 (47.63)
SED		0.06	0.06	0.06	0.09	0.08	0.61	0.58	4.21
CD (0.05)	NS	0.12	0.14	0.13	0.19	0.17	1.32	1.26	9.18

Figures in parenthesis are square root transformed values; PC- pre-count; DAS- days after spraying; *extrapolated

Table 53. Effect of entomopathogens on hoppers at Moncompu, EESP, *kharif* 2022

Treatment	No. of GLH / 25 hills						No. of BPH/ 25 hills					
	I SPRAY			II SPRAY			I SPRAY			II SPRAY		
	PC	7 DAS	15 DAS	PC	7 DAS	15 DAS	PC	7 DAS	15 DAS	PC	7 DAS	15 DAS
Lecanicillium saksenae @ 1 x 10^7 cfu ml $^{-1}$ KAU 7714 (20 g talc formulation/ L)	19.50 (4.46)	11.00 (3.37)	8.00 (2.89)	13.75 (3.76)	9.50 (3.15)	7.25 (2.77)	140.00 (11.80)	73.50 (8.55)	48.50 (6.97)	87.25 (9.31)	59.50 (7.72)	42.25 (6.48)
Beauveria bassiana @1 x 10^8 cfu ml^{-1} NBAIR Bb 5 (20 g talc formulation / L)	14.00 (3.80)	10.00 (3.23)	8.00 (2.88)	13.25 (3.69)	9.75 (3.19)	9.00 (3.05)	164.50 (12.74)	128.50 (11.25)	71.25 (8.37)	133.75 (11.58)	94.75 (9.75)	71.50 (8.47)
Metarhizium anisopliae @ 1 x 10^8 cfu ml $^{-1}$ NBAIR Ma 4 (20 g talc formulation / L)	16.00 (4.02)	10.50 (3.27)	9.25 (3.09)	11.75 (3.50)	8.50 (2.98)	5.75 (2.49)	192.50 (13.72)	158.00 (12.48)	96.25 (9.79)	153.50 (12.39	111.75 (10.58)	91.50 (9.57)
Thiamethoxam	20.25 (4.53)	6.75 (2.68)	1.25 (1.27)	16.00 (4.05)	6.50 (2.63)	2.25 (1.57)	222.25 (14.84)	58.75 (7.65)	43.25 (6.59)	48.50 (6.93)	25.25 (5.00)	9.00 (2.81)
Control	14.25 (3.80)	22.25 (4.74)	22.00 (4.71)	19.00 (4.38)	22.75 (4.80)	26.50 (5.19)	208.25 (14.38)	235.00 (15.23)	318.75 (17.76)	223.75 (14.95)	256.25 (16.00)	285.00 (16.88)
SED		0.36	0.38	0.31	0.29	0.31		1.04	1.00	0.63	0.57	0.68
CD (0.05)	NS	0.77	0.83	0.67	0.63	0.68	NS	2.27	2.18	1.37	1.25	1.48

Figures in parenthesis are square root transformed; PC- pre-count; DAS- days after spraying; *extrapolated

Table 54. Effect of entomopathogens on earhead bugs and their natural enemies at Moncompu, EESP, *kharif* 2022

Treatment	No. of Ear head bugs / 25 hills						Natural enemies No./ plot			Yield (kg/ ha) *
	I SPRAY			II SPRAY			Mirid	Spi-der	Coc-cinel-lid	
	PC	7DAS	15DAS	21DAS/ PC	7 DAS	15 DAS				
Lecanicillium saksenae @ 1 x 10^7 cfu ml $^{-1}$ KAU 7714 (20 g talc formulation/ L)	25.00 (5.03)	19.75 (4.48)	14.75 (3.89)	17.50 (4.22)	13.75 (3.76)	10.50 (3.31)	37.75 (6.18)	12.25 (3.57)	19.25 (4.43)	1350 (36.67)
Beauveria bassiana @1 x 10^8 cfu ml^{-1} NBAIR Bb 5 (20 g talc formulation / L)	16.75 (4.12)	13.25 (3.64)	8.25 (2.71)	12.25 (3.55)	7.00 (2.72)	4.50 (2.03)	45.50 (6.78)	10.25 (3.25)	14.75 (3.90)	1185 (34.35)
Metarhizium anisopliae @ 1 x 10^8 cfu ml $^{-1}$ NBAIR Ma 4 (20 g talc formulation / L)	19.50 (4.41)	13.50 (3.67)	7.75 (2.76)	10.25 (3.25)	4.50 (2.22)	2.50 (1.59)	36.75 (6.09)	12.75 (3.61)	14.50 (3.86)	1087 (32.95)
Thiamethoxam	23.50 (4.87)	14.75 (3.89)	10.50 (3.30)	12.50 (3.57)	9.50 (3.14)	4.25 (2.13)	36.50 (6.07)	11.25 (3.41)	21.00 (4.62)	1425 (37.73)
Control	15.00 3.91	18.50 (4.35)	17.75 (4.25)	14.00 (3.80)	12.75 (3.60)	15.50 (3.97)	45.75 (6.79)	9.50 (3.14)	19.75 (4.46)	1031 (32.05)
CD (0.05)	NS	NS	NS	NS	NS	1.15	NS	NS	NS	3.63

Figures in parenthesis are square root transformed; PC- pre-count; DAS- days after spraying; *extrapolated

Table 55. Effect of entomopathogens on sucking pests and their natural enemies at Navsari, EESP, *kharif* 2022

Treatment	No. of Ear head bugs / 10 hills			Natural enemies No./ plot			Grain Yield (kg/ ha) *	Straw yield Kg/ha
	PC	I SPRAY	II SPRAY	Mirid	Spider	Cocci-nellid		
Lecanicillium saksenae @ 1 x 10^7 cfu ml $^{-1}$ KAU 7714 (20 g talc formulation/ L)	9.77 (3.20)	8.00 (2.90)	10.25 (3.28)	9.25 (3.12)	6.25 (2.60)	6.75 (2.69)	4789 (69.20)	7093 (84.22)
Beauveria bassiana @1 x 10^8 cfu ml^{-1} NBAIR Bb 5 (20 g talc formulation / L)	9.21 (3.11)	8.25 (2.95)	11.25 (3.42)	9.00 (3.08)	6.00 (2.55)	7.00 (2.74)	4884 (69.88)	7184 (84.76)
Metarhizium anisopliae @ 1 x 10^8 cfu ml $^{-1}$ NBAIR Ma 4 (20 g talc formulation / L)	8.90 (3.06)	6.75 (2.69)	9.75 (3.20)	8.50 (2.99)	6.75 (2.69)	6.75 (2.69)	4948 (70.34)	7154 (84.58)
Thiamethoxam	8.96 (3.07)	4.00 (2.11)	5.75 (2.49)	4.25 (2.18)	3.00 (1.86)	3.00 (1.86)	5339 (73.07)	7261 (85.21)
Control	8.92 (3.07)	13.25 (3.70)	20.93 (4.62)	9.75 (3.20)	7.75 (2.87)	8.50 (3.00)	4488 (66.99)	7384 (85.93)
SED		0.16	0.17	0.13	0.10	0.12	0.79	
CD (0.05)	NS	0.35	0.37	0.28	0.22	0.26	1.72	NS

Figures in parenthesis are square root transformed; PC- pre-count; DAS- days after spraying; *extrapolated

Table 56. Effect of entomopathogens on sucking pests and their natural enemies at Raipur, EESP, *kharif* 2022

Treatment	No. of Ear head bugs / 25 hills					Natural enemies No./ plot			Yield (kg/ ha) *
	I SPRAY			II SPRAY		Ground beetles	Spider	Cocci-nellid	
	PC	7 DAS	15 DAS	7 DAS	15 DAS				
Lecanicillium saksenae @ 1 x 10^7 cfu ml $^{-1}$ KAU 7714 (20 g talc formulation/ L)	4.25 (2.17)	4.00 (2.11)	2.75 (1.79)	2.50 (1.73)	1.50 (1.40)	1.25 (1.31)	2.00 (1.56)	2.00 (1.56)	7100 (84.24)
Beauveria bassiana @1 x 10^8 cfu ml^{-1} NBAIR Bb 5 (20 g talc formu-lation / L)	4.25 (2.17)	3.25 (1.92)	3.50 (1.98)	2.50 (1.73)	2.00 (1.58)	1.00 (1.22)	1.50 (1.40)	1.75 (1.49)_	6963 (83.43)
Metarhizium anisopliae @ 1 x 10^8 cfu ml $^{-1}$ NBAIR Ma 4 (20 g talc formulation / L)	4.25 (2.17)	2.50 (1.73)	2.50 (1.73)	2.25 (1.65)	1.50 (1.40)	2.00 (1.56)	1.50 (1.40)	2.50 (1.73)	7075 (84.10)
Thiamethoxam	4.25 (2.17)	2.25 (1.63)	4.00 (2.10)	3.25 (1.920	2.50 (1.73)	1.00 (1.22)	1.25 (1.31)	1.00 (1.22)	7138 (84.46)
Control	5.25 (2.38)	4.75 (2.28)	4.25 (2.17)	5.50 (2.440	6.00 (2.54)	3.00 (1.86)	3.25 (1.92)	2.50 (1.73)	6275 (79.20)
SED		0.18		0.13	0.14	0.13	0.17	0.14	1.54
CD (0.05)	NS	0.38	NS	0.28	0.30	0.27	0.36	0.30	3.35

Figures in parenthesis are square root transformed values; PC- pre-count; DAS- days after spraying; *extrapolated

Table 57. Location versus treatment interaction

Treatment	Mean no. of bugs (No./25 hills)	
	7 DAS	15 DAS
T1- *L. saksenae* @ 1x10^{7}cfu ml^{-1} KAU 7714 (20 g talc formulation /L)	**5.78**^{c} (2.35)	**4.47**^{c} (2.06)
T2- *B. bassiana* strain NBAIR-Bb5a @ 1x10^{8}cfu ml^{-1} (5 g talc formulation /L)	7.08^b (2.60)	5.95^b (2.38)
T3- *M. anisopliae* strain NBAIR-Ma4 @ 1x10^{8}cfu ml^{-1} (5 g talc formulation /L)	7.31^b (2.63)	6.23^b (2.43)
T4- Thiamethoxam 0.2 g/L	**4.86**^{d} (2.14)	**3.90**^{d} (1.93)
T5- Untreated	12.17^a (3.41)	12.33^a (3.43)
CD (0.05)	0.11	0.13

NCIPM

Area -01 ha,

Location: Bambawar, District GautamBudh Nagar (UP)

Large scale demonstration of bio-intensive pest management in rice was carried out at farmer's field in the village Bambawar, District GB Nagar (UP) in one ha area with Pusa basmati 1121. Plant growth parameters of 25 days old nursery, where seed treatment with *T. harzianum* was done, showed a significant (p=<0.05 in t Test) improvement in shoot length (16.26%), shoot fresh weight (35.94%) and shoot dry weight (46.66%), root fresh weight (134.52%) and root dry weight (59.78) in BIPM over farmers practice (FP). After transplanting in the main field total number of tillers (15.56) and number of panicle-bearing tillers (18.57) were also significantly higher in BIPM over FP.

The incidence of insect pests such as YSB, leaf folders remained below ETL in BIPM and FP. However, the population of BPH crossed ETL at 100 DAT with a significantly lower population in BIPM (17.32/hill) over FP (23.78/hill in FP). In BIPM field BPH was not found up to 60 DAT whereas at the same time, its appearance was noted in FP (0.15/hill). Similar was the case with leaf blast. The appearance of sheath blight and bakane was noted in FP from 45DAT, whereas in BIPM it was absent upto 60 DAT. At 100 DAT incidence of YSB, BPH and Bakane was significantly lower in BIPM over FP, whereas the incidence of other pests were at par in both. Spider was the major predator noted in rice with a significantly higher population in BIPM throughout the season compared to FP.

Economic analysis revealed significant increase in yield (20%) along with a reduction in the cost of cultivation (11%) and higher net return (51.6%) and BC ratio in BIPM (2.71) over FP (2.0). In FP fields farmers applied 4 sprays of chemical insecticides and fungicides, whereas in BIPM two sprays of Azadirachtin 1500 ppm @ 5ml/litre, two sprays of *Pseudomonas fluorescencs* were done. Overall BIPM strategy proved successful in managing pest problems in basmati rice with a higher benefit-cost ratio and the conservation of natural enemies without the application of chemical pesticides, ,

Table 58. Plant growth parameters of BIPM and FP rice fields

Plant growth parameters	BIPM	FP	t Test P value	% Change in BIPM over FP
25 days old seedlings				
Root length (cm)	4.553	4.551282	0.986	0.04
Shoot length (cm)	37.721	32.44513	0.0008	16.26
Root Fresh Weight (g)	0.059	0.025184	0.002	134.52
Root Dry Weight (g)	0.022	0.01369	3.65E-05	59.78
Shoot Fresh Weight (g)	0.348	0.256316	5.91E-07	35.94
Shoot Dry Weight (g)	0.08375	0.057105	8.26E-05	46.66
Main field				21.44
No. of tillers/hill	20.64	17	0.02	15.56
Number of panicle bearing tillers/hill	17.33333	15	0.039	18.57
Yield q/ha	37.5	31.25	0.012	

Table 59. Scenario of pests and natural enemies in BIPM and FP fields of basmati rice

	45DAT			60DAT			100DAT		
Pest	BIPM	FP	t-Test P value	BIPM	FP	t-Test P value	BIPM	FP	t-Test P value
YSB (% Dead heart/White ear)	0.10	6.05	0.003	0.25	5.1	0.070	1.15	3.8	0.000
Lea f folder (% leaf damage)	0.25	6.55	0.002	0.5	4.45	0.002	2.35	2.25	0.83
BPH (no/hill)	0.00	0	-	0	0.15	-	17.32	23.78	0.018
Spider (No/hill)	2.95	0.37	0.004	3.73	1.82	0.043	4.45	3.94	0.012
Leaf Blast (% incidence)	0.00	0	-	0	0	-	0.75	1.4	0.095
Neck blast (% incidence)	0	0	-	0	0	-	1.25	3.15	0.069
Sheath Blight (% incidence)	0.00	5.6	-	0	8.35	-	4.3	2.7	0.354
BLB (% incidence)	0	0	-	0	0	-	1.9	2.05	0.673
Bakane (% incidence)	0.00	0.75	-	0	0.7	-	0.15	0.6	0.034

t-Test: Two-Sample Assuming Unequal Variances

Table 60. Economics of BIPM in rice

Parameters	BIPM	FP	% Change in BIPM over FP
Cost (Rs/ha)	55404	62615	-11.5
Yield (Qt/ha)	37.5	31.25	20
Gross return (Rs/ha)	150000	125000	20
Net return (Rs/ha)	94596	62385	51.6
BC Ratio	2.71	2.00	

Fig 20. Large scale demonstration of bio-intensive pest management in rice

UBKV

The result of the experiments in rice from Table 61. showed that dead heart incidence in BIPM fields was 3.83 and 4.79 per cent at 45 and 60 DAT, respectively. The BIPM field showed 60.68% per cent reduction over control of white ear head whereas the Chlorantraniliprole 18.5 SC treated field showed 76.46% reduction over control. The highest yield was recorded from Chlorantraniliprole 18.5 SC treated field (4435.41 Kg/ha) followed by BIPM field (4321.37 Kg/ha). The cost: benefit ratio was 1:1.51, 1:1.68 and 1:1.02 for BIPM field, farmers practice plot and untreated control plots, respectively.

Table 61. Large scale demonstration of BIPM in rice at UBKV, Pundibari during 2022.

Treatments	Stem Borer						Leaf folder				Yield (Kg/ha)	Per cent yield increase over control (%)	Benefit: cost
	Per cent dead hearts		Mean	Per cent reduction over control	Per cent White Ear head	Per cent reduction over control	Per cent leaf damage		Mean	Per cent reduction over control			
	45 DAT	60 DAT					45 DAT	60 DAT					
BIPM	3.83	4.79	4.31	62.25	2.89	60.68	3.75	3.32	3.54	63.41	4321.37	8.41	1.51
Chloran – traniliprole 18.5 SC @30 g a.i/ha	2.32	2.85	2.59	75.36	1.73	76.46	2.96	1.75	2.36	75.62	4435.41	11.27	1.68
Untreated control	10.21	10.76	10.49	-	7.35	-	9.18	10.13	9.66	-	3986.02	-	1.02

PAU, Ludhiana

IV. 1.3. Large scale demonstrations on bio-intensive pest management in organic *basmati* rice

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, Barnala and Faridkot districts in organic *basmati* rice over an area of 336 acres. BIPM package includes seed bio-priming with *Trichoderma harzianum* @ 15g/ kg of seeds, 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 and augmentative releases of *T. chilonis* and *T. japonicum* each @ 1,00,000 parasitoids/ha were conducted 5-6 times at weekly interval starting from 30 days after transplanting (DAT) and compared with untreated control. Tricho-cards each having approximately 1000 parasitized eggs were cut into 100 strips and were stapled uniformly to the underside of the leaves in biocontrol treatment. The data were recorded on dead hearts due to stem borer and leaf damage due to leaf folder at vegetative state (45 and 60 DAT). White ear incidence was recorded a week prior to harvest. Grain yield was recorded on plot basis and economics was worked out.

Based on the mean of all locations (Table 62.), mean dead heart incidence in biocontrol fields was 1.63 and 1.77 per cent at 45 and 60 DAT, respectively. The corresponding figures in untreated control were 3.48 and 4.13 per cent. The mean reduction of dead heart incidence in release fields was 55.15 per cent over control. Similarly, leaf folder damage was significantly lower in BIPM fields as compared to untreated control. The damage was 2.55 and 2.21 per cent at 45 and 60 DAT, respectively as compared to 6.13 and 6.57 per cent in untreated control with a mean reduction of 62.52 per cent. The mean incidence of white ears was significantly lower in biocontrol field (2.74 %) as against untreated control (5.56 %) resulting in a reduction of 50.72 per cent (Table 63.). Grain yield in biocontrol field (27.75 q/ha) was significantly better as compared to 25.12 q/ha in untreated control, respectively. The yield increase in release fields was 10.47 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. 7231/- per hectare over untreated control with cost-benefit ratio of 1: 2.89.

Table 62. Large scale demonstrations of biocontrol of rice pests in organic *basmati* rice during 2022

Treatments	Dead hearts (%)				Leaf folder damaged leaves (%)			
	45 DAT	60 DAT	Mean	% reduction over control	45 DAT	60 DAT	Mean	% reduction over control
BIPM*	1.63[a]	1.77[a]	1.70[a]	55.15	2.55[a]	2.21[a]	2.38[a]	62.52
Untreated control	3.48[b]	4.13[b]	3.81[b]	-	6.13[b]	6.57[b]	6.35[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 63. Large scale demonstrations of biocontrol of rice pests and yield of organic *basmati* rice during 2022

Treatments	White ears incidence (%)	% reduction over control	Paddy yield (q/ha)	% increase over control	Net returns over control (Rs./ha)	Cost bene-fit ratio
BIPM*	2.74[a]	50.72	27.75[a]	10.47	7231.00	1:2.89
Untreated control	5.56[b]	-	25.12[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 21. Field release of Tricho-strips in rice

AAU, Jorhat

Location : Satkhelia, Jorhat, Dangdhara, Golaghat, Baruati gaon, Gohain Gaon and Deodhai Gaon, Sivsagar

Variety : Ranjit

Area : 50 ha

Date of transplanting: 1st -2nd week of July' 2022

Treatments: 3

T1 : The practices followed in BIPM package

- Seedling root dip treatment with *Pseudomonus fluorescens* @ 2 % solution,
- Two sprays of Azadirachtin 1500 ppm @3 ml/litre at 45 and 65 DAT against foliar and sucking pests,
- Erection of bird perches @ 15 nos /ha,
- Spray of *P. fluorescens* @ 1.5 kg/ha against foliar diseases
- Six releases of *T. japonicum* @ 1,00,000 /ha at ten days interval starting from 30 DAT against *Scirpophaga* spp. and *Cnaphalocrocis* spp,

T2: Chemical control (PoP recommendation Chlorantraniliprole 18.5 SC@ 0.3 ml/L)

T3: Untreated control

Results: Dead heart (%), WEH (%) and LFDL (%) were significantly lower in BIPM and Chemical control plot than control. However, no significant difference was observed in BIPM and chemical control in terms of Dead heart(%), WEH(%) LFDL(%) and Yield. BIPM and chemical control plots recorded 4570 kg/ha yield and 4780.71 kg/ha yield which were 25.91% and 29.18% more yield than control.

Table 64. Evaluation of BIPM module against insect pests of rice

Treatments	Dead heart (%)		WEH (%)	LFDL (%)		Grain yield (kg/ha)	Pest reduction over contro(%)		Yield increase over con-trol(%)
	45DAT	60DAT	100DAT	45DAT	60DAT		WEH%	LFD%	
BIPM Package	6.94 (13.95)	3.99 (10.67)	2.93 [a] (6.52)	5.78 (13.76)	3.21 (8.77)	4570.00	53.56	49.44	25.91
Chemical control	5.30 (11.30)	2.96 (8.42)	2.62 (6.13)	4.08 (10.96)	2.47 (6.13)	4780.71	58.47	61.10	29.18
Untreated control	7.79 (14.97)	6.72 (14.97)	6.31 (13.46)	7.48 (15.73)	6.35 (!4.44)	3385.57			
CD = 0.05	NS	2.19	3.79	2.68	2.67	526.90			

Table 65. Evaluation of BIPM module against insect pests of rice

Treatments	Post count (spider/m^2)		Post count coccinellids/m^2	
	45 DAT	60 DAT	45 DAT	60 DAT
IPM package	1.36	2.78	0.74	1.67
Farmer's' practice	1.02	0.62	0.46	0.32
Untreated control	1.17	2.55	0.73	1.63
CD = 0.05	NS	0.487	NS	0.85

WEH

Application of Trichocard

Collection of data

BIPM demonstration plot

Harvesting of BIPM demonstration plot

Fig 22. Application of BIPM

CAU, Pasighat

Location: Farmer fields at Mirem, Bodak, Sille villages, East Siang district

Area: 10 ha

Treatments: 02

Replications: 05

Design: Large sampling CRD

Variety: Local

Treatments:

T_1 = BIPM Package

- Seed bio-priming with *Pseudomonas fluorescens* 10g/L
- Seedling root dip with *Pseudomonas fluorescens*@10 g/L for 1hour before transplanting
- Need based application of *Beauveria bassiana* NBAIR Bb 5a foliar spray @5g/kg for sucking pests
- Two sprays of *Pseudomonas fluorescens*@ 10g/L against foliar diseases after transplanting and 20 days after transplanting.
- Sex pheromone traps for mass trapping of yellow stem borer adults @15/acre
- Releases of *Trichogramma chilonis* and *Trichogramma japonicum* @ 100,000/ha (5-6 releases to be made during season) at 7 days interval starting from 30 DAT for stem borer and leaf folder infestation

T_2 = POP recommendation (Chlorantraniliprole 18.5 SC @ 0.3 ml/L and alternative with Imidacloprid 17.8 SL @ 0.5 ml/lit water against sucking pests at 15 days intervals)

Table 66. Efficacy of different modules on pest incidence, natural enemies and yield of Rice

Modules	Dead heart (%)		Leaf folder damage (%)		Hoppers (No./hill)		Natural enemies/ m^2		Yield (q/ha)
	Pre-T	Post-T	Pre-T	Post-T	Pre-T	Post-T	Pre-T	Post-T	
BIPM Module	3.71	2.56	4.39	2.55	9.07	5.35	3.20	3.26	37.50
Farmers practice	3.63	2.13	4.26	2.45	8.21	3.28	2.56	2.02	38.79
't' value	0.89	0.09	0.69	0.35	0.46	0.04	0.19	0.02	0.66
Remarks	NS	NS	NS	NS	NS	S	S	S	NS

S: Significant, NS: Non significant, Pre-T: Pre treatment mean, Post-T: Post treatment mean

Results:

The data pertaining to the efficacy of different modules against pest incidence, natural enemies and yield of Rice is presented in the Table No 66. Though, the chemical module documented the lowest dead hearts due to yellow stem borers (2.13 %) and leaf folder damage (2.45 %) which were statistically at par with BIPM module (2.56 % dead hearts and 2.55% leaf folder damage). However, the BIPM module recorded the significantly higher hoppers incidence (5.35 hoppers/hill) and natural enemies (3.26/m^2) as compared to chemical module (3.28 hoppers/hill and 2.02 natural enemies/m^2). The yield did not differ significantly in BIPM (37.50 q/ha) and in chemical module (38.79 q/ha). Cost benefit ratio was high in BIPM module *i.e.,* 1.62 as compared POP 1.24.

Fig 23. **FLD plot view at Farmer's Field and Leaf folder damage in Paddy**

OUAT

Variety: Pooja

TREATMENTS

T1: BIPM package

T2: Farmers Practice

Chlorantraniliprole 18.5% SC 200ml/ha or Lambda-cyhalothrin 2.5% EC 500ml/ha

T3: Untreated control

Location: Biridi village of Khandapada block and Biruda of Nayagarh district

Area: 5 ha

Season: Kharif 2022

No. of beneficiaries: 10

Results: The dead heart (DH), white ear head (WEH) and leaf folder (LF), incidence in BIPM demonstrated plots were 4.18, 2.88 and 3.90%, respectively as compared to 3.49, 2.24 and 3.16% infestation in farmers practice (FP) with the use of chemical pesticides. Significantly higher DH (7.30%), WEH (7.38%) and LF (9.64%) infestation was noticed in untreated control. No significant difference was observed in yield in BIPM package (39.04 q/ha) and FP (40.22q/ha). The benefit cost ratio in BIPM treated plots was found (1.33) as against 1.40 in FP and 1.19 and untreated control, respectively (Table 67.).

Table 67. BIPM demonstration in paddy at Biridi and Biruda village of Nayagarh district

Treatments	DH (%)	WEH(%)	LF (%)	Yield (q/ha)	B:C ratio
BIPM package	4.18 (2.04)	2.88 (1.69)	3.90 (1.97)	39.04	1. 33
Farmer's Practice	3.49 (1.86)	2.24 (1.49)	3.16 (1.77)	40.22	1.40
Untreated Control	7.30 (2.70)	7.38 (2.70)	9.64 (3.08)	31.21	1.19
S.E. (m) ±	(0.05)	(0.07)	(0.08)	1.12	
C.D. (0.05)	0.14	0.21	0.23	3.36	

Figures in the parentheses are square root transformation values

IV. 1.4. Management of rice stem borer and leaf folder using entomopathogens

KAU, Thrissur

Field experiments were laid out at two locations (Palakkad and Thissur) to evaluate the effect of need based application of three entomopathogens, viz., *Heterorhabditis indica, Bacillus thuringiensis* and *Beauveria bassiana* (all NBAIR strains) for the management of rice stem borer and leaf folder.

Design: RBD Variety: Jyothi

Treatments: 5 Replications: 4

Results of experiment at Pattambi, Palakkad district

Significant difference was observed among the treatments in terms of stem borer infestation. Plots treated with the insecticide chlorantraniliprole consistently recorded the lowest number of dead hearts/white earheads per m^2.

The cumulative mean number of dead hearts/white ear heads was significantly low in chlorantraniliprole treated plot (7.50 no./m^2). Among the bioagents, both *Bacillus thuringiensis* and *Beauveria bassiana* were on par with mean values of 13.12 and 16.75 dead hearts/ white ear heads per m^2 respectively. The infestation of leaf folder was very low and did not cross ETL at any stage during the study due to the activity of carabid beetle, *Ophionea nigrofasciata* (Tablr 68.).

Fig 24. Field view of experiment on management of rice stem borer and leaf-folder using entomopathogens at Pattambi.

Table 68. Effect of entomopathogens on incidence of stem borer in rice (Pattambi)

Treatments	Number of dead hearts/white ear per m^2					Cumulative mean number per m^2	Per cent reduction over control
	Precount	7 DAS_1	14 DAS_1	7 DAS_2	14 DAS_2		
T1: *Heterorhabditis indica*	14.75 (3.66)	21.00 $(4.46)^a$	32.50 $(5.73)^a$	24.50 $(4.94)^a$	7.75 $(2.78)^a$	21.44 $(4.62)^a$	-
T2: *Bacillus thuringiensis*	16.25 (3.93)	16.25 $(3.99)^a$	17.50 $(4.23)^b$	13.50 $(3.66)^b$	5.25 $(2.32)^{ab}$	13.12 $(3.62)^c$	35.21
T3: *Beauveria bassiana*	15.25 (3.84)	17.00 $(4.11)^a$	27.25 $(5.26)^a$	15.75 $(3.95)^b$	7.00 $(2.57)^a$	16.75 $(4.08)^{bc}$	17.28
T4: Chlorantraniliprole 18.5 SC	20.00 (4.38)	8.50 $(2.88)^b$	13.50 $(3.68)^b$	6.00 $(2.31)^c$	2.00 $(1.49)^b$	7.50 $(2.71)^d$	62.96
T5: Untreated control	19.25 (4.37)	17.50 $(4.15)^a$	29.25 $(5.43)^a$	25.75 $(5.05)^a$	8.50 $(2.94)^a$	20.25 $(4.49)^{ab}$	-
CD (0.05)	NS	0.88	0.70	0.83	0.88	0.52	

(Values in parenthesis are square root transformed values)

Results of experiment at Kanimangalam, Thrissur district

Plots treated with the insecticide chlorantranliprole consistently recorded the lowest level of stem borer and leaf folder infestation. The cumulative mean number of dead hearts was low in plots treated with insecticides (1.12 no/m^2), which was on par with *B. thuringiensis* (1.93 no/m^2) (Table 69).

Mean cumulative number of leaf folds was significantly low in chemical treated plots (0.94 no./m^2). Among bioagents, *B. thuringiensis* and *B. bassiana* recorded significantly low cumulative mean number of 2.50 and 2.75 dead hearts/white ear heads/m^2 and were on par with each other. Overall, among the bioagents, *B. thuringiensis* and *B. bassiana* showed a consistent reduction on the infestation by stem borer and leaf folder (Table 70.).

Fig 25. Field view of experiment on management of rice stem borer and leaf-folder using entomopathogens at Kanimangalam.

Table 69. Effect of entomopathogens on incidence of stem borer in rice (Kanimangalam)

Treatments	Number of dead hearts/white ear per m^2					Cumulative mean number per m^2	Per cent reduction over control
	Precount	7 DAS$_1$	14 DAS$_1$	7 DAS$_1$	14 DAS$_2$		
T1: *Heterorhabditis indica*	9.75 (3.16)	9.50 (3.08)^a	7.75 (2.82)^a	2.75 (1.65)^{ab}	5.00 (2.29)^a	6.25 (2.49)^a	12.22
T2: *Bacillus thuringiensis*	8.75 (2.93)	4.75 (2.07)^{bc}	1.50 (1.31)^b	0.51 (0.96)^b	1.00 (1.18)^{bc}	1.93 (1.35)^c	72.89
T3: *Beauveria bassiana*	6.50 (2.59)	6.75 (2.58)^{ab}	4.00 (2.09)^{ab}	1.75 (1.40)^{ab}	2.25 (1.45)^{abc}	3.68 (1.90)^b	48.31
T4: Chlorantraniliprole 18.5 SC	3.75 (2.03)	2.00 (1.35)^c	1.50 (1.16)^b	0.50 (0.92)^b	0.50 (0.92)^c	1.12 (0.93)^c	84.27
T5: Untreated control	7.75 (2.84)	10.00 (3.12)^a	8.75 (3.02)^a	5.25 (2.24)^a	4.50 (2.18)^{ab}	7.12 (2.67)^a	-
CD (0.05)	NS	0.75	0.94	0.91	1.00	0.44	

(Values in parenthesis are square root transformed values)

Table 70. Effect of entomopathogens on incidence of leaf folder in rice (Kanimangalam)

Treatments	Number of leaf folds per m^2					Cumulative mean number per m^2	Per cent reduction over control
	Precount	7 DAS_1	14 DAS_1	7 DAS_2	14 DAS_2		
T1: *Heterorhabditis indica*	5.00 (2.21)	5.75 (2.36)	6.25 (2.55)^a	4.50 (2.18)^a	4.00 (2.06)^a	5.12 (2.24)^a	-
T2: *Bacillus thuringiensis*	5.50 (2.23)	4.00 (1.99)	2.75 (1.78)^c	1.75 (1.47)^b	1.50 (1.27)^{bc}	2.50 (1.57)^c	39.32
T3: *Beauveria bassiana*	3.50 (1.86)	4.50 (2.10)	2.75 (1.78)^{bc}	2.00 (1.58)^{ab}	1.75 (1.49)^{abc}	2.75 (1.66)^{bc}	33.25
T4: Chlorantraniliprole 18.5SC	6.00 (2.42)	2.25 (1.45)	0.75 (1.05)^d	0.25 (0.83)^c	0.50 (0.96)^c	0.94 (0.95)^d	77.18
T5: Untreated control	3.75 (1.91)	4.00 (1.97)	5.25 (2.38)^{ab}	4.00 (2.07)^{ab}	3.25 (1.91)^{ab}	4.12 (2.01)^{ab}	-
CD (0.05)	NS	NS	0.59	0.62	0.76	0.41	

(Values in parenthesis are square root transformed values)

Results from two locations suggested that the entomopathogenic bacterium *B. thuringiensis* and the fungus *B. bassiana* could be viable alternatives to insecticides for the management of stem borer and leaf folder in rice.

IV. 1.5. Evaluation of entomopathogens against sucking pests of rice (MPKV Pune)

MPKV, Pune

Variety: VDN -1832

Plot size: size 3.00 x 2.50 m with 30 x 15 cm spacing

Treatments: 4

Replications: 5

RBD

The population of plant hoppers was recorded from 10 hills selected at random at weekly interval starting from 20 days after transplanting and recorded yield (q/ha).

Results:

Among the two entomopathogenic fungi, three sprays of *B. bassiana* NBAIR Bb5a @ 5g/l recorded low leaf hopper population 14.92/10 hills, higher percentage reduction of hoppers (65.09%), maximum yield (41.32 q/ha) and maximum C:B ratio (1:2.97) followed by *Lecanicillium saksenae* @ 5g/l which recorded hopper population (16.25/10 hills) and the per cent reduction (61.99%) and was found significantly superior over control. The standard check Thiamethoxam 25 WDG recorded significantly lowest hopper population (2.91/10 hills) and the highest percent reduction of hopper over control (93.19%) with 46.32 q/ha yield of rice and highest C:B ratio (1:3.36) (Table 71.). .

Table 71. Evaluation of entomopathogens against sucking pests of rice (Brown Plant hopper)

TN	Treatment	Dose g/lit	Population of BPH				Per cent Re-duc-tion over control	Yield q/ha	% in-crease over con-trol	B: C ratio
			Pre-count	Post count						
				I Spray	II Spray	Cu-mu-la-tive Mean				
1	*Lecanicillium saksenae* KAU ITCC7714 (1 × 10^8 Spores/g)	5	28.00 (5.38)*	17.83 (4.26)	14.67 (3.92)	16.25 (4.15)	61.99	40.41	9.25	2.91
2	*Beauveria bassiana* NBAIR Bb 5a (1 × 10^8 Spores/g)	5	27.75 (5.36)	17.67 (4.25)	12.17 (3.59)	14.92 (3.97)	65.09	41.32	11.25	2.97
3	Thiamethoxam 25% WDG	0.2	26.75 (5.31)	3.33 (2.07)	2.50 (1.85)	2.91 (1.98)	93.19	46.32	2083	3.36
4	Untreated Control		27.25 (5.31)	36.17 (6.08)	49.33 (7.08)	42.75 (6.60)	-	36.67	-	2.81
	SE +/-		0.08	0.54	0.35	0.37		0.95		
	CD @ 5%		N.S.	1.26	1.16	1.45		2.95		

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

Table 72. Cost and Economics

Treatment	Cost of Insecti-cides	La-bour cost	Total cost of appli-cation	Cost of Culti-vation	Total cost of culti-vation	Yield	Rate	Gross returns	Net return	B: C ratio
	Rs.	Rs	Rs	Rs	Rs	(q/ha)	Rs/qt	Rs.	Rs.	
Lecanicillium saksenae KAU ITCC7714 (1 × 10^8 Spores/g)	1500	1050	2550	39154	41704	40.41	3000	121230	79526	2.91
Beauveria bassiana NBAIR Bb 5a (1 × 10^8 Spores/g)	1500	1050	2550	39154	41704	41.32	3000	123960	82256	2.97
Metarhizium anisopliae (1 × 10^8 Spores/g)	1500	1050	2550	39154	41704	43.26	3000	129780	88076	3.11
Thiamethoxam 25% WDG	1105	1050	2255	39154	41409	46.32	3000	138960	97551	3.36
Untreated Control	-	-	-	39154	39154	36.67	3000	110010	70856	2.81

Fig 26. Field trial for evaluation of entomopathogens against BPH on rice during 2022

Fig 27. Field trial for evaluation of entomopathogens against BPH of rice at ARS Farm, Vadgaon Maval, Dist. Pune

IV. 1.6. Field evaluation of entomopathogens and plant growth promoting bacteria against Rice stem borer, Leaf folder, and Brown planthopper (ICAR-NRRI)

Table 73. The bio-control efficacy of entomopathogens against rice insect pests (ICAR-NRRI) at cuttack

Treatment Details	Plant height (cm)*	Yellow stem borer damage (White ear head damage %)**	Leaf folder damage (Leaf damage %)**	Yield (kg/ha)*	Yield increase over control (%)
T_1-*Bacillus albus* NBAIR-BATP (1 x 10^8 cfu/ml) @ 10ml/L	86.92 $(9.82)^a$	3.15 $(1.90)^b$	1.63 $(1.45)^b$	4009.4 $(63.81)^c$	11
T_2-*Bacillus thuringiensis* NRRI Bt Biocb 7 (1 x 10^8cfu/ml) @10ml/L	84.82 $(9.71)^b$	3.41 $(1.97)^b$	1.64 $(1.46)^b$	4325.0 $(66.26)^b$	20

T_3-Thiamethoxam@0.2g/L	84.88 (9.71)^{b}	1.29 (1.32)^{c}	0.87 (1.71)^{c}	4589.4 (68.24)^{a}	27
T_4-Untreated Control	82.90 (9.60)^{c}	5.83 (2.51)^{a}	2.80 (1.81)^{a}	3630.6 (60.75)^{d}	
p value	=0.000	=0.000	=0.000	=0.000	

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

The experiment was conducted at ICAR-NRRI, Cuttack to test the bio-efficacy of identified bio-control agents (NBAIR-BATP, and NRRI Bt Biocb 7) along with recommended insecticide as positive control and untreated control as negative control under field condition. The experiment was conducted by employing susceptible rice variety, TN-1 and evaluated against major rice insect pests occurring under ICAR-NRRI field condition. The results shown that spray of both entomopathogens shown less white ear-head compared to untreated control which recorded maximum white ear-head damage caused by yellow stem borer whereas least white ear-head damage was observed in the thiamethoxam insecticide application treatment (Table 73.). Similarly, with respect to leaf folder damage highest leaf damage was observed in untreated control and significantly less leaf damage was observed in insecticidal and both entomopathogens sprayed plots. Pertaining to plant height, significant increase in values was observed in insecticidal and both entomopathogens sprayed plots than the plants of untreated control. Though, highest grain yield/plot was obtained in the thiamethoxam insecticide treatment both the entomopathogens sprayed plots caused significantly superior grain yield than the untreated control (Table 73.). Thus, the experiment shows both entomopathogens were effective in reducing the damage caused by rice yellow stem borer and rice leaf folder and resulting in increased yield than the untreated control.

Table 74. The bio-control efficacy of entomopathogens against rice insect pests (ICAR-IIRR) at Hyderabad

S. No.	Treatment	DH(%)		WE (%) @ pre Harvest	Leaf folder damage (%)	Natural enemies' population/ 10 hills	Yield (kg/ha)
		45 DAT	60 DAT				
T-1	*Bacillus albus* NBAIR-BATP (1 x 10^8 cfu/ml) @ 10ml/L	4.72	8.80 (17.12)	13.93 (21.89)	10.01	5.17	3633.33
T-2	*Bacillus thuringiensis* NRRI Bt Biocb 7 (1 x 10^8cfu/ml) @10ml/L	5.01	7.79 (16.11)	13.37 (21.42)	6.59	6.33	3800.00
T-3	Thiamethoxam@0.2g/L	5.00	7.43 (15.76)	10.25 (18.62)	8.07	4.67	3966.67
T-4	Untreated Control	4.50	9.67 (17.93)	18.56 (25.49)	8.49	5.33	3183.33
SEM			1.00	0.59			145.60
SED			1.42	0.84			205.91

CD (0.05)		NS	3.02	1.79	NS	NS	438.88

*DH – Dead heart, WH- White ear head

The experiment was conducted at ICAR-IIRR, Hyderabad to test the bio-efficacy of identified bio-control agents (NBAIR-BATP, and NRRI Bt Biocb 7) along with recommended insecticide as positive control and untreated control as negative control under field condition. The results shown that spray of both entomopathogens shown less dead heart and white ear-head damage compared to untreated control which recorded maximum dead heart and white ear-head damage caused by yellow stem borer whereas least white ear damage was observed in the thiamethoxam insecticide application treatment (Table 74.). Though, highest grain yield/plot was obtained in the thiamethoxam insecticide treatment both the entomopathogens sprayed plots resulted in significantly superior grain yield than the untreated control (Table 74.). Thus, the experiment shows both entomopathogens were effective in reducing the damage caused by rice yellow stem borer and resulting in increased grain yield than the untreated control.

IV. 2. Biological Control of Maize Pests

MAIZE:

IV. 2.1. Evaluation of native isolates of entomopathogens (ANGRAU & UAS (R) against maize Fall armyworm

ANGRAU: Among the native isolates of entomopathogens, *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) as two sprays was effective with significantly low fall armyworm incidence(16.29%) in) after chemical, emamectin benzoate upto 60 days crop age and was on par with other isolates. Cob yield was significantly high in *M. rileyi* (Anakapalle strain AKP-Nr-1) (66.298 q/ha) after Chemical, Emamectin benzoate (69.295 q/ha) and low in untreated control (39.740 q/ha) (Table 75.).

Table 75. Evaluation of native isolates of entomopathogens against maize fall armyworm

Treatment	FAW damage %**		FAW damage upto 60 days crop age	Percent reduction in FAW damage over control	Cob yield Q/ha	Percent increase in yield over control
	Before spraying	After spraying				
T1: *Bacillus thuringiensis* RARS TPT –C33 1% @ 10 g/L	15.94 (1.196)	4.87 (0.683)	20.920 (1.318)	70.17	63.95	60.92
T2: *Metarhizium rileyi* (Anakapalle strain AKP Nr-1) concentration 1x10^8 spores/ml @ 5 g/lt	12.36 (1.069)	3.88 (0.579)	16.285 (1.191)	76.24	66.298	66.83
T3: *Metarhizium rileyi* (UAS, Raichur strain AKP Nr-1) concentration 1x10^8 spores/ml @ 5 g/lt	16.81 (1.221)	4.69 (0.670)	21.500 (1.33)	71.27	53.690	35.10
T4:Emamectin benzoate 5SD @ 0.4 g/L	13.19 (1.110)	2.05 (0.310)	15.248 (1.176)	87.44	69.295	74.37
T5 : Untreated control	12.92 (1.107)	16.33 (1.213)	29.260 (1.465)	-	39.740	-

CD (0.05)	NS	0.116	0.142		16.163	
CV%	9.353	10.937	**7.128**		17.902	

Three sprays at 20,35,50 days after sowing

** Values in parenthesis are logarithmic transformed values

Fig 28. Field efficacy of *Metarhizium rileyi* and *Bacillus thuringiensis* against fall armyworm in maize

UAS, Raichur

Results: One day before spray, larval population ranged from 1.32 to 1.46 larvae per plant which was statistically non-significant. Ten days after second spray lowest larval population of 0.18 larva per plant was noticed *M. rileyi* (AKP-Nr-1) @ 1×10^{8} spores/ml (5g/L) which was at par with *M. rileyi* (KK-Nr-1) @ 1×10^{8} spores/ml (5g/L) which recorded 0.24 larva per plant. The highest per cent microbial infection of 10.56 was noticed in *M. rileyi* (AKP-Nr-1) @ 1×10^{8} spores/ml (5g/L) which was at par with *M. rileyi* (KK-Nr-1) @ 1×10^{8} spores/ml (5g/L) which recorded 10.18 per cent. Highest grain yield of 62.12 q/ha was noticed in *M. rileyi* (AKP-Nr-1) @ 1×10^{8} spores/ml (5g/L) which was at par with *M. rileyi* (KK-Nr-1) @ 1×10^{8} spores/ml (5g/L) which 61.38 q/ha while in untreated control recorded 41.25q/ha grain yield (Table 76.).

Table 76. Evaluation of native isolates of entomopathogens against maize Fall armyworm during 2022-23

Sl. No.	Treatment Details	Dos-age (g/l)	Number of larvae per plant*			Plant damage (%) #	Microbial infection (%) #	Grain yield (q/ha)
			IDBS	10 days after each spray				
				I Spray	II Spray			
1	*Bacillus thuringiensis* RARS TPT–C33 1%	10.0	1.36 (1.36)	0.68 (1.09)	0.36 (0.93)	5.18 (13.16)	6.32 (14.56)	58.50
2	*Metarhizium rileyi* (Anakapalle strain AKP Nr-1) 1×10^{8}spores/ml	5.00	1.42 (1.39)	0.42 (0.96)	0.18 (0.82)	3.64 (11.00)	10.56 (18.96)	62.12
3	*Metarhizium rileyi* (KK-Nr-1) 1×10^{8} spores/ml	5.00	1.38 (1.37)	0.46 (0.98	0.24 (0.86)	3.88 (11.36)	10.18 (18.61)	61.38
4	Emamectin benzoate 5WG	0.40	1.46 (1.40)	0.14 (0.80)	0.20 (0.72)	1.24 (6.39)	0.75 (4.97)	65.50
5	Untreated control	--	1.32 (1.35)	1.44 (1.39)	1.48 (1.41)	19.56 (26.25)	3.26 (10.40)	41.25

S Em ±	0.21	0.08	0.02	0.03	1.36	0.51
CD (P=0.05)	NS	0.25	0.07	0.11	4.08	1.56

1 DBS - 1 day before spraying
* Figures in parentheses are square root transformed values
# Figures in parentheses are arcsine transformed values

IV. 2.2. Large scale demonstration of bioefficacy of multiple insecticide tolerant *Trichogramma chilonis* NBAIR MITS for the management of fall armyworm in maize

ANGRAU: Locations: 4 villages in Srikakulam district, Andhra Pradesh

Area covered : 30 acres

Farmers benefitted: 12 farmers

Mutliple insecticide tolerant *Trichogramma chilonis* NBAIR MITS cards (1,00,000 eggs/ha) (2 releases , first release after one week of sowing & second release one week after first release + spraying chlorantraniliprole 18.5 SC@ 0.4 ml/L at 35 days after sowing provided good reduction in fall armyworm damage (24.43%) with high egg parasitism (15.23%), increased yield (5.56%) and high incremental benefit cost ratio (2.83) compared to POP Recommendation (Insecticidal check: Azadirachtin 1500 ppm @ 2 ml/lt at 15 days after sowing + chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing +Emamectin benzoate 5 SG @ 0.4 g /L at 35 days after sowing.

Table 77. Bioefficacy of multiple insecticide tolerant *Trichogramma chilonis* NBAIR MITS for the management of fall armyworm in maize

Treatment	FAW damage upto 60 DAS		Percent Reduction in FAW damage	Egg parasitism %	Cob yield Q/ha	Percent increase in yield	Incremental Benefit cost ratio
	Damaged plants /25 m ^{2} plot	Damage %					
T1: Mutliple insecticide tolerant *Trichogramma chilonis* cards (1,00,000 eggs/ha) (2 releases , first release after one week of sowing & second release one week after first release)	14.25	8.63	24.43	15.23	92.68	5.56	2.83
T2: POP Recommendation (Insecticidal check: Azadirachtin 1500 ppm @ 2 ml/lt at 15 days after sowing + chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing +Emamectin benzoate 5 SG @ 0.4 g /L at 35 days after sowing)	19.75	11.42	-	0.0	87.8	-	-

*Spraying chlorantraniliprole 18.5 SC@ 0.4 ml/L at 35 days after sowing in T1



Fig 29. Large scale demonstration on Multiple insecticide tolerant trichogramma chilonis NBAIR MITS for management of maize fall armyworm

UAS Raichur:

Results: One day before treatment imposition, the number of egg patches ranged from 3.24 to 3.68 per plant and ten days after release the number of egg patches were low in T_1 (0.25 egg patches/plant. Ten days after treatment imposition T_1 recorded 0.38 larva per plant with highest egg parastisation of 33.50 per cent while in T_2 it was 2.85 per cent. The treatment comprising biocontrol agents recorded 58.25q/ha grain yield while the farmers practices recorded 61.50 q/ha (Table 78.).

Table 78. Large scale demonstration of bioefficacy of multiple insecticide tolerant *Trichogramma chilonis* NBAIR MITS for the management of fall armyworm in maize during 2022-23

Sl. No.	Treatment Details	Egg patches per plant (No.)*		Larvae per plant (No.) *		Dam-aged plant (%)#	Parasi-tisation (%)#	Grain yield (q/ha)
		IDBS	10 DAS	IDBS	10 DAS			
T_1	Mutliple insecticide tolerant *Trichogramma chilonis* cards (1,00,000 eggs/ha) (2 releases , first release after one week of sowing & second release one week after first release)	3.68 (2.04)	0.25 (0.87)	1.66 (1.47)	0.38 (0.94)	10.58 (18.98)	33.50 (35.37)	58.25
T_2	POP Recommendation (Insecticidal check: Azadirachtin 1500 ppm @ 2 ml/lt at 15 days after sowing + chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing +Emamectin benzoate 5 SG @ 0.4 g /L at 35 days after sowing)	3.24 (1.93)	3.50 (2.00)	1.58 (1.44)	0.14 (0.80)	4.50 (12.25)	2.85 (9.72)	61.50
S Em ±		**0.17**	**0.05**	**0.11**	**0.07**	**0.13**	**0.31**	**0.65**
CD (P=0.05)		**NS**	**0.15**	**NS**	**0.21**	**0.41**	**0.95**	**1.89**

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

IV. 2.3. Large scale demonstration of BIPM module for the management of maize FAW

ANGRAU: Locations: 5 villages in Srikakulam , Vizianagaram districts, Andhra Pradesh
Area covered : 40 acres
Farmers benefitted: 12 farmers

BIPM module (Installation of pheromone trap @ 10 /acre + release of *Trichogramma chilonis* (1,00,000 eggs /ha) two weekly releases from one week after sowing + Spraying ICAR- NBAIR *Metarhizium anisopliae* (NBAIR Ma35) @ 5 g/L two times at 25, 35 days after sowing) provided good reduction in fall armyworm damage (35.94%) with high egg parasitism (9.58%), increased yield (5.38%) and high incremental benefit cost ratio (4.78) compared to POP Recommendation (Insecticidal check: Azadirachtin 1500 ppm @ 2 ml/lt at 15 days after sowing + chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing +Emamectin benzoate 5 SG @ 0.4 g /L at 35 days after sowing.

Fig 30. Evaluation of BIPM module for the management of maize fall armyworm

Table 79. Evaluation of BIPM module for the management of maize fall armyworm

Treatment	FAW damage upto 60 DAS		Percent Reduction in FAW damage	Egg parasitism %	Cob yield Q/ ha	Percent increase in yield	Incremental Benefit cost ratio
	Damaged plants /25m^2 plot	Damage %					
T1: BIPM module • Installation of pheromone trap @ 10 / acre • Release of *Trichogramma chilonis* (1,00,000 eggs /ha) (2 releases, first release after one week of sowing & second one after one week of first release • ICAR- NBAIR *Metarhizium anisopliae* (NBAIR Ma35) @ 5 g/L (2 sprays, at 25, 35 days after sowing)	14.25	9.18	35.94	9.58	91.87	5.38	4.78
T2: POP Recommendation Insecticidal check • Azadirachtin 1500 ppm @ 2 ml/lt at 15 days after sowing • Chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing • Emamectin benzoate 5 SG @ 0.4 g /L at 35 days after sowing	22.67	14.33	-	0.0	86.93	-	-

MPKV, Pune

Location: Dairy Farm of College of Agriculture, Pune.

Variety: 'Phule Rajershi'

Date of sowing: 06.07.2022
spacing: 60 x 20 cm spacing
Treatments: 2
Area: 5 ha area.

Observation: The 50 plants were randomly selected for FAW incidence and larval mortality. Observations on number of damaged plants per plot, number of dead larvae (due to bacteria/virus/fungus) per plot, per cent egg parasitism and number of predators per plant and yield/ha were calculated. The data were transformed to √(x+0.5) and arcsine values before statistical analysis.

Results:

The data presented in the Table 80. revealed that the fall armyworm incidence was moderate during the growth period. FAW attack was observed within one week after germination.

Plant damage: The per cent plant damage varied between 57.81 to 58.36 in pre-count with no significant differences amongst the treatments. The lowest mean per cent of plant damage/plot (9.83%) was observed in the BIPM which was significantly superior over POP recommended spraying which recorded highest 14.49 per cent plant damage.

Number of dead larva: Highest dead larva/plot was recorded in BIPM (0.67) as compared to 0.33 in POP recommended spraying.

Egg parasitisation : An egg parasitisation was significantly highest in BIPM plots (38.33 %) followed by 3.67% in POP recommended spraying.

No. of predators/plot: It was maximum in BIPM treated plots (0.93/plant).

Yield: Highest yield (36.49 qt./ha.) was recorded in the BIPM plot with highest B:C ratio of 1.77 which was significantly superior over POP recommended spraying (31.67 q./ha.) with B:C ratio of 1.70.

Table 80. Effect of BIPM against fall armyworm *Spodoptera frugiperda* in maize

Tr No	Treatment details	Egg masses/ plant		Damaged plants/plot (%)		No. of dead larvae/plot		Per cent egg parasit-ism	No. of Pred-ators/ plant	Yield (qt/ ha)	B:C
		Pre count	Post count	Pre count	Post count	Pre-count	Post count				
T1	BIPM module	1.00 (1.22)*	0.33 (0.91)	58.36 (49.81)**	9.83 (18.27)	1.67 (1.47)	0.67 (0.68)	38.83 (38.55)	0.93 (1.20)	36.49	1:1.77
T2	POP recommendation Spraying Azadirachtin 1500 ppm @ 2 ml/L at 15 days after sowing + Chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing + Emamectin benzoate 5SG@ 0.4gm/L at 35 days after sowing	0.93 (1.20)	0.67 (0.68)	57.81 (49.49)	14.49 (22.37)	1.33 (1.35)	0.33 (0.91)	3.67 (11.04)	0.33 (0.91)	31.67	1:1.70
	"t" value	0.11	0.10	1.36	1.56	0.14	0.09	2.39	0.10	1.91	
	Remarks	N.S.	Sig.	N.S.	Sig.	N.S.	Sig.	Sig.	Sig.	Sig.	

*Figures in parenthesis $\sqrt{x+0.5}$ transformed values.
**Figures in parenthesis are arc sin value

Table 81. Cost and Economics

Treatment	Cost of Insecticides	Labour cost	Total cost of application	Cost of Cultivation	Total cost of cultivation	Yield qt/ha	Rate	Gross returns	Net return	B: C ratio
	Rs.	Rs	Rs	Rs	Rs	(t/ha)	Rs/qt	Rs.	Rs.	
T1: BIPM module 1. Pheromone trap @ Rs. 26/- + Lure @ Rs. 20/- No. Trap 25 x 46/- = 1150/- 2. Trichocard @ 100/ card, 2 releases @ 5 card/ha = 100 x 10 card = 1000/- 3. NBAIR Bt @ 2 lit for two sprays @ 1500/- = Rs. 1500 x 2 = 3000/- 4. Metarhizium @ 2.5 kg for one spray @ 200/- = Rs 200 x 2.5 = 500/- 5. Collection and destruction of egg masses @ 5 labour x 350/- = 1750/- ---------- **7400**	7400	1050	8450	43686	52136	36.19	2550	92284	41048	**1.77**
T2**: POP recommendation** 1. Azadirachtin 1500 ppm @ 1 lit for one spray Rs. 820 x 1 spray = 820/- 2. Chlorantraniliprole 18.5 SC @ 200 ml/ha = Rs. 525/- for 75 ml = 1400/- 3. Emamectin benzoate 5SG @ 200 g/ha = Rs.570/- for 250 g = 456/- --------- **2676/-**	2676	1050	3726	43686	47412	31.67	2550	80758	33346	1.70

Fig 31. Large scale demonstration of BIPM module for the management of maize FAW at Dairy Farm of College of Agriculture, Pune

PAU, Ludhiana

The demonstrations on the BIPM module for the management of fall armyworm (FAW) were conducted at farmer's fields on an area of **10 acres** in Hoshiarpur, Jalandhar and Ludhiana districts of Punjab in collaboration with Krishi Vigyan Kendra, Nurmahal (Jalandhar) and Farm Advisory Service Centre (Hoshiarpur).

Treatments

- **T1: BIPM module**

Release of *Trichogramma chilonis* (1,00,000 eggs/ ha) (2 releases, first release after one week of sowing & second one after one week of first release) + two sprays of NBAIR Bt-25 @ 10 ml/L at 10 days interval + 2 sprays of NBAIR *Metarhizium anisopliae* (Ma-35) @ 5g/L at 10 days interval

- **T2: Chemical Control (University POP recommendation)**

One spray each of chlorantraniliprole 18.5 SC @ 0.4 ml / L and spinetoram 11.7 SC @ 0.5 ml/L at appearance of pest

T3 : Untreated control

Each demonstration area was divided into three blocks representing three treatments, *viz*. BIPM, chemical control and untreated control. Each block was further divided into 10 units (each unit representing one replication). The observations were recorded from 50 random selected plants from each unit at weekly interval and per cent damage was worked out on the basis of total and infested plants. The larval count from each unit was also recorded. The yield was recorded at harvest on whole plot basis and expressed as quintals per hectare.

Based on the mean of nine locations (Table 82.), the plant infestation in BIPM module was 15.47 per cent and in chemical control, it was 3.87 per cent. However, both the treatments were significantly better than untreated control (32.39 %). Similarly, larval count BIPM (1.63/ 10 plants) and chemical control (0.41 / 10 plants) were significantly less than in untreated control (3.33 / 10 plants). Grain yield in BIPM and chemical control was 35.28 and 43.56 quintals per hectare, respectively. However, lowest grain yield was recorded in untreated control (28.38 q/ha).

Table 82. Large scale demonstrations of BIPM module for FAW in maize during 2022

Treatments	Plant infestation* (%)	% reduction over control	Number of larvae/ 10 plants**	% reduction over control	Yield (q/ha)
BIPM module	15.47 (23.02)	52.24	1.63 (1.61)	51.05	35.28
Chemical control	3.87 (11.29)	88.05	0.41 (1.19)	87.69	43.56
Untreated control	32.39 (34.60)	-	3.33 (2.07)	-	28.38
LSD (p=0.05)	(2.04)	-	(0.12)	-	2.33
CV (%)	8.90	-	7.51	-	6.52

Pooled mean of 9 locations; * Figures in parentheses are arc sine transformed values;
** Figures in parentheses are square root transformed values

Fig 32. BIPM trials

AAU, Anand

Results: (Table No. 83 & 84)

Large scale demonstration of BIPM module for the management of maize FAW was carried out in Panchmahal district during *kharif* 2022-23 and results revealed that no significant difference between BIPM module and POP recommendation in terms of number of damaged plants per plot Highest number of dead larvae (due to bacteria/virus/fungus) was recorded in BIPM module (13.64/plot) as compared to POP recommendation (2.89/plot). Highest population of coccinellids (1.04/plant) was documented in BIPM module as compared to POP recommendation (0.69/plant). Similarly spiders population was highest (2.96/plant) in BIPM module as compared to POP recommendation (1.49/plant).

Highest grain and fodder yield of 39.80 and 55.30 q/ha was recorded in the treatment POP recommendation as compared to BIPM module 34.60 and 48.50 q/ha.

Table 83. Effect of different modules on insect pests and natural enemies in maize 2022-23

Treatments	No. of damaged plants/plot		No. of dead larvae (due to bacteria/virus/ fungus) /plot	No. of coccinellids per plant		No. of spider per plant	
	BS	Pooled over period and spray	Pooled over period and spray	BS	Pooled over period and spray	BS	Pooled over period and spray
T_1-BIPM module	3.85 (14.32)	2.72 (6.90)	3.76 (13.64)	1.33 (1.27)	1.24 (1.04)	1.97 (3.38)	1.86 (2.96)

T_2 - POP recommendation (Spraying Azadirachtin 1500 ppm @ 2 ml/L at 15 days after sowing + Chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing + Emamectin benzoate 5SG@ 0.4gm/L at 35 days after sowing	3.99 (15.42)	2.60 (6.26)	1.84 (2.89)	1.37 (1.38)	1.09 (0.69)	1.75 (2.56)	1.41 (1.49)
S. Em.± (T)	0.15	0.10	0.08	0.06	0.08	0.09	0.09
C.D. at 5% T	NS	NS	0.30	NS	NS	NS	0.34
C. V. (%)	12.15	11.68	13.88	13.20	16.80	15.74	13.44

Note: Figures are √x + 0.5 transformed values whereas those in parentheses are retransformed values; **NS**: Non-significant; **BS:** Before spray

Table 84. Effect of different modules on yield in maize 2022-23

Treatments	Grain Yield (q/ha)	Fodder Yield (q/ha)
T_1-BIPM module	34.60b	48.50b
T_2-POP recommendation (Spraying Azadirachtin 1500 ppm @ 2 ml/L at 15 days after sowing + Chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing + Emamectin benzoate 5SG@ 0.4gm/L at 35 days after sowing	39.80a	55.30a
S. Em ±(T)	1.74	1.66
C.D. at 5 % T	5.16	4.94
C. V. (%)	14.75	10.12

TNAU:

BIPM module for the management of maize fall armyworm was demonstrated in farmers field in Kongalnagaram with the following treatments.

T1: BIPM module

- Installation of pheromone trap @ 10 traps/acre
- Release of *Trichogramma chilonis* (1,00,000 eggs/ ha) (2 releases, first release after one week of sowing & second one after one week of first release)
- NBAIR Bt-25 @ 10ml/L (Spraying on 15 days after sowing)
- ICAR-NBAIR *Metarhizium anisopliae* (Ma-35) @ 5g/L (Spraying on 25 days after sowing)
- Collection and destruction of egg masses of fall armyworm at regular interval

T2: Spraying Azadirachtin 1500 ppm @ 2 ml/L at 15 days after sowing + Chlorantraniliprole18.5 SC@ 0.4 ml/L at 25 days after sowing

Data on damaged plants, dead larvae, egg parasitisation, predators and yield were recorded. In BIPM module and insecticide treated plots fall armyworm damage was 11.36 and 10.31 per cent respectively on 10 Days after first spraying. Plant with fall armyworm damage in newly emerged leaves was 3.18 per cent in insecticide treated plots which is significantly lower than the damage in BIPM mdule (8.48%) on 10 days after second spraying. Numbers of dead larvae ranged between 0.244 and 0.480 per plant on 10 days after first spraying (Table 85). Parasitisation by *Telenomus* sp was significantly higher in BIPM module (14.83%) than in insecticide treated plots (4.44%). Though there was 3.31 per cent reduction in yield in BIPM module when compared to insecticide treated plot, the CB ratio was high (1.58) in BIPM module (Table 86).

Table 85. Efficacy of BIPM module on maize fall armyworm

Treatments	Damaged Plants* (%)			Dead Larvae** (Nos./Plant)		
	Pre treatment	10DAFS (Newly emerged leaves)	10DASS (Newly emerged leaves)	Pre treatment	10DAFS	10DASS
T1-BIPM Module	35.482 (36.558)	11.355 (19.692)^{b}	8.475 (16.923)^{b}	0.310 (0.558)	0.481 (0.694)^{a}	0.480 (0.693)^{a}
T2 – POP recommendation	35.324 (36.465)	10.313 (18.731)^{a}	3.183 (10.276)^{a}	0.320 (0.564)	0.213 (0.462)^{b}	0.244 (0.469)^{b}
SED	NS	0.092	0.105	NS	0.003	0.002
Cd (P=0.05)		0.194	0.220		0.007	0.005

DAFS- Days After First Spraying; DASS- Days After Second Spraying;
* Figures in parentheses are arcsine transformed values;** Figures in parentheses are square root transformed values;
In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD

Table 86. Effect of BIPM module on natural enemies of maize fall armyworm and yield of maize

Treatments	Parasitisation** (%)			Predators/plant* (Nos.)			Yield (kgs / acre)	% decrease in yield	CB ratio
	Pre treatment	10DAFS	10DASS	Pre treatment	10DAFS	10DASS			
T1-BIPM Module	10.358 (18.768)	14.831 (22.649)^{a}	14.561 (22.431)^{a}	0.345 (0.587)	0.422 (0.650)	0.420 (0.648)^{a}	2450.33 (49.49)^{b}	3.31	1.58
T2 – POP recommendation	10.145 (18.572)	4.438 (12.052)^{b}	10.474 (18.868)^{b}	0.407 (0.638)	0.380 (0.62)^{b}	0.38 (0.62)^{b}	2534.20 (50.34)^{a}		1.55
SED	NS	0.632	0.331	NS	NS	0.003	0.221		
Cd (P=0.05)		1.327	0.695			0.006	0.466		

DAFS- Days After First Spraying; DASS- Days After Second Spraying;
* Figures in parentheses are arcsine transformed values;** Figures in parentheses are square root transformed values;
In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD

CAU Pasighat:

Season: *Rabi*, 2022-23

Location: Farmer fields at Jampani and Jorkong villages, East Siang district

Area: 05 ha

Treatments: 02

Design: Large sampling CRD

Variety: NSP Maize Hybrid

Treatments:

T_1 = BIPM Package

- Installation of pheromone trap @ 10 traps/acre
- Release of *Trichogramma chilonis* (1,00,000 eggs/ ha) (2 releases, first release after one week of sowing & second one after one week of first release)
- NBAIR Bt-25 @ 10ml/L (1-2 sprays depending on pest incidence, first spray after 20 days after sowing to target early instars of FAW larvae)
- ICAR-NBAIR *Metarhizium anisopliae* (Ma-35) @ 5g/L (1-2 sprays depending on pest incidence), first spray 10 days after first spray of Bt-25 to target late instars of FAW larvae
- Collection and destruction of egg masses of fall armyworm at regular interval

T_2 = **POP recommendation (**Spraying Azadirachtin 1500 ppm @ 2 ml/L at 15 days after sowing + Chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing + Emamectin benzoate 5SG@ 0.4gm/L at 35 days after sowing**)**

Table 87. Efficacy of different modules on pest incidence, percent defoliation and yield of Maize

Modules	No. of FAW larva/plant		No. of dead FAW larva/ plant	Defoliation (%) Post-T	No. of Predators/plant		Yield (q/ ha)
	Pre-T	Post-T	Post-T		Pre-T	Post-T	
BIPM Module	1.74	0.61	0.28	8.58	0.61	0.73	35.60
Farmers practice	1.80	0.73	0.23	9.10	0.65	0.35	33.80
't' value	0.25	0.55	0.42	0.34	0.33	2.70	1.39
Remarks	NS	NS	NS	NS	NS	S	NS

S: Significant, NS: Non significant, Pre-T: Pre treatment mean, Post-T: Post treatment mean

Results:

The data pertaining to the field efficacy of two different modules against FAW incidence, percent defoliation and yield of Maize is presented in the Table No. 87. There was no significant differences observed between BIPM and POP (Chemical control) modules except for the predators which are significantly higher in BIPM module (0.73/plant). However, the BIPM module recorded comparatively lower incidence of fall armyworm (0.61 larvae/plant), defoliation (8.58 % leaf damage). Whereas, yield recorded in BIPM (36.60 q/ha) was statistically on par with the POP module (33.80 q/ha). However, C:B ratio was higher in BIPM module 1.90 as compare to 1.45 in POP module.

Dead FAW larva due to EPF

Parasitic wasp in Maize

Predatory Coccinellid in Maize

Predatory Earwig in Maize

Dead FAW larva due to EPV

FAW incidence in Maize leaves

FLD plot at Farmer'd field

FAW incidence in Maize Cob

Fig 33. BIPM trial on Maize

SKUAST - Jammu

Plot size:- Large plot Size (2.0 ha)

Treatment details –

1. **Treatment 1** – BIPM module
   - Installing pheromone traps @ 10/acre
   - Release of *Trichogramma chilonis* (1,00,000 adults/ha) (2 releases, first release after one week of sowing & second one after one week of first release)

- NBAIR Bt-25 @ 10 ml/L (1-2 sprays depending on pest incidence, first spray after 20 days after sowing to target early instars of FAW larvae).
- ICAR-NBAIR *Metarhizium anisopliae* (Ma-35) @ 5g/L (1-2 sprays depending on pest incidence), first spray 10 days after first spray of Bt-25 to target late instars of FAW larvae
- Collection and destruction of egg masses of fall armyworm at regular interval

2. **Treatment 2** – POP recommendation (Spraying Azadirachtin 1500 ppm @ 2ml/L at 15 days after sowing + Chlorantraniliprole 18.5 @ 0.4 ml/L at 25 days after sowing + Emamectin benzoate 5SG @ 0.4 gm/L at 35 days after sowing
3. **Treatment 3** – Untreated Control

Table 88. Effect of BIPM module on natural enemies of maize fall armyworm and yield of maize

	Per cent plant damaged	No. of dead larvae per m^2	No. of predators (Spiders) per m^2	Grain Yield (q/ha)
T 1 - BIPM module	12.30	23.37	2.35	42.50
T 2 - POP recommendation (Spraying Azadirachtin 1500 ppm @ 2ml/L at 15 days after sowing + Chlorantraniliprole 18.5 @ 0.4 ml/L at 25 days after sowing + Emamectin benzoate 5SG @ 0.4 gm/L at 35 days after sowing	19.84	18.59	0.21	29.17
T3 - Untreated Control	78.67	1.56	2.40	12.00
CD @ 5%	8.61	2.35	0.56	6.87

Large plot trial (2.0 ha) on the effectiveness of BIPM module developed by NBAIR **(Treatment 1)** including installation of pheromone traps @ 10/acre, 2 releases of *Trichogramma chilonis* @ 1,00,000 adults/ha at weekly interval when 1-2 adult moths are caught in pheromone trap, spray of azadirachtin 1500 ppm @ 5ml/l water to kill eggs and neonates, one Spray of NBAIR Bt-25 @ 10 ml/litre one week of the neem spray and one spray of *Metarhizium anisopliae* (NBAIR Ma-35) (1×10^8 cfu/g) @ 5gm/litre **POP recommendation Treatment 2** - (Spraying Azadirachtin 1500 ppm @ 2ml/L at 15 days after sowing + Chlorantraniliprole 18.5 @ 0.4 ml/L at 25 days after sowing + Emamectin benzoate 5SG @ 0.4 gm/L at 35 days after sowing) and untreated control **(Treatment 3)** - was conducted at the farmer's field. Number of *S. frugiperda* dead larvae / m^2 area was significantly highest in BIPM package (23.37 *S. frugiperda* dead larvae per m^2) followed by Treatment 2 (18.59 dead larvae per m^2). Plant damage (%) was accordingly lowest in BIPM package (12.30% plant damage) followed by Treatment 2 (19.84% plant damage). Grain yield was accordingly highest in BIPM package (42.50 q/ha).

Fig 34. Installing pheromone traps

Fig 35. *Spodoptera frugiperda* and *Chilo partellus* infestation, Installation of pheromone traps in farmer's field

Fig 36. Clipping of tricho cards and training on its use and benefits at different farmer's field

Fig 37. Distributing *Metarhizium anisopliae*, *B.t.* and Neem Product and training on its use and benefits to the beneficiary farmers

IV. 2.4. Demonstration of BIPM module against fall armyworm, *Spodoptera furgiperda*

AAU, Jorhat

Target pests: *Spodoptera furgiperda*

Location: Diphu, Dist. Karbi Anglong

Variety: Kishan

Plot size: 400m^2

Date of sowing: 23.10.2022

Treatments:

T1:BIPM module

- Installation of pheromone trap @ 10 traps/acre
- Release of *Trichogramma chilonis* (1,00,000 eggs/ ha) (2 releases, first release after one week of sowing & second one after one week of first release)
- NBAIR Bt-25 @ 10ml/L (1-2 sprays depending on pest incidence, first spray after 20 days after sowing to target early instars of FAW larvae)
- ICAR-NBAIR *Metarhizium anisopliae* (Ma-35) @ 5g/L (1- 2 sprays depending on pest incidence), first spray 10 days after first spray of Bt-25 to target late instars of FAW larvae
- Collection and destruction of egg masses of fall armyworm at regular intervals
- Spraying Azadirachtin 1500 ppm @ 2 ml/L at 15 days after germination

T2: POP recommendation (Chlorantraniliprole 18.5 SC@ 0.4 ml/L at 25 days after sowing + Emamectin benzoate 5SG@ 0.4gm/L at 35 days after sowing)

Results: .

Number of larvae per plant and percent plant damage was more in BIPM plots, whereas the number of predators per plant and percent egg parasitism was significantly higher in BIPM plots. No no significant difference in yield and cob damage. (Table 89)

Table 89. Evaluation of BIPM module in comparison with farmers practice against the incidence of FAW on Maize

Treatment	No. of larvae/plant		% plant damage				Percent egg parasitism (%)	Number of predators per plant	Yield (Q/ha)
	Pre treatment	Post treatment	pretreatment		Postreatment				
			Leaf	Cob	Leaf	Cob			
BIPM plot	4.57	2.14	5.27 (13.20)	3.85 (11.26)	3.64 (10.94)	2.21 (7.91)	5.57 (13.22)	3.71	30.71
Chemical	4.00	1.5	5.40 (13.40)	3.96 (11.43)	2.20 (8.72)	1.61 (5.16)	1.42 (4.61)	1.28	31.72
"t" value	0.824	1.77	0.304	0.265	3.09	0.134	3.40	3.83	0.407
Remarks	NS	S	NS	NS	S	NS	S	S	NS

Fig 38. View of maize field

PJTSAU, Hyderabad

Treatments:

T1: BIPM module

- Installation of pheromone trap @ 10 traps/acre
- Release of *Trichogramma chilonis* (1,00,000 eggs/ ha) (2 releases, first release after one week of sowing & second one after one week of first release)
- NBAIR Bt-25 @ 2ml/L (1-2 sprays depending on pest incidence, first spray after 20 days after sowing to target early instars of FAW larvae)
- ICAR-NBAIR *Metarhizium anisopliae* (Ma-35) @ 5g/L (1-2 sprays depending on pest incidence), first spray 10 days after first spray of Bt-25 to target late instars of FAW larvae

T2: Farmer's practice (chemical control)

Design :Block

Plot Size/treatment : 0.50 acre

Variety : Local

Season :*Yasangi* 2022-23

Separate blocks will be used for each treatment giving sufficient isolation distance between the treatment blocks

PJTSAU:

Results: One day before treatment imposition the number of egg patches ranged from 3.72 to 3.84 per plant. The BIPM module recorded 11.25%, 31.50% and 30.52% plant damage, parastisation and mycosis per cent with 61.56 q/ha grain yield while the farmers practices recorded 4.86, 3.12 and nil per cent of plant damage, parastisation and mycosis with highest grain yield of 66.42 q/ha (Table 90).

Table 90. Large scale demonstration of BIPM module for the management of maize FAW during 2022-23

Sl. No.	Treatment Details	Egg patches per plant (No.)*		Larvae per plant (No.) *		Dam-aged plant (%)#	Para-sitisa-tion (%)#	My-cosis (%)#	Grain yield (q/ha)
		IDBS	10 DAS	IDBS	10 DAS				
1.	T_1 - BIPM • Installation of pheromone trap @ 10 acre • Release of *Trichogramma chilonis* (1,00,000 eggs /ha) (2 releases, first release after one week of sowing & second one after one week of first release •ICAR- NBAIR *Metarhizium anisopliae* (NBAIR Ma35) @ 5 g/L (2 sprays, at 25, 35 days after sowing)	3.84 (2.08)	0.38 (0.94)	1.84 (1.53)	0.36 (0.93)	11.25 (19.60)	31.50 (34.14)	30.52 (33.52)	61.56
2.	T2 - POP Recommendation Insecticidal check • Azadirachtin 1500 ppm @2 ml/lt at 15 days after sowing • Chlorantraniliprole 18.5 SC @ 0.4 ml/L at 25 days after sowing • Emamectin benzoate 5 SG @ 0.4 g /L at 35 days after sowing	3.72 (2.05)	3.78 (2.07)	1.72 (1.49)	0.16 (0.81)	4.86 (12.74)	3.12 (10.17)	0.00 (0.00)	66.42
S Em ±		**0.09**	**0.04**	**0.13**	**0.09**	**0.04**	**0.28**	**0.33**	**0.54**
CD (P=0.05)		**NS**	**0.12**	**NS**	**0.27**	**0.13**	**0.85**	**1.01**	**1.63**

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

Results revealed that BIPM package recorded almost similar pest incidence (45.74% damaged plants/plot) as in the Farmer's practices (46.56%), yield of 21.78q/acre and benefit: Cost ratio of 3.23 while the Farmers practice recorded yield of 22.16q/acre and 3.26 ratio (Table 91.).

Table.91. Evaluation of BIPM package for the management of Fall armyworm in Maize Selling price of maize : Rs.1962/q

Treat-ments	% damaged plants/ plot	No.of dead lar-vae/plot	No.of preda-tors/plot	Egg para-sitisation (%)	Larval parasi-tisation (%)	Yield (q/ acre)	Csts (Rs.)	B: C Ratio
BIPM package	45.74	7.37	51.12	7.50	2.89	21.78	10,100	3.23
Farmer's practices	46.56	0.00	43.55	4.78	1.34	22.16	10,200	3.26

Fig 39. Damage by the fall armyworm on maize

IV. 2.5. Large scale demonstration of Maize Stem Borer, *Chilo partellus* using *Trichogramma chilonis.*
MPUAT

Variety: Location specific recommended variety

Treatments: 3

Treatment details:

T1: Three releases of *Trichogramma chilonis* @ 1,00,000/ha/release at 15, 22 and 29 days after crop germination

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

T3: Untreated control

Table 92. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2022-23.

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	12.89	48.78	30.49	39.41
2.	Spinosad 45 SC @ 1.0ml/ 3 lit (farmers practice)	10.47	58.40	32.10	46.77
3.	Untreated control	25.17	-	21.87	-

Results

The dead heart incidence in fields with the releases of *T. chilonis* was 12.89 per cent and in chemical control, it was 10.47 per cent. The reduction in incidence over control was 48.78 and 58.40 per cent in T_1 and T_2, respectively. The yield in *T. chilonis* (T_1) (30.49q/ha) and Spinosad 45 SC (T_2) (32.10 q/ha) fields were significantly more than in untreated control (21.87 q/ha).

IV. 3. Biological Control of Sorghum Pests

IIMR (Millet), Hyderabad

IV. 3.1. Management of FAW in Sorghum using biocontrol agents (ICAR-IIMR-Hyderabad) – Rabi 2022

Trial 1:

Location: Off season Nursery, Warangal

Plot size: 0.5 acre/ treatment

Variety: CSV 29 R (Popular Rabi variety)

Treatments: 2

Replications: 15

DOS: 6.11.2022

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 ie 10 days post 2nd spray. The yield data was recorded at harvest.

There was numerical reduction in egg patches/ 10 plants, no. of larvae/ 10 plants and whorl damage to the extent of 6.5 %, 5.46 % and 8.15 %, respectively in plots which received the bio-control module treatment (T1). Statistically there was no difference between the treatments T1 and T2.

Though statistically there was no differences between treatments for grain and fodder yields, there was yield penalty in bio-control module (T1) to the tune of 3.1 and 4.2 % in the grain and fodder yieldsin comparison to the Standard practice (T2) (Table 93).

Thus biocontrol module is effective , safe to the environment.

Table. 93. Efficacy of bio-control module for management of Fall armyworm in Sorghum (Rabi, 2022-23)

Treatment	Egg patches /10Plants (30 DAE)	Larvae/10Plants (45 DAE)	Whorl damage % (45 DAE)	Grain Yield (t/ha.)	Fodder yield(t/ha)
Release of *Trichogramma chilonis* 1 card/acre twice (first release one week of planting & second one after one week of first release + spray of *Metarhizium anisopliae (*Ma 35) 0.5 % at 20, 35 DAE	1.31^{a}	1.35^{a}	15.39^{a}	3.42^{a}	6.64^{a}
Standard Plant protection practice (Need based application of Chlorantraniprole (18.5%SL) @ 0.3 ml/L (20 DAE of this experiment)	1.23^{a}	1.28^{a}	14.23^{a}	3.53^{a}	6.93^{a}

*Means followed by same letter are significantly not different (*P*= 0.05) by LSD*

DAE: Days after crop emergence

Trial 2:

Location: Center for Rabi Sorghum, Solapur

Plot size: 0.5 acre/ treatment

Variety: CSV 29 R (Popular Rabi variety)

Treatments: 2

Replications: 15

DOS: 15.10.2022

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

There was numerical reduction in egg patches/ 10 plants, no. of larvae/ 10 plants and whorl damage to the extent of 27.0 %, 10.4 % and 13.7 %, respectively, in plots which received the bio-control module treatment (T1). Statistically there was no difference between the treatments T1 and T2.

There was yield penalty in bio-control module (T1) to the tune of 3.3 and 4.7 % in the grain and fodder yields in comparison to the Standard practice (T2) (Table 94) though statistically there was no differences between treatments for grain and fodder yields, Thus, biocontrol module is effective , safe to the environment.

Table. 94. Efficacy of bio-control module for management of Fall armyworm in Sorghum (Rabi, 2022-23)

Treatment	Egg patches /10Plants (30 DAE)	Larvae/10Plants (45 DAE)	Whorl damage % (45 DAE)	Grain Yield (t/ha.)	Fodder yield(t/ha)
Release of *Trichogramma chilonis* 1 card/acre twice (first release one week of planting & second one after one week of first release + spray of *Metarhizium anisopliae (*Ma 35) 0.5 % at 20, 35 DAE	1.08[a]	0.85 a	9.62 a	2.65 a	5.62 a
Standard Plant protection practice (Need based application of Chlorantraniprole (18.5%SL) @ 0.3 ml/L (20 DAE of this experiment)	0.85[a]	0.77 a	8.46 a	2.74 a	5.90 a

Means followed by same letter are significantly not different (p= 0.05) by LSD

DAE: Days after crop emergence

Conclusion:

Release of *Trichogramma chilonis* @ one card/acre twice at weekly intervals commencing from 7 DAE, 14DAE followed by spray of *Metarhizium anisopliae* (Ma 35) @ 0.5 % at 20, 35 DAE was found to decrease the number of egg patches, larvae numbers and whorl damage caused by *Spodoptera frugiperda*, and was statistically on par with use of Chlorantraniprole 18.5 % SL at 20 DAE and thereafter need based.

IV. 3.2. Demonstration of BIPM module for the management of FAW on Sorghum and Millets during 2022-23

UAS, Raichur

Observations: In each treatment five plants were randomly selected to record the number of egg patches, larvae per plant and per cent plant damage and the per cent egg parastization and per cent mycosis was worked out by taking the account of number of eggs parasitized in each egg patches and cadavers in each treatment. Final grain yield (q/ha) was recorded in each treatment.

Results: One day before treatment imposition the number of egg patches ranged from 1.04 to 1.14 per plant. Ten days after treatment imposition the BIPM module recorded 0.18 egg patches per plant, 0.28 larvae per plant with 6.50 per cent plant damage while untreated control recorded 1.28 egg patches per plant, 1.18 larvae per plant with 9.50 per cent plant damage, respectively. The BIPM module recorded 10.54 q/ha grain yield while untreated control recorded 9.88 q/ha grain yield (Table 95).

Table 95. Large scale demonstration of BIPM module for the management of sorghum FAW during 2022-23

Sl. No.	Treatment Details	Egg patches per plant (No.)*		Larvae per plant (No.) *		Damaged plant (%)#	Parasitisation (%)#	Grain yield (q/ha)
		IDBS	10 DAS	IDBS	10 DAS			
T_1	Biointensive module: Release of *Trichogramma chilonis* 1 lakh/ha (2 releases, first release one week of planting & second one after one week of release + spray of *Metarhizium anisopliae* NBAIR Ma 35 @ 5 ml/litre at 20, 45 DAE	1.04 (1.24)	0.18 (0.82)	1.14 (1.28)	0.28 (0.88)	6.50 (14.75)	11.50 (19.82)	10.54

T_2	POP recommendation (Seed treatment with Fortanza duo @ 6 ml/kg of seed)	1.12 (1.27)	0.06 (0.75)	1.12 (1.25)	0.08 (0.76)	1.06 (5.91)	2.50 (9.10)	11.68
T_3	Untreated control	1.14 (1.28)	1.28 (1.31)	1.16 (1.29)	1.18 (1.31)	9.50 (18.25)	0.00 (0.00)	9.88
S Em ±		**0.04**	**0.03**	**0.18**	**0.04**	**0.05**	**0.41**	**0.85**
CD (P=0.05)		**NS**	**0.12**	**NS**	**0.13**	**0.15**	**1.25**	**2.59**

PULSES

IV. 4. Biological Control of Chickpea Pests

IV. 4.1. Biological suppression of chickpea pod borer *Helicoverpa armigera* and soil borne diseases of chickpea (*Fusarium* wilt, Dry root rot and Collar rot)

AAU, Jorhat

Target pests: *Helicoverpa armigera*

Location: ICR farm, AAU, Jorhat

Season: *Rabi,* 2023

Date of Sowing: 24.11.2022

Variety: GNG 2207

Plot size: 40m^2

Experiment design: RBD

Treatment: 4

Replication:5

Results:

The initial population of *Helicoverpa armigera* was varied from 4.6-6.6 larvae/m row length. After 15 days of treatment, population of *H. armigera* was significantly lower in all the treatments. In chemical treatment plots, no larvae were observed at 10 ten days after application. Incidence of fusarium wilt was varied from 0.026-0.046% and wilt symptom was observed after 60 days. The percent pod damage was significantly higher in control (45.75%) followed by pheromone traps @25 per ha (26.55%), seed treatment with @10g/Kg and soil application twice @5kg/ha of *Trichoderma harzianum* NBAIR strain at 25 & 50 days after sowing + Spraying of *Bacillus thuringiensis* NIBSM Bt 18 1% @10ml/L two sprays at pod initiation and pod formation stage at 15 days interval (23.18%) and lowest was observed in chemical treatment (9.27%) where as the number of coccinellids/5 plants were significantly higher (4/5 plants) in treatment T1 and lowest in T3. All the treatments showed significantly higher yield than control (838.2kg/ha). The maximum yield was recorded in chemical control(1203.2 kg/ha) followed by seed treatment with @10g/Kg and soil application twice @5kg/ha of *T. harzianum* NBAIR strain at 25 & 50 days after sowing + spraying of *B. thuringiensis* NIBSM Bt 18 1% @10ml/L two sprays at pod initiation and pod formation stage at 15 days interval (1055.2kg/ha) and pheromone traps treatment (984.6 kg/ha) with yield increase 30.31%, 20.56% and 14.86% , respectively over control (Table 96)

Table 96. Efficacy of different treatments against chick pea pod borer *Helicoverpa armigera* and soil borne diseases of chickpea

Treatments	Pre treat count	Number of larvae/ m row length (DAT)				Disease incidence (%)			% damage pod	No. of cocci-nellids/5 plants	Yield (kg/ha)	Yield increase over con-trol %)
		3	7	10	15	30	60	90				
T1 - Seed treatment with @10g/Kg and soil application twice @5kg/ha of *Trichoderma harzianum* NBAIR strain at 25 & 50 days after sowing + Spraying of *Bacillus thuringiensis* NIBSM Bt 18 1% @10ml/L two sprays at pod initiation and pod formation stage at 15 days interval	5.8	4.4	3.2	1.8	0.8	0.046 (1.84)	0	0	23.18 (28.74)	4.00	1055.2	20.56
T2 - Pheromones traps @ 25/ ha (NBAIR Product)	6.2	4.8	3.6	2.0	1.2	0.026 (0.84)	0	0	26.55 (30.97)	3.40	984.6	14.86
T3 - POP recommendation (Application of chlorantraniliprole 18.5 SC@ 0.3 ml/L	4.6	2.4	0.6	0	0	0.030 (1.08)	0	0	9.27 (17.56)	0,60	1203.2	30.31
T4 - Untreated control	6.6	6.8	7.2	7.8	4.6	0.040 (1.76)	0	0	45.75 (42.54)	3.80	838.2	-
CD (0.05)	**NS**	**2.95**	**2.00**	**1.78**	**1.93**	**NS**			**3.17**	**3.43**	**123.82**	

SKUAST - Jammu

Number of treatments: 4; Number of replications: 5 and Design: RBD

Observations:

- Number of larvae / m row length before spray and 3, 7, 10 and 15 days after spray
- Disease incidence at 30, 60, 90 days after sowing
- Total and damaged pods at harvest
- Record natural enemies from 5 plants in each plot

Pod yield will be recorded on whole plot basis

Results:

Seed treatment with @ 10 g/Kg and soil application twice @ 5 kg/ha of *Trichoderma harzianum* NBAIR strain at 25 & 50 days after sowing + spraying of *Bacillus thuringiensis* NIBSM Bt 181% @ 10 ml/L two sprays at pod initiation and pod formation stage at 15 days interval (Treatment 1) recorded lowest number of *Helicoverpa* larvae and consequent pod damage (8.78%), while in untreated plots it was 29.56% (Table 97). Grain yield was also significantly highest in Treatment 1 (7.34 q/ha), followed by treatment 2 - pheromone traps @ 25 / ha (6.71 q/ha) and treatment 3 - POP recommendation (6.88 q/ha). Wilt incidence was the lowest in T1 (10.55% after 90 days of sowing (Table 98).

Table 97. Number of larvae per meter row length and per cent pod damage by chickpea pod borer

Treatments	Number of larvae / m row length				Pod damage (%)
	3 DAS	7 DAS	10 DAS	15 DAS	
T_1 - Seed treatment with @ 10 g/Kg and soil application twice @ 5 kg/ha of *Trichoderma harzianum* NBAIR strain at 25 & 50 days after sowing + Spraying of *Bacillus thuringiensis* NIBSM Bt 181% @ 10 ml/L two sprays at pod initiation and pod formation stage at 15 days interval	2.28	1.68	1.36	1.86	8.78 (17.24)
T_2 - Pheromone traps @ 25 / ha (NBAIR Product)	2.00	1.82	1.62	1.82	13.23 (21.33)
T_3 - POP recommendation (Novaluron 10 EC @ 2 ml/L - Profenophos 50 EC @ 2 ml/L and Carbendazim + Mancozeb soil drenching @ 25 & 50 days after sowing	2.32	1.88	1.68	2.28	14.89 (22.69)
T_4 Untreated Control	4.28	4.80	5.32	5.22	29.56 (32.94)
C.D. at 5%	**0.752**	**0.620**	**0.710**	**0.561**	**(1.932)**

DAS – Days after Spray

Table 98. Per cent disease incidence and chickpea grain yield as affected by the application of various treatments

Treatments	Per cent disease incidence			Grain Yield (q/ha)
	30 DAS	60 DAS	90 DAS	
T_1 - Seed treatment with @ 10 g/Kg and soil application twice @ 5 kg/ha of *Trichoderma harzianum* NBAIR strain at 25 & 50 days after sowing + Spraying of *Bacillus thuringiensis* NIBSM Bt 181% @ 10 ml/L two sprays at pod initiation and pod formation stage at 15 days interval	2.33 (8.78)	8.67 (17.12)	10.55 (18.95)	7.34
T_2 - Pheromone traps @ 25 / ha (NBAIR Product)	6.23 (14.45)	24.12 (29.41)	28.67 (32.37)	6.71
T_3 - POP recommendation (Novaluron 10 EC @ 2 ml/L - Profenophos 50 EC @ 2 ml/L and Carbendazim + Mancozeb soil drenching @ 25 & 50 days after sowing	5.51 (13.58)	10.98 (19.35)	12.76 (20.93)	6.88
T_4 Untreated Control	6.16 (14.37)	25.34 (30.22)	30.23 (33.35)	4.63
C.D. at 5%	**(1.193)**	**(1.250)**	**(1.143)**	**0.452**

DAS- Days after Sowing

UAS, Raichur

IV. 4.2. Large scale demonstration of entomopathogenic fungi, *Metarhizium rileyi* against chick pea pod borer, *Helicoverpa armigera*

Observations: Number of larvae per plant, pod damage (%) and grain yield (q/ha).

Results: Ten days after spray, *Metarhizium rileyi* KK-Nr-1 recorded 1.75 larvae/ plant with 9.75% pod damage while FP it was 1.15 larvae/ plant with 3.50% pod damage. *M. rileyi* KK-Nr-1 recorded 15.18 q/ha grain yield while FP recorded 17.36 q/ha grain yield (Table 99).

Table 99. Large scale demonstration of entomopathogenic fungi, *Metarhizium rileyi* against chick pea pod borer, *Helicoverpa armigera*

Sl. No.	Particulars	Pod borer, *H armigera* No. of larvae per plant*			Pod damage (%) #	Grain Yield (q/ha)
		1 DBS	7 DAS	10 DAS		
1.	T_1-*Metarhizium rileyi* KK-Nr-1 (1×10^8 spores/g) @ 5 g/L	4.85 (2.31)	2.15 (1.63)	1.75 (1.50)	9.75 (18.19)	15.18
2.	T_2 - Emamectin benzoate 5 SG @ 0.2 gm/L	4.51 (2.24)	1.50 (1.41)	1.15 (1.28)	3.50 (10.78)	17.36
S Em ±		**0.05**	**0.03**	**0.05**	**0.44**	**0.35**
CD (P=0.05)		**NS**	**0.12**	**0.15**	**1.33**	**1.06**

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

MPUAT

IV. 4.3. Biological suppression of pod borer, *Helicoverpa armigera* infesting chickpea

Design: Randomized Block Design; **Replications:** 5; **Treatments:** 5

Treatment details:

T1: ***Beauveria bassiana* NBAIR Bb5a @ 1×10^8 spore/gm @ 5 gm/L**

T2: *Bacillus thuriengiensis* NBAII *Bt*G4 2% @ 2 ml/lit

T3: Spray of *Ha*NPV NBAIR1 (1.5×10^{12} OBs/ha)

T4: Quinalphos 25EC @250g a.i/ha

T5: Untreated control

Observations:

1. Number of larvae/m. row length before spray and 3, 7, 10 and 15 days after spray.
2. Total and damaged pods at harvest.
3. Record natural enemies from 5 plants in each plot.
4. Pod yield was recorded on whole plot basis.

Results:

Each block was divided into five plots to record the incidence of pod borer, per cent pod damage and grain yield and each plot was considered as a replication. Before treatment, the larval population ranged from 3.4-4.5 larvae/ plant which was statistically non-significant. The maximum reduction was recorded in quinalphos 25 EC @ 250g a.i/ha treatment (1.9 larvae/ plant) and the minimum reduction was observed in *B. bassiana* @ 1×10^8 conidia /gm @ 5 gm/l (2.89 larvae/ plant) at ten days after spray; whereas, the untreated control recorded least reduction in larval population (5.25 larvae/ plant) at ten days after spray. Minimum per cent pod damage was recorded in treatment of quinalphos 25 EC @ 250g a.i/ha (9.89%) and maximum was in *B. bassiana* @ 1×10^8 conidia /gm @ 5 gm/l (17.21%). The highest grain yield obtained in quinalphos treatment (15.10 q/ha) which was at par with *Ha*NPV treatments (15.10 t/ha).

Table 100. Effect of different treatments on population of *H. armigera* and pod damage of Chickpea during *Rabi*

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* @ 1x10^8 conidia /gm @ 5 gm/l	3.9	3.7	3.5	2.89	3.2	17.21	9.89
2.	*Bt* @ 1 Kg/ha	3.4	3.1	3.4	2.4	2.4	14.16	11.90
3.	Quinalphos 25 EC @ 250g a.i/ha	3.8	3.0	2.6	1.9	2.0	9.89	16.25
4.	*Ha*NPV (1.5 × 10^{12} POBS/ ha)	3.9	3.7	3.54	2.5	2.8	11.67	15.10
5.	Untreated control	4.5	4.0	4.67	5.25	6.5	23.14	7.89

IV. 5. Biological Control of Cowpea Pests

IV. 5.1. Evaluation of entomopathogens against cowpea sucking pests

KAU, Kumarakom

Treatments: 3; Replications:7; **Plot size**: 40m^2; **Design of experiment**: Randomized Block Design.

Observations: Aphids: Pre-spraying count and post-spraying count of aphids on five randomly selected plants (terminal shoots) of each plot before as well as 3, 7 and 10 days after spray Pod bug: Pre-spraying count and post-spraying count of pod bugs per plot before as well as 3, 7 day and 10 days after spray. Yield (kg)

Results:

The mean observation of 2 sprays on number of pod bugs (Table 101) revealed that there is no significant difference in number of pod bugs among the three treatments at different intervals after first and second spray. Even though the variation in population of pod bug was not significantly different among the treatments, lowest count was noticed in plots treated with *Lecanicillium saksenae*10 days after first spray, 3 and 7 days after second spray. Analysis of data on yield revealed that, there was no significant difference in yield among the treatments.

One week after treatment, a**s**ignificant reduction in population of cowpea aphids was recorded (Table 102), wherein maximum reduction in aphids was observed in Dimethoate 30 EC treated plots (12.07) per plant. The population of aphids in plots treated with *L. saksenae*a and Dimethoate 30 EC were found to be on par but significantly superior over untreated plots on 7th day, 10 th day after first spray and 3rd day after second spray. Analysis of data on yield revealed that, there was no significant difference in yield among the treatments but highest yield was recorded in plot treated with Dimethoate 30 EC (5.20 kg/plot)

Table 101. Evaluation of entomopathogens against cowpea pod bug

Treatment	No. of pod bugs (*Riptortus pedastris*) per plot							Yield (kg/plot)
	Precount	3 DAS1	7 DAS1	10 DAS1	3 DAS2	7 DAS2	10 DAS2	
T1: *Lecanicilliumsaksenae*KAU ITCC7714 (1×10^{8}cfu/ml) @5ml/L	4.00 (1.14)	1.14 (1.04)	2.14 (1.07)	0.00 (1.00)	0.00 (1.00)	0.86 (1.03)	1.00 (1.04)	4.20

T2: Dimethoate 30 EC 2 ml/L (KAU recommendation) two sprays at 15 days interval when the pest reaches ET	1.43 (1.05)	1.14 (1.04)	1.57 (1.05)	0.43 (1.02)	1.43 (1.05)	1.14 (1.04)	0.71 (1.03)	5.20
T3: Untreated control	1.57 (1.06)	1.14 (1.04)	2.00 (1.07)	1.43 (1.05)	1.86 (1.06)	1.43 (1.05)	0.00 (1.00)	4.00
CV	7.67	6.12	6.25	5.05	8.53	7.32	5.20	20.13
CD (0.05%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

DAS – Days after spraying Figures in parentheses are logarithmic transformed values

Table 102. Evaluation of entomopathogens against cowpea aphids, *Aphis craccivora*

Treatment	No. of cowpea aphid (*Aphis craccivora)* per plant							Yield (kg/plot)
	Precount	3 DAS1	7 DAS1	10 DAS1	3 DAS2	7 DAS2	10 DAS2	
T1: *Lecanicillium saksenae*KAU ITCC7714 (1×10^{8}cfu/ml) @5ml/L	42.97 (6.18)	61.34 (7.67)	14.70 (3.71) a	8.98 (2.95)a	1.78 (1.29)a	2.56 (1.54)	2.58 (1.55)	4.20
T2: Dimethoate 30 EC 2 ml/L (KAU recommendation) two sprays at 15 days interval when the pest reaches ET	76.13 (8.19)	83.71 (9.02)	12.07 (3.37) a	9.71 (2.92)a	3.23 (1.69)a	2.55 (1.55)	2.15 (1.34)	5.20
T3: Untreated control	47.03 (6.76)	74.15 (8.55)	26.94 (5.15) b	20.84 (4.49)b	8.36 (2.88)b	5.00 (2.14)	4.16 (1.93)	4.00
CD (0.05%)	NS	NS	0.56	0.36	0.20	NS	NS	NS
CV	32.02	17.23	18.45	17.46	22.90	27.66	34.25	20.13

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

KAU, Vellayani
Results:

In the management of pea aphid, *Apis craccivora*, chitin enriched oil formulation (CEO) of *L. saksenae* @ 10mL/L@10^8 spores mL^{-1}was equally effective as Thiametoxam 25 WDG 2gm/10L14 DAS. Second and third spraying exhibited similar responses wherein, the population in CEO was significantly less compared to chemical treatment (Table 103). In the case of pod bug, *Riptortus pedestris*, the bug population reduced significantly by the second week after treatment of first spray (Table 104), Two weeks after second spray the population supressed in CEO of *L.saksenae* as well as in thiamethoxam. The natural enemy population recorded during the experimental period revealed that in both the treatments the population did not vary, however it was significantly lower than control plots (Table 105). There was 58-76% yield increase in the treated plots, although they did not vary significantly from each other (Table 106).

Table 103. Effect of improved formulations of *Lecanicillium saksenae* in the management of pea aphid *Aphis craccivora* in cowpea

Treatments	No.of aphids / 15 cm twig /plant							
	Pre Count	First spraying		Second spraying			Third spraying	
		Post Count		Pre count	Post count		7 DAS	14 DAS
		7DAS	14 DAS		7 DAS	14 DAS		
T1- CEO of *L. saksenae*@ 10mL/L@10^8 spores mL^{-1}	456.87 (21.07)	303.54 (17.34)	159.13 (12.54)	96.6 (9.40)	59.11 (6.88)	16.48 (3.64)	1.71 (1.22)	0 (0.70)

T2-Thiamethoxam 25 WDG 2gm/10L	367.51 (19.00)	297.15 (17.03)	128.05 (11.03)	104.96 (10.46)	80.45 (8.65)	40.45 (6.02)	6.28 (2.59)	0 (0.70)
T3- Control	349.70 (18.50)	352.81 (18.51)	271.84 (16.25)	189.65 (13.25)	141.14 (11.73)	139.82 (11.70)	60.45 (7.60)	25.82 (4.98)
CV	15.75	14.33	18.50	27.81	37.27	30.622	31.53	35.42
CD (0.05%)	**NS**	**NS**	**(2.86)**	**NS**	**NS**	**(2.54)**	**(1.39)**	**(0.88)**

Table 104. Effect of improved formulations of *L. saksenae* in the management of *Riptortus pedestris* in cowpea

Treatments	Post Count of bugs /plot				
	Pre count	First spraying		Second spraying	
		7DAS	14 DAS	7DAS	14 DAS
T1- CEO of *L. saksenae* @10mL/L@10^8 spores mL^{-1}	6.14 (2.46)	3.42 (1.84)	1.85 (1.35)	0.42 (0.92)	0 (0.70)
T2-Thiamethoxam 25 WDG 2gm/10L	7.85 (2.78)	4.0 (1.99)	2.85 (1.68)	1.42 (1.35)	0 (0.70)
T3- Control	8.85 (2.96)	7.0 (2.63)	5.42 (2.30)	3.28 (1.90)	2.28 (1.64)
CV	13.06	12.41	14.10	22.59	15.83
CD (0.05%)	**NS**	**(0.31)**	**(0.29)**	**(0.36)**	**(0.18)**

Table 105. Natural enemy population in the management of *Riptortus pedestris* in cowpea

Treatments	Post Count /plot				
	Pre count	First spraying		Second spraying	
		7 DAS	14 DAS	7 DAS	14 DAS
T1- CEO *L. saksenae* 10mL/L @10^8 spores mL^{-1}	6.71 (2.48)	9.28 (3.0)	11.42 (3.35)	12.71 (3.55)	14.28 (3.77)
T2-Thiamethoxam 25 WDG 2gm/10L	7.85 (2.77)	9.28 (3.03)	9.85 (3.13)	11.0 (3.31)	13.14 (3.61)
T3- Control	11.85 (3.43)	13.85 (3.72)	14.85 (3.85)	16.28 (4.03)	17.42 (4.17)
CD (0.05%)	**0.67**	**(0.45)**	**(0.33)**	**(0.25)**	**(0.22)**
CV	20.09	11.99	8.23	6.09	5.02

Table 106. Effect of *L. saksenae* and thiamethoxam on yield of cowpea

Treatments	Yield (kg)	% increase
T1- Chitin enriched oil formulation of *L.saksenae*	52.087	76.27
T2-Thiamethoxam 25 WDG 2gm/10L	47.01	58.57
T3- Control	29.57	
CV	24.29	
CD (0.05%)	**12.21**	

MPKV, Pune

The experiment was laid out on the "All India Coordinated Research on Biocontrol Farm", Agril. Entomology Section, College of Agriculture, Pune. The cowpea variety "PhuleVithai" was sown on 02.12.2022 in plot size 5.00 × 4.00 m with 45 × 10 cm spacing in Randomized Block Design with three treatments replicated seven times. The first spray was applied on 20.01.2023 while 2nd spray on 05.02.2023. Pre-spraying count and post-spraying count of aphids on five randomly selected plants (terminal shoots) of each plot was recorded before as well as 3, 7 and 10 days after each treatment and recorded yield (q/ha)

Results:

Data in Table 107 revealed that two sprays of *Lecanicillium saksenae* KAU ITCC 7714 (1×10^8 cfu/ml) at fortnightly interval found superior in suppressing aphid population (av. 36.91 aphids/shoot/plant) with 11.13 q/ha yield of cowpea and maximum B: C ratio (1:1.84). However, two sprays of Imidacloprid 17.8% SL were significantly superior over rest of the treatments and showed 19.55 aphids/shoot/plant and highest yield (13.16 q/ha) with highest B: C ratio (1:2.16). Highest population of aphids was recorded in untreated control (83.73 aphids/shoot/plant) with lowest yield of cowpea (8.56 q/ha).

Table 107. Efficacy of entomopathogen against cowpea aphids after two sparys

Treatment	Dose (gm or ml/lit)	Aphid population/ terminal shoot/plant					Yield (qt/ha)	B:C ratio
		Pre count	Post count after two sprays					
			3 DAS	7 DAS	10 DAS	Mean		
T1:*Lecanicillium saksenae* KAU ITCC 7714 (1×10^8 cfu/ml)	5	74.66 (8.66)*	54.00 (7.38)	38.62 (6.25)	18.10 (4.31)	36.91 (5.98)	11.13	1.84
T2: Imidacloprid 17.8% SL	0.4	72.34 (8.53)	28.56 (5.39)	20.24 (4.55)	11.04 (3.40)	19.55 (4.44)	13.16	2.16
T3: Untreated Control	-	73.11 (8.56)	80.28 (8.99)	84.68 (9.23)	86.24 (9.31)	83.73 (9.17)	8.56	1.51
SEm±		0.29	0.31	0.26	0.19	0.36	0.67	-
CD at 5%		**N.S.**	**0.94**	**0.79**	**057**	**1.08**	**2.01**	

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

SKUAST - Jammu

Number of treatments: 3; Number of replications: 7; Design: RBD

Two sprays at 15 days interval when the pest reaches ET

Observations recorded-

- Pre-spray count and post-spray count of aphids on five randomly selected plants (terminal shoots) of each plot before as well as 3, 7 and 10 days after each treatment
- Pre-spray count and post-spray count of pod bugs on five randomly selected plants (terminal shoots) of each plot before as well as 3, 7 and 10 days after each treatment
- Yield (Kg)

Results:

Lecanicillium saksenae KAU (1×10^8cfu/ml) @ 5 ml/L (Treatment 1) recorded significantly lowest aphid (37.17 aphids per 10 cm terminal shoot) and pod bug (1.93 bugs per 10 cm terminal shoot) incidence, followed by Thiamethoxam 25 WG @ 1g/ L – Treatment 2 (59.14 aphids and 2.24 pod bugs per 10 cm terminal shoot, respectively). Grain yield also was significantly higher in treatment 1 (9.99 q/ha) and treatment 2 (9.046 q/ha) as compared to control (7.051 q/ha) (Table 108 & 109).

Table 108. Pre and Post spray count of cowpea aphid nymphs and adults

Treatments	Pre spray count	Post spray count (mean no. per 10 cm terminal shoot)		
		3 DAS	7 DAS	10 DAS
T1 - *Lecanicillium saksenae* KAU (1 x 10^8cfu/ml) @ 5 ml/L	131.97 (11.53)	91.77 (9.32)	50.00 (7.14)	37.17 (6.18)
T2 - Thiamethoxam 25 WG @ 1g/ L	127.81 (11.35)	51.91 (7.27)	49.37 (7.09)	59.14 (7.75)
T3 - Untreated Control	128.16 (11.36)	131.0 (11.49)	135.14 (11.67)	138.74 (11.82)
CD at 5%	(N.S.)	(1.751)	(0.226)	(0.262)

Figures in parenthesis are square root transformed values

DAS – Days After Spray

Table 109. Pre and Post spray count of cowpea pod bug nymphs and adults

Treatments	Pre spray count	Post spray count (mean no. per 10 cm terminal shoot)			Grain Yield (Q / ha)
		3 DAS	7 DAS	10 DAS	
T1 - *Lecanicillium saksenae* KAU (1 x 10^8cfu/ml) @ 5 ml/L	7.20	5.23	3.11	1.93	9.990
T2 - Thiamethoxam 25 WG @ 1g/ L	6.99	2.09	2.17	2.24	9.046
T3 - Untreated Control	7.07	7.37	7.89	8.21	7.051
CD at 5%	N.S.	0.298	0.24	0.166	0.481

DAS – Days After Spray

IV. 6. Biological Control of Greengram Pests

IV. 6.1. Evaluation of different entomopathogens against spotted pod borer, *Maruca virtata in* greengram

ANGRAU

Results: Spotted pod borer, *Maruca virtata* incidence and pod damage was significantly low in *Bacillus thuringiensis* NBAIR Bt G4 2% @ 10 ml/ lit (0.398 larvae/plant and 27.44%) asthree sprays from pre flowering resulted in higher grain yield (4.581q/ha) compared to POP recommendation (Azadirachtin 1% 1500 ppm @ 2 ml/L+ Chlorpyriphos @ 2.5 ml/L+ Acephate @ 1.5 g/L) (Table 110).

Table 110. Evaluation of entomopathogens against spotted pod borer in Green gram

Treatment	Number of larvae / plant*	Pod damage %	Grain Yield q/ha
T1: *Bacillus thuringiensis* NBAIR Bt G4 2% @ 10 ml/ lit	0.398 (3.593)	27.48 (1.444)	4.581

T2- POP recommendation (Azadirachtin 1% 1500 ppm @ 2 ml/L+ Chlorpyriphos @ 2.5 ml/L+ Acephate @ 1.5 g/L)	0.346 (3.277)	32.6 (1.486)	3.421
T3-Untreated Control	0.716 (4.835)	57.26 (1.685)	1.619
CV%	9.99	9.632	28.535
CD (0.05)	**0.454**	**0.169**	**1.066**

Values in parenthesis are logarithmic transformed values;* Values in parenthesis are arc sin transformed values

AAU, Anand

Results:

The data on the evaluation of different entomopathogens against spotted pod border, *Maruca vitrata* in green gram is presented in the Table 111. The lowest larval population was documented in the treatment T_2-POP recommendation (Azadirachtin 1% 1500 ppm) (10.59 larvae/meter row length) which was statistically at par with the treatment T_1- *Bacillus thuringiensis* NBAIR *Bt*G4 2% (10.92 larvae/meter row length). The treatment T_2- POP recommendation (Azadirachtin 1% 1500 ppm) showed highest percent pest reduction over control (57.13%) as compared to treatment T_1- *B. thuringiensis* NBAIR *Bt*G4 2% (55.79%).

Further, treatment T_2- POP recommendation (Azadirachtin 1% 1500 ppm) recorded the significantly lowest pod damage (4.30%) as compared to treatment T_1- *B. thuringiensis* NBAIR *Bt*G4 2% (6.63%). Due to significant low pod damage in T_2- POP recommendation (Azadirachtin 1% 1500 ppm), it recorded the highest yield (15.14 q/ha) which was statistically at par with the treatment T_1- *B. thuringiensis* NBAIR *Bt*G4 2% (14.86 q/ha). The highest (73.82%) increase in yield over untreated control was obtained in the treatment T_2- POP recommendation (Azadirachtin 1% 1500 ppm).

Table 111. Evaluation of different entomopathogens against spotted pod border, *Maruca vitrata* in green gram during 2022-23

Treatments	No. of larvae/meter row length		Pest reduction over control (%)	Pod damage (%)	Yield (q/ha)	Yield increase over control (%)	B:C Ratio
	BS	Pooled over Sprays					
T_1-*Bacillus thuringiensis* NBAIR *Bt*G4 2% @ 10 ml/lit	4.16* (16.81)	3.38[a] (10.92)	55.79	14.92**[b] (6.63)	14.86[a]	70.61	9.6
T_2-POP recommendation (Azadirachtin 1% 1500 ppm) @ 2 ml/L	4.01 (15.58)	3.33[a] (10.59)	57.13	11.97[a] (4.30)	15.14[a]	73.82	12.1
T_3-Untreated control	3.82 (14.09)	5.02[b] (24.70)	-	26.56[c] (19.99)	8.71[b]	-	7.6
SEm±	0.19	0.07	-	0.66	0.83	-	-
C. V. (%)	12.69	12.27	-	14.11	16.94	-	-
C.D. at 5%	NS	0.21	-	1.91	2.55	-	-

Note: *Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values; **Figures outside the parentheses are arcsine transformed values, those inside are retransformed values, NS = Non –significant, BS: Before Spray

SKUAST - Jammu

Number of treatments: 3; Number of replications: 7; Design: RBD

Two sprays: First spray at flowering stage and second spray 15 days after first spray

Observations recorded-

- Pod damage (%) recorded at 15 days after spraying
- Number of larvae / meter row length
- Yield (q/ha)

Results:

Bacillus thuringiensis NBAIR*Bt*G4 2% @ 10 ml/L (treatment 1) recorded significantly lowest pod damage(11.05%), while in untreated control it was 21.66%. Number of larvae per meter row length was also lowest in treatment 1 (1.34 larvae / m) and the grain yield was highest in treatment 1 (11.92 q/ha), while in control it was 7.36 q/ha (Table 112).

Table 112. Per cent pod damage, number of larvae and grain yield of green gram

Treatments	Pod damage (%)	No. of larvae / m row length	Grain Yield (q/ha)
T1 - *Bacillus thuringiensis* NBAIR-BtG4 2% @ 10 ml/L	11.05 (19.40)	1.34	11.92
T2 - Azadirachtin 1% 1500 ppm @ 2 ml/L	13.15 (21.25)	1.83	10.18
T3 - Untreated Control	21.66 (27.68)	4.49	7.36
CD at 5%	(1.578)	0.160	0.488

Figures in parenthesis are arc-sine transformed values

DAS – Days After Spray

TNAU

IV. 6.2. Evaluation of entomopathogen and azadirachtin against spotted pod border, *Maruca vitrata* in green gram

A field trial to evaluate the effect of *Bacillus thuringiensis* NBAIR *Bt*G4 against spotted pod border, *Maruca vitrata* in greengram was conducted in farmer's field at Chemmanur.

Results:

Results revealed that *B. thuringensis* NBAIR *Bt*G4 2% @ 1ml/litre was significantly better than Azadirachtin 1% 1500 ppm @ 2 ml/L with 44.95% reduction in the number of larvae at 15 Days After Spray. The pod damage was reduced to the tune of 22.70% and 14.25% in *B. thuringensis* NBAIR *Bt*G4 2% @ 1ml/litre and Azadirachtin 1% 1500 ppm @ 2 ml/L, respectively. In *B. thuringensis* NBAIR *Bt*G4 2% @ 1ml/litre treated plot, 8.92% increase in yield (Table 113).

Table 113. Effect of entomopathogenand Azadiractin on spotted pod borer, *Maruca vitrata*

Treatment	Larva / meter row length			Pod damage (%)		Yield Kg/ha	CB ratio
	Pre count	15 DAS	% reduction over control	15 DAS	% reduction over control		
T1:*Bacillus thuringensis* NBAIR *Bt*G4 2% @ 1ml/litre	5.02 (2.240)	1.03 (1.015)[a]	44.95	5.41 (2.325)[a]	22.70	489.79 (22.130)[a]	2.62
T2: Azadiractin 1% 1500ppm @ 2ml/litre	5.10 (2.258)	3.42 (1.849)[b]	13.54	8.62 (2.936)[b]	14.25	470.06 (21.679)[b]	2.52

T3: Untreated control	5.23 (2.287)	4.63 (2.152)[c]		12.28 (3.504)[c]		449.67 (21.205)[c]	2.45
CV	1.442	1.104		0.874		1.146	
SD	NS	0.105		0.014		0.137	
CD (0.05)		**0.022**		**0.030**		**0.289**	

DAS- Days After Spray; Figures in parentheses are square root transformed values
In a column means followed by same letter(s) are not significantly different (p=0.05) by LSD

IV. 7. Biological Control of Red gram Pests

UHAS

IV. 7.1. Evaluation of bio-control agents against pod borers in red gram

Results:

At the time harvest of crop, the data on pod borer damage revealed that a significant difference among the treatments, recording significantly minimum per cent pod damage of 3.49 in insecticidal sprays followed by the Bt treatment (T2) with 4.32% pod damage and both the treatments were significantly superior compared to untreated control 11.83% damage. Maximum yield (16.82 q/ha) was recorded in T2 followed by T1 (15.44 q/ha) and both treatments were at par with each other and significantly superior over untreated control.

Table 114. Evaluation of bio-control agents against pod borers in red gram

Treatments	Pod damage Percentage (%)		Mean Pod damage (%)	Grain damage (%)	Yield (q/ha)
	I Spray	II Spray			
T1: *Bacillus thuringiensis* (NBAIR *Bt*G4 2%) @ 10ml/L	4.28 (11.94)	4.36 (12.05)	4.32 (12.00)	24.42 (29.61)	15.44
T2: POP recommendation (Chlorantraniliprole 18.5% SC@ 0.4 ml/lit)	3.52 (10.81)	3.24 (10.37)	3.49 (10.77)	22.34 (28.21)	16.82
T3: Untreated control	13.14 (21.25)	10.18 (18.61)	11.83 (20.12)	37.86 (37.97)	9.82
SEm	0.60	0.31	0.08	0.6	1.04
CD (0.05%)	1.82	0.9	0.24	1.2	3.21

COMMERCIAL CROPS

IV. 8. Biological Control of Cotton Pests

Cotton

IV. 8.1. Large scale evaluation of bio-intensive management of pink bollworm on Bt cotton (RCH 926)

(PAU, Ludhiana, PJTSAU, Hyderabad, UAS, Dharwad)

I. PAU, Ludhiana:

The trial was done at village Khiali Chaihanwali (District Mansa) with the following treatments

1. BIPM - 4000 m^2

- Standard practice of plant protection till 55th day or appearance of PBW

- Timely sowing (3.5.2022)
- Erection of pheromone traps (Funnel type) @ 20 traps/acre
- Releases of *Trichogrammatoidea bactrae* 100,000/ha, 8 releases starting from 55 days after germination at weekly interval
- Application of azadirachtin 1500 ppm @ 2ml/L of water

2. Chemical Control (University POP recommendation) - 4000 m^2

- Fenpropathin 10 EC @ 300 ml/ acre
- Emamectin benzoate 5 SC @ 100 g/acre

3. Untreated control - 100 m^2

The data on various parameters of pink bollworm damage was recorded based on rosette flowers (at weekly intervals), green boll damage (90, 120 and 150 DAS), open boll and loculi damage (at harvest) and seed cotton yield (at harvest). The incidence of pink bollworm remained low throughout the cropping season. Overall, the damage of pink bollworm in BIPM based on rosette flowers (Table 115), green bolls, open bolls and loculi (Table 116) was comparatively low as compared to untreated control. However, lowest damage was recorded in chemical control (Fig 40.).

Table 115. Effect of BIPM on rosette flower damage by pink bollworm in *Bt* cotton during 2022

Dates	Rosette flowers (%)		
	BIPM	Chemical con-trol	Untreated control
28.6.2022	0.00	0.00	0.00
6.7.2022	0.00	0.00	0.00
13.7.2022	0.00	0.00	0.00
20.7.2022	1.00	0.00	2.00
27.7.2022	1.00	0.00	2.00
4.8.2022	2.00	1.00	3.00
11.8.2022	3.00	1.00	4.00
18.8.2022	2.00	0.00	3.00
25.8.2022	0.00	0.00	1.00
1.9.2022	0.00	0.00	0.00
8.9.2022	0.00	0.00	2.00
16.9.2022	1.00	0.00	2.00
23.9.2022	1.00	0.00	2.00
Mean	0.85 (1.29)	0.15 (1.05)	1.62 (1.55)
LSD (P=0.05)	(0.06)		
CV %	17.38		

Table 116. Effect of BIPM on boll damage by pink bollworm and seed cotton yield of *Bt* cotton during 2022

Treatments	Green boll damage (%)			Open boll damage (%)	Loculi damage (%)	Seed cotton yield (q/ha)
	90 DAS	120 DAS	150 DAS			
BIPM module	1.00 (1.37)	2.00 (1.71)	2.00 (1.71)	3.00 (1.98)	1.88 (1.68)	8.35
Chemical control	0.00 (1.00)	1.00 (1.37)	1.00 (1.37)	1.04 (1.42)	0.77 (1.32)	9.20
Untreated control	3.00 (1.98)	4.00 (2.23)	4.00 (2.20)	6.04 (2.64)	3.59 (2.13)	7.50
LSD (p=0.05)	(0.24)	(0.29)	(0.27)	(0.21)	(0.22)	1.05
CV (%)	17.76	17.53	16.22	11.55	13.70	13.44

DAS- Days after sowing; Figures in parentheses are square root transformed values

Fig 40. Large scale evaluation of biointensive management of pink bollworm on *Bt* cotton at village Khiali Chahihanwali (District Mansa) during 2022

PJTSAU, Hyderabad

IV. 8.2. Large scale validation of BIPM of pink bollworm on cotton at PAU, Ludhiana

In *kharif* 2022, BIPM plots recorded higher infested bolls (6.22 %) compared to the BIPM package (4.76), Yield was higher in the farmer's practices (12.69 q/acre) compared to BIPM package (10.08) (Table 117).

Table 117. Bio-intensive management of Pink Bollworm in Bt cotton

Treatment	No.of good opened bolls (no./ plant)	No.of rosette flowers (no./plant)	Green bolls (no./ plant)	No.of par-asitised larvae (no./plant)	Infestation (%) by Boll dissection	Yield (q/acre)	Costs (Rs.)	B : C ratio
BIPM	0.70 (0.60)	1.18 (1.09)[a]	9.60 (3.16)	6.45 (2.64)[a]	6.22 (2.93)[b]	10.08[b]	17,735.0	3.09
FP	0.87 (0.68)	1.02 (0.98)[a]	10.87 (3.36)	0.67 (1.26)[b]	4.76 (2.17)[a]	12.69[a]	15,000.0	5.09
CD (0.05)	NS	0.22	NS	0.83	0.34	0.98		
CV (%)	12.98	12.35	8.01	20.15	12.61	15.27		

Dissection of bolls each week to know infestation levels by pink bollworm

II. UAS, Dharwad

The results indicated that the per cent rosette flower in T_1 was 7.38 per cent while in untreated control it was 11.76 per cent. Similarly the number of PBW larvae in T_1 was 10.44 larvae per 10 bolls while in untreated control it was 13.46 larvae per 10 bolls. The good opened bolls and bad opened bolls in T_1 was 31.26 and 15.62, respectively while in untreated control it was 24.85 and 22.64, respectively. Locule damage in T_1 was 30.68 per cent while in untreated control it was 43.26 per cent. T_1 recorded 25.36 q/ha seed cotton yield while untreated control recorded 21.46 q/ha (Table 118).

Table 118. Large scale evaluation of biointensive management of pink bollworm on *Bt* cotton

Sl. No.	Treatment Details	Rosette flowers % *	PBW larvae per 10 bolls	GOB /plant	BOB /plant	Locule damage (%)	Seed cotton yield (q/ha)
1.	**T_1:** 1. Erection of Pheromone Traps (Funnel type) @ 20/acre 2. Release of *T. bactrae* @ 100000/ ha 6-8 releases from 55 DAS 3. Application of azadiractin 1500 ppm @ 2ml/lit	7.38 (15.76)	10.44 (3.31)	31.26 (5.64)	15.62 (4.01)	30.68 (33.63)	25.36
2.	**T_2:** 1. Profenophos 50 EC @ 2.0 ml/lt at 70 DAS 2. Thiodicarb 75 wp @ 1.0 gm/lt at 90 DAS 3. Lamda cyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS	3.14 (10.21)	6.38 (2.62)	43.24 (6.61)	11.38 (3.45)	22.54 (28.34)	27.84

3.	T_3: Untreated Control	11.76 (20.06)	13.46 (3.74)	24.85 (5.03)	22.64 (4.81)	43.26 (41.13)	21.46
S Em ±		**0.08**	**0.03**	**0.11**	**0.08**	**0.05**	**0.51**
CD (P=0.05)		**NS**	**0.11**	**0.33**	**0.24**	**0.15**	**1.53**

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

TNAU:

In the demonstration trial conducted in farmer's field rosette flowers due to pink boll worm was 1.03 per cent in BIPM plots while it was 2.14 per cent in the control plot on 110 Days After Sowing (DAS). On 110 DAS, green boll damage due to pink boll worm was 6.72 per cent in BIPM plots while it was 9.76 per cent in the control plot. Observations on bad open bolls were taken on 130, 140 and 150DAS. There was 15.98 per cent reduction in the bad open bolls in BIPM module whereas 28.91 per cent reduction in bad open bolls was observed in insecticides treated plots. The yield was maximum in insecticide sprayed plots (1876Kg/ha) followed by 1788Kg/ha and 1573Kg/ha in BIPM and control plots respectively. CB ratio was higher in insecticide treated plots (1:1.53) than in BIPM plot (1:1.46) (Table 119)

Table 119. Biointensive management of Pink bollworm in Bt Cotton

Treatments	Rosette flowers % * 110 DAS	Green boll damage % * 110 DAS	Bad open bolls % *			Mean Bad open bolls% *	% decrease from control	Yield Kg/ ha**	% increase over control	CB ratio
			130 DAS	140 DAS	150 DAS					
T1: BIPM module	1.03 (5.824)[a]	6.72 (15.024)[b]	14.68 (22.528)[b]	15.53 (23.208)[b]	17.72 (24.894)[b]	15.98	19.96	1788.33 (42.288)[b]	13.65	1.46
T2: Insecticides spray	1.25 (6.419)[b]	5.25 (13.245)[a]	12.57 (20.765)[a]	13.84 (21.840)[a]	16.16 (23.702)[a]	14.19	28.91	1875.96 (43.311)[a]	19.22	1.53
T3: Control	2.14 (8.412)[c]	9.76 (18.204)[c]	18.15 (25.215)[c]	20.25 (26.743)[c]	21.48 (27.611)[c]	19.96	-	1573.58 (39.668)[c]	-	1.21
SEd	0.033	0.074	0.096	0.083	0.099	-	-	0.121	-	
CD (P=0.05)	0.069	0.155	0.201	0.175	0.209	-	-	0.254	-	

DAS – Days after sowing

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

In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD Values are mean of ten replications.

IV. 8.3. Evaluation of efficacy of entomofungal pathogens and botanicals for the management of sucking pests in cotton (PJTSAU, Hyderabad, UAS, Raichur, TNAU, Coimbatore)

PJTSAU, Hyderabad

The trial was conducted at ErrupAlem village, Khammam dt. The plot size/treatment : 400 sq.m. Results revealed that Acetamiprid recorded lesser population of leaf hoppers (4.05/plant) compared to *L. lecanii* (5.98/ plant). Yield was higher in Acetamiprid treatd plots (9.19 q/acre) compared to *L. lecanii* (6.37 q/acre) while control plots recorded least yield (2.55 q/acre) and highest pest (8.42/plant) (Table 120).

Table 120. Population of Leafhoppers, *Amrasca biguttula biguttula* and yield in different treatments

Treatment	Population of leafhoppers (mean no./plant)						Yield (q/ acre)
	First spray			Second spray			
	Pre count	3 day count	7 day count	Pre count	3 day count	7 day count	
T1 *L. lecanii* (1X 10^8) CFU/ml	5.83 (2.41)	4.04 (2.01)^{ab}	5.98 (2.44)^{b}	6.26 (2.49)	3.89 (2.62)^{b}	6.64 (2.58)^{b}	6.37^{b}
T2 Acetamiprid 20% SP	6.52 (2.53)	2.90 (1.74)^{a}	4.05 (2.01)^{a}	6.29 (2.54)	2.89 (1.76)^{a}	3.73 (1.92)^{a}	9.19^{a}
T3 Untreated Control	5.98 (2.49)	5.98 (2.24)^{b}	8.42 (2.90)^{c}	5.89 (2.45)	6.66 (3.07)^{c}	12.10 (3.98)^{c}	2.55^{c}
CD at 5%	NS	0.40	0.36	NS	0.67	0.17	0.51
CV	14.23	12.09	13.03	5.38	17.99	13.85	7.24

UAS, Raichur

Leafhopper population ranged from 12.68 to 13.12 per plant a day before spray. Among the biocontrol agents, *L. leccani* (ICAR-NBAIR-VL-18) 1×10^8 @ 5gm/l recorded highest reduction of leafhopper population over control (50.73 %). Reduction of thrips population over control was highest in *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l (53.81 %). Similarly the per cent reduction of aphid population was highest (72.59%) in *L. leccani* (ICAR-NBAIR-VL-18) 1×10^8 @ 5gm/l. Highest seed cotton yield of 26.84 q/ha was noticed in *L. leccani* (ICAR-NBAIR-VL-18) 1×10^8 @ 5gm/l while untreated control recorded 19. q/ha (Table 121).

Table 121. Evaluation of efficacy of entomofungalpathogens for the management of sucking pests in *Bt* cotton

Sl. No.	Treatment Details	Dos-age (g/l)	No. of leafhoppers/plant				No. of thrips/plant				No. of aphids/plant				Seed cotton yield (q/ha)
			IDBS	3DAS	7 DAS	ROC (%)	IDBS	7 DAS	10 DAS	ROC (%)	IDBS	7 DAS	10 DAS	ROC (%)	
T_1	*Lecanicillium leccani* (ICAR-NBAIR-VL-18)	1×10^8 @ 5gm/l	12.85 (3.65)	7.36 (2.80)	6.18 (2.58)	50.73 (45.42)	7.38 (2.81)	4.04 (2.13)	3.16 (1.91)	53.81 (47.18)	18.56 (4.37)	5.82 (2.51)	4.36 (2.20)	72.59 (58.43)	24.36
T_2	Acetamiprid 20 SP	0.2 gm/lit	13.12 (3.69)	4.84 (2.31)	4.04 (2.13)	67.69 (55.36)	7.46 (2.82)	3.82 (2.08)	3.04 (1.88)	55.99 (48.44)	17.84 (4.28)	3.88 (2.09)	3.04 (1.88)	81.37 (64.43)	26.84
T_3	Untreated control	-	12.68 (3.63)	14.18 (3.83)	14.36 (3.85)	0.00 (0.00)	7.62 (2.85)	7.84 (2.89)	7.92 (2.90)	0.00 (0.00)	18.28 (4.33)	18.46 (4.35)	18.68 (4.38)	0.00 (0.00)	19.68
S Em ±			0.13	0.09	0.06	-	0.15	0.03	0.07	-	0.21	0.08	0.04	-	0.35
CD (P=0.05)			NS	0.28	0.18	-	NS	0.09	0.21	-	NS	0.24	0.12	-	1.06

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

TNAU

Aphid population was minimum in Spiromesifen 240SC @ 7 ml/10 L (10.33) followed by *Lecanicillium lecanii* NBAIR Vl 8 (1×10^8spores /g) @ 5 g/l (35.42Nos.), Azadirachtin 1500ppm @ 2 ml/L (40.45Nos.) and *Beauveria bassiana* NBAIR Bb5a (1×10^8spores /g) @ 5 g/ l (44.73Nos.) on 7days after first spraying (Table 122). The same trend was observed after second spraying also. There was 75.81 per cent reduction in the population of aphids in *L. lecanii* NBAIR Vl 8 (1x10^8spores /g) @ 5 g/l when compared to the control after second spraying (Table 122). Whiteflies population was reduced to the tune of 80. 8 per cent in Spiromesifen 240SC @ 7 ml/10 L followed by Azadirachtin 1500ppm @ 2 ml/L (65.17%), *L. lecanii* NBAIR Vl 8 (1x10^8spores /g) @ 5 g/l (56.46%) and *B. bassiana* NBAIR Bb5a (1x10^8spores /g) @ 5 g/ l (50.45%) on 7days after second spraying (Table 123) .

In case of thrips, there was 42.86 per cent reduction in the population in Spiromesifen 240 SC @ 7 ml/10 L when compared to control followed by *B. bassiana* NBAIR Bb5a (1x10^8spores /g) @ 5 g/ l (25.71%), Azadirachtin 1500 ppm @ 2 ml/L (20.00%) and *L. lecanii* NBAIR Vl 8 (1x10^8spores /g) @ 5 g/l (10.86%) on 7 days after second spraying (Table 124). Leaf hopper population was reduced to the tune of 72.73 per cent in Spiromesifen 240 SC @ 7 ml/10 L treated plots when compared to control followed by *B. bassiana* NBAIR Bb5a (1x10^8 spores /g) @ 5 g/ l (68.13%), Azadirachtin 1500ppm @ 2 ml/L (63.54%) and *L. lecanii* NBAIR Vl 8 (1x10^8 spores /g) @ 5 g/l (60.19%) on 7days after second spraying. CB ratio was maximum in Spiromesifen 240SC @ 7 ml/10 L (1.62) followed by *L. lecanii* NBAIR Vl 8 (1x10^8spores /g) @ 5 g/l (1.47) (Table 125).

Table 122. Effect of entomofugal pathogens and botanicals on aphids in cotton

Treatments	Population of Aphids / 3 leaves					
	First spray			Second spray		
	Pre count	3 DAS	7 DAS	Pre count	3 DAS	7 DAS
T1: *Lecanicillium lecanii*	55.75 (7.168)	48.76 (6.96)^{bc}	35.42 (5.89)^{b}	25.43 (4.765)	16.25 (3.97)^{b}	8.56 (2.88)^{b}
T2: *Beauveria bassiana*	54.33 (6.639)	43.19 (6.55)^{b}	44.73 (6.66)^{bc}	25.67 (4.832)	19.67 (4.38)^{b}	10.72 (3.22)^{b}
T3: Azadirachtin 1500 ppm(2ml/l)	55.66 (7.116)	56.48 (7.49)^{c}	40.45 (6.29)^{bc}	24.25 (4.641)	17.51 (4.00)^{b}	9.25 (3.00)^{b}
T4: Spiromesifen 240 SC	54.51 (7.207)	15.64 (6.77)^{bc}	10.33 (7.21)^{c}	25.35 (4.743)	5.57 (6.45)^{c}	3.15 (5.94)^{c}
T5: Absolute control	55.62 (7.168)	42.56 (3.95)^{a}	37.25 (3.19)^{a}	23.66 (4.545)	14.82 (2.29)^{a}	5.57 (1.68)^{a}
CD (0.05)	NS	0.946	1.249	NS	1.253	0.931
SEd	NS	0.450	0.595	NS	0.597	0.443

Figures in parentheses are square root transformed values
In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD Values are mean of four replications.

Table 123. Effect of entomofugal pathogens and botanicals on whiteflies in cotton

Treatments	Population of Whiteflies / 3 leaves					
	First spray			Second spray		
	Pre count	3 DAS	7 DAS	Pre count	3 DAS	7 DAS
T1: *Lecanicillium lecanii*	8.33 (2.771)	4.16 (2.02)^{b}	4.25 (2.03)^{bc}	3.15 (1.725)	2.74 (1.64)^{b}	1.45 (1.19)^{b}
T2: *Beauveria bassiana*	7.66 (2.679)	3.15 (1.76)^{ab}	3.02 (1.74)^{ab}	2.82 (1.615)	2.53 (1.58)^{ab}	1.65 (1.28)^{b}
T3: Azadirachtin 1500 ppm(2ml/l)	6.83 (2.503)	3.15 (1.77)^{ab}	2.86 (1.69)^{ab}	3.25 (1.636)	2.65 (1.62)^{ab}	1.16 (1.07)^{ab}

T4: Spiromesifen 240 SC	8.06 (2.716)	2.45 (1.56)[a]	2.59 (1.59)[a]	3.33 (1.686)	2.09 (1.44)[a]	0.66 (0.80)[a]
T5:Absolute control	7.16 (2.577)	4.27 (2.06)[b]	4.54 (2.13)[c]	3.23 (1.622)	4.75 (1.92)[c]	5.33 (1.81)[c]
CD (0.05)	NS	0.331	0.387	NS	0.186	0.281
SEd	NS	0.158	0.184	NS	0.088	0.134

Figures in parentheses are square root transformed values.

In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD Values are mean of four replications.

Table 124. Effect of entomofugal pathogens and botanicals on thrips in cotton

Treatments	Population of Thrips/ 3 leaves					
	First spray			Second spray		
	Pre count	3 DAS	7 DAS	Pre count	3 DAS	7 DAS
T1: *L. lecanii*	2.89 (1.636)	2.01 (1.41)[a]	2.45 (1.56)[ab]	2.16 (1.338)	1.8 (1.34)[b]	1.56 (1.25)[bc]
T2: *B. bassiana*	3.16 (1.604)	2.85 (1.68)[abc]	3.33 (1.82)[bc]	2.33 (1.425)	1.96 (1.39)[bc]	0.66 (1.15)[ab]
T3: Azadirachtin 1500 ppm(2ml/l)	3.33 (1.696)	2.94 (1.71)[bc]	2.72 (1.64)[abc]	2.66 (1.558)	1.45 (1.20)[a]	1.06 (1.19)[b]
T4: Spiromesifen 240 SC	2.76 (1.597)	2.43 (1.55)[bc]	2.16 (1.46)[a]	2.33 (1.420)	1.72 (1.31)[ab]	0.45 (1.03)[a]
T5: Absolute control	3.25 (1.653)	3.58 (1.88)[c]	3.66 (1.91)[c]	2.5 (1.497)	2.25 (1.49)[c]	1.75 (1.32)[c]
CD (0.05)	NS	0.287	0.301	NS	0.124	0.131
SEd	NS	0.137	0.143	NS	0.059	0.062

Figures in parentheses are square root transformed values

In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD Values are mean of four replications

Table 125. Effect of entomofugal pathogens and botanicals on cotton leafhopper and yield of cotton

Treatments	Population of Leaf hopper/ 3 leaves						Yield q/ ha	C B Ratio
	First spray			Second spray				
	Pre count	3 DAS	7 DAS	Pre count	3 DAS	7 DAS		
T1: *L. lecanii*	4.16 (1.962)	2.45 (1.565)[c]	3.62 (1.903)[d]	9.64 (2.918)	7.25 (2.693)[d]	4.16 (2.039)[d]	13.25 (3.640)[b]	1.47
T2: *B. bassiana*	3.99 (1.887)	3.25 (1.803)[d]	3.38 (1.838)[c]	9.42 (2.940)	6.45 (2.539)[b]	3.33 (1.825)[b]	12.38 (3.518)[c]	1.29

T3: Azadirachtin 1500 ppm (2ml/l)	4.23 (1.977)	2.16 (1.470)[b]	2.83 (1.682)[b]	8.66 (2.836)	5.1 (2.258)[a]	3.81 (1.952)[c]	11.59 (3.404)[d]	1.21
T4: Spiromesifen 240 SC	4.05 (1.914)	1.75 (1.323)[a]	2.41 (1.552)[a]	9.82 (3.013)	6.74 (2.596)[c]	2.85 (1.688)[a]	13.75 (3.708)[a]	1.62
T5: Absolute control	4.25 (1.854)	4.51 (2.124)[e]	4.66 (2.159)[e]	9.32 (2.953)	9.66 (3.108)[e]	10.45 (3.232)[e]	10.72 (3.274)[e]	1.18
CD (0.05)	NS	0.027	0.031	NS	0.047	0.045	0.063	
SEd	NS	0.012	0.014	NS	0.022	0.021	0.03	

Figures in parentheses are square root transformed values

In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD Values are mean of four replications

IV. 9. Biological Control of Sugarcane Pests

IV. 9.1. Field evaluation of ICAR-NBAIR endophytic entomopathogenic strains against shoot borers (*Chilo infuscatellus* and *Chilo sacchariphagus indicus*) (ANGRAU)

Sugarcane Early shoot borer, *Chilo infuscatellus* incidence upto 120 days after planting was significantly low in Cholorantraniliprole treatment (9.23 % DH) and was on par with the, *Metarhizium anisopliae* NBAIR Ma35 (9.7 % DH); *Beauveria bassiana* NBAIR Bb45 (13.01 % DH). Internode borer incidence (%) and Internode borer intensity (%) was significantly low in Cholorantraniliprole (47.5 % and 4.58 %) with higher cane yield (89.66 t/ha) at par with *M. anisopliae* NBAIR Ma35 (52.5 % and 5.15 %) recorded cane yield (86.28t/ha) ; *B. bassiana* NBAIR Bb45 (60% and 5.04 %) recorded cane yield (84.25t/ha) (Table 126) .

Table 126. Evaluation of ICAR-NBAIR endophytic entomopathogenic strains against shoot borers (*Chilo infuscatellus* and *Chilo sacchariphagus indicus*)

Treatment	ESB incidence (%DH)			Internode borer incidence %	Internode borer intensity %	Cane Yield (t/ha)
	45 DAP	60 DAP	Upto 120 DAP			
T1- *Metarhizium anisopliae* NBAIR Ma35 (ST + 3 sprays)	5.01 (0.695)	4.64 (0.552)	9.7 (0.967)	52.5 (1.707)	5.153 (0.668)	86.275
T2 : *Beauveria bassiana* NBAIR Bb45 (ST+3 sprays)	6.04 (0.776)	5.13 (0.691)	13.01 (1.044)	60 (1.772)	5.043 (0.661)	84.245
T3 –Chlorantraniliprole (ST+ 3 sprays)	5.09 (0.702)	4.43 (0.616)	9.23 (0.934)	47.5 (1.663)	4.58 (0.588)	89.655
T4- Control	10.89 (1.020)	7.2 (0.793)	22.37 (1.234)	68.5 (1.835)	7.620 (0.879)	61.42
CD(0.05)	0.164	0.148	0.165	0.168	2.659	13.323
CV%	12.842	13.275	9.857	6.057	21.823	10.36

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

Fig 41. Efficacy of endophytic entomopathogensin the management of shoot borers in sugarcane

MPKV, Pune

IV. 9.2. Large scale demonstration of EPN against white grubs in sugarcane ecosystem

(MPKV, Pune)

The experiment was laid out on the farmer's field of at A/p. Vadhu Bk., Tal. Shirur of Pune district. The planting of sugarcane variety CoM. 265 was done on 20.02.2022 with 90 x 60 cm spacing in plot size of 5 ha in Chi-square Test having two treatments. The data on efficacy of EPN against white grubs in sugarcane indiacted that clump mortality was in the range of 10.67 to.11.03 per cent before application of entomopathogenic nematodes and it was statistically non-significant as given in Table 127.

The post count observations at 30 days after first and second applications recorded significant differences amongst all the treatments. The soil application of *Heterorhabditis indica* @ 1 x 10^5 (NBAIR WP formulation) @ 10 kg/ha was found effective with 4.40 per cent clump mortality and 58.76 per cent reduction over pre count observatios. However, Fipronil 40% + Imidacloprid 40 WG was significantly superior in suppressing clump mortality due to white grubs (3.77 %) with highest per cent reduction (65.82 %) over precount.

Table 127. Efficacy of entomopathogenic nematodes against white grub in sugarcane

Tr. No.	Treatment Details	Dose (kg ha)	Clump Mortality (%)				Per cent reduction over pre count
			Pre count	30 DAA (I application)	30 DAA (II application)	Mean	
T1	*Heterorhabditis indica* @ 1 x 10^5 (NBAIR WP formulation)	10	10.67 (19.07)*	5.94 (14.11)	2.87 (9.75)	4.40 (12.11)	58.76
T2	Fipronil 40% + Imidacloprid 40 WG	0.500	11.03 (19.39)	5.47 (13.53)	2.07 (8.27)	3.77 (11.20)	65.82
		"t" value	0.17	0.13	0.23	0.16	
		Remarks	NS	Sig.	Sig.	Sig.	

DAA- Days After Application

*Figures in parenthesis are arc sin transformed values.

IV. 9.3. Large scale demonstrations of proven biocontrol technologies against sugarcane stalk borer, *Chilo auricilius (*PAU, Ludhiana)

Large scale demonstrations on the effectiveness of *T. chilonis* against stalk borer, *Chilo auricilius* were carried out over an area of 6122 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, Fatehgarh Sahib and Amritsar 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 (2.77 %) was comparatively less than untreated control (6.38 %) (Table 128). The yield was also relatively more in released fields (732.90 q/ha) as against untreated control (671.20 q/ha). The cost benefit ratio was higher in biocontrol fields (1: 1.62) as compared to 1: 1.49 in untreated control (Table 129). 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 56.58 per cent.

Table 128. Large-scale demonstrations using *T. chilonis* against *Chilo auricilius* in sugarcane during 2022

Demonstrations	Mean incidence of *C. auricilius* (%)		Per cent reduction over control
	Biocontrol*	Untreated control	
PAU in collaboration with four sugarcane mills of Punjab	2.81	6.35	55.75
PAU, Ludhiana	2.63	6.51	59.60
Overall Mean	2.77[a]	6.38[b]	56.58

*10-12 releases of *T. chilonis* @ 50,000 per ha at 10 days interval during July to October

Table 129. Cost Benefit analysis (2022)

Treatments	Yield (q/ha)	Additional yield over control (q/ha)	Gross returns (Rs)	Cost of cultivation (Rs/ha)	Cost Benefit ratio
Biocontrol	732.90	61.70	263844.00	163050.00	1: 1.62
Untreated control	671.20	-	241632.00	161800.00	1: 1.49

Price of sugarcane: Rs. 360/- per quintal during 2022

Large scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *C. infuscatellus* were carried out over an area of 726 acres in collaboration with KVKs and Regional Station (Gurdaspur) in Hoshiarpur, Moga, Barnala, Jalandhar, Gurdaspur, Patiala, Kapurthala and Ludhiana 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 (3.18 %) and chemical control (1.47 %) was significantly less than untreated control (7.45 %). The reduction in incidence over control was 57.32 and 80.27 per cent in released fields and chemical control, respectively (Table 130). The yield in control (667.30 q/ha) was significantly lower than released fields (725.50 q/ha) and chemical control (839.24 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. The cost benefit ratio in biocontrol (1: 1.58) and chemical control (1: 1.75) was higher as compared to untreated control (1:1.48) (Table 131).

Table 130. Large scale demonstrations using *T. chilonis* against *C. infuscatellus* in sugarcane

Treatments	Incidence (%)	Per cent reduction over control	Yield (q/ha)
Biocontrol*	3.18[b]	57.32	715.50[b]
Chlorantraniliprole 18.5 SC @ 375 ml/ ha	1.47[a]	80.27	840.10[a]
Untreated control	7.45[c]	-	667.30[c]

*8 releases of *T. chilonis* @ 50,000 per ha at 10 days interval during Mid-April to end-June

Table 131. Cost Benefit analysis (2022)

Treatments	Yield (q/ha)	Additional yield over control (q/ha)	Gross returns (Rs.)	Cost of cultivation (Rs/ha)	Cost Benefit ratio
Biocontrol	725.50	58.20	261180.00	165050.00	1: 1.58
Chlorantraniliprole 18.5 SC @ 375 ml/ ha	839.24	171.94	302126.40	172500.00	1:1.75
Untreated control	667.30	-	240228.00	161800.00	1: 1.48

Price of sugarcane: Rs. 360/- per quintal during 2022

IV. 9.4. Large scale demonstrations of proven biocontrol technologies against sugarcane top borer, *Scirpophaga excerptalis (*PAU, Ludhiana)

Large-scale demonstrations on the effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 480 acres in collaboration with KVKs in Hoshiarpur, Jalandhar, Patiala, Kapurthala and Ludhiana 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 2.61 and 1.19 per cent, respectively. However, both the treatments were significantly better than untreated control (5.67%). The reduction in incidence over control was 53.97 and 79.01 per cent in released fields and chemical control, respectively (Table 132). The yield in control (664.8 q/ha) was significantly lower than release fields (717.2 q/ha) and chemical control (831.5 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 in biocontrol (1: 1.56) and chemical control (1: 1.73) was higher as compared to untreated control (1:1.48) (Table 133).

Table 132. Large scale demonstrations using *T. japonicum* against *Scirpophaga excerptalis*

Treatments	Incidence (%)	Per cent reduction over control	Yield (q/ha
Biocontrol*	2.61[b]	53.97	717.2[b]
Chlorantraniliprole 0.4 GR @ 25 kg/ha	1.19[a]	79.01	831.5[a]
Control	5.67[c]	-	664.8[c]

*8 releases of *T. japonicum* @ 50,000 per ha at 10 days interval during Mid-April to end-June

Table 133. Cost Benefit analysis

Treatments	Yield (q/ha)	Additional yield over control (q/ha)	Gross returns (Rs.)	Cost of cultivation (Rs/ha)	Cost Benefit ratio
Biocontrol	717.20	52.4	258192.00	165050.00	1: 1.56
Chlorantraniliprole 0.4 GR @ 25 kg/ha	831.50	167.7	299340.00	172500.00	1:1.73
Control	664.80	-	239328.00	161800.00	1: 1.48

Price of sugarcane: Rs. 360/- per quintal during 2022

IV. 9.5. Field evaluation of *Metarhizium anisopliae* against sugarcane white grub *Holotrichia* sp. (PJTSAU)

In *Kharif* 2022, demonstration plots recorded 47.22% of damaged plants, while the Check plots registered 31.56% of damaged plants at 60 DAT. No.of grubs /10m row length and Cane yield was 12.67 and 22.36 t/acre in demonstration compared to 6.35 and 46.25 t/acre in the Check plots (Table 134).

Table 134. Impact of *Metarhizium anisopliae* against sugarcane whitegrub, *Holotrichia* sp.

S. No	Treatments	Damaged plants (%)		No.of grubs/10m row length		Cane Yield t/acre	Returns/ acre*	Costs / acre (Rs.)	B:C ratio
		Before treatment	60 DAT	Before treatment	60 DAT				
1	T1 - Demonstration (*Metarhizium anisopliae* NBAIR Ma 16 strain @ 2.5kg/ha) mixed in 250kg of FYM)	56.43	47.22	12.67	12.34	22.36	63,055.20	12000	5.25
2	T2 - Check (Fipronil 40% + imidacloprid 40 WG @ 5ml/L)	52.11	31.56	14.23	6.35	46.25	130,425.00	10000	13.04

* selling price of cane Rs.2820.00/t

IV. 9.6. Large scale demonstration of *Trichogramma* spp. against sugarcane borers. (OUAT, UAS, Raichur)

OUAT

The trial was conducted in 5 ha of sugarcane (Variety : (SABITA) at Biridi village of Khandapada block and Biruda of Nayagarh district. The crop was sown during 3rd week of February to last week of February 2022. 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 12.26% and 2.75% as against 12.70% and 2.80% in FP indicating comparable level of infestation. But, much higher levels of infestation due to ESB (13.04%) and TSB (2.96%) 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 (80.04 t/ha) and B: C ratio (1.72) were recorded in BIPM package where as in FP(71.97 t/ha) with B: C ratio (1.63). Lowest yield (56.85 t/ha) and B: C ratio (1.38) were noted in untreated control (Table 135).

Table 135. Effect of *Trichogramma* spp. against borer pests of sugarcane (Sabita)

Treatments	Early shoot borer(%)		Top shoot borer(%)		Yield (t/ ha)	B:C ratio
	Pre re-lease	Post release	Pre re-lease	Post release		
T1 - BIPM package Release of *T. chilonis* @ 50,000/ha at 10 days interval after 45 DAP (8 times) & *T. Japonicum 5-6 months after planting*	12.26	6.16 (2.48)	2.75	0.0.85 (0.92)	80.04	**1.72**
T2 - Farmer's practice (Pesticide application)	12.70	5.23 (2.29)	2.80	0.68 (0.83)	72.97	**1.63**
T3 = Untreated control	13.04	15.12 (3.89)	2.96	3.50 (1.87)	56.85	**1.38**
S.E. (m) ±	**-**	**0.08**	**-**	**0.04**	**2.50**	
C.D(P = 0.05)	**NS**	**0.23**	**NS**	**0.12**	**7.26**	

Figures in the parentheses are square root transformation values

UAS, Raichur

IV. 9.7. Large scale demonstrations of *Trichogramma* spp. (ICAR-NBAIR HTTS) against borers (early shoot borer) in sugarcane Observations:

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

Before treatment imposition dead hearts ranged from 17.75 to 18.50 per cent. Two months after treatment imposition minimum of 1.55 per cent dead hearts were noticed in farmers practice which was followed by release of *T. chilonis* (TTS) which recorded 2.85 per cent while untreated control recorded 12.55 per cent dead hearts. The highest cane yield of 121.25 t/ha was recorded in farmers practice and it was followed by *T. chilonis* (TTS) release plot 116.50 t/ha while untreated control recorded 107.25 t/ha (Table 136).

Table 136. Large scale demonstrations of *Trichogramma* spp. (ICAR-NBAIR HTTS) against borers (early shoot borer) in sugarcane during 2022-23

Sl. No.	Particulars	Dead hearts (%)* Before re-lease	Dead hearts (%)* After final release	Cane yield (t/ha)
1.	T_1 - Releases of *T. chilonis* (TTS)	18.50 (25.21)	2.85 (9.60)	116.50
2.	T_2 - Farmer's practice	17.75 (24.64)	1.55 (7.08)	121.25
3.	T_3 - Untreated control	18.25 (25.41)	12.55 (20.75)	107.25
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

OILSEEDS

IV. 10. Biological Control of Groundnut Pests

IV. 10.1. Evaluation of entomopathogens against leaf miner and tobacco caterpillar in groundnut (UAS Raichur; ANGRAU Anakapalle; TNAU Coimbatore)

ANGRAU

Results: Groundnut leaf miner damage and *Spodoptera litura* damage recorded significantly low in *Bacillus thuringiensis* RARS TPT C33 @ 2 g / L (2.56% and 9.75%) with higher pod yield (30.86q/ha) followed by *Metarhizium rileyi* (AKP Nr1) @ 5 g/L (2.7% and 10.95%) with pod yield 28.57q/ha and it was on par with Emamectin benzoate 5 SD@ 0.4 g/L (Table 137).

Table 137. Evaluation of entomopathogens against leaf miner and tobacco caterpillar in groundnut

Treatment	Leaf miner damage %		Percent reductionin Leaf miner damage over control	*Spodoptera litura* plant damage %		Percent reduction in *Spodoptera* damage over control	Pod Yield q/ha
	After First spray	After Second spray		After First spray	After Second spray		
T1: *Bacillus thuringiensis* RARS TPT C33 @ 2 g / lit	3.96 (0.598)	2.56 (0.400)	57.83	3.05 (0.462)	9.75 (0.988)	38.95	30.863
T2- *Metarhizium rileyi* (KKNr1) @ 5 g/L	4.31 (0.623)	3.15 (0.490)	48.11	3.4 (0.509)	14.22 (1.029)	10.96	29.457
T3: *Metarhizium rileyi* (AKP Nr1) @ 5 g/L	3.61 (0.546)	2.7 (0.417)	55.52	2.37 (0.345)	10.95 (0.997)	31.44	28.567
T4: Emamectin benzoate 5SD @ 0.4 g/L	4.58 (0.658)	2.61 (0.417)	57.0	2.09 (0.278)	9.57 (0.979)	40.08	31.473
T5-Untreated Control	6.12 (0.882)	6.07 (0.781)	-	5.01 (0.928)	15.97 (1.199)	-	23.49
CV%	13.901	18.364		20.33	7.216		9.341
CD (0.05)	**0.173**	**0.173**		**0.383**	**0.145**		**5.06**

Values in parenthesis are logarithmic transformed values

Fig 42. Evaluation of entomopathogens against leaf miner and tobacco caterpillar in groundnut

UAS, Raichur

Observations: Number of active miner per 20 leaflet -Leaf miner

Number of larvae per mrl - *Spodoptera*

Pod and Halum yield.

Results: Among the biocontrol agents highest per cent reduction of leaf miner over control was noticed in T_1 *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) (69.84%) while in T_3 it was 84.62% reduction in leaf miner population over control. Similarly the per cent reduction of defoliator was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) (65.62%) while in T_3 it was 78.64% reduction in defoliator. Among the biocontrol agents highest pod and halum yield of 24.28 q/ha and 28.68 q/ha was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) (Table 138).

Table 138. Evaluation of entomopathogens against leaf miner and tobacco caterpillar in groundnut during 2022-23

Sl. No.	Treatment Details	Dosage (g/l)	Leafminer (Active mines/20 leaflets)			ROC (%)	Defoliator (No. of larvae/ mrl)			ROC (%)	Yield (q/ha)	
			IDBS	7 DAS	10 DAS		IDBS	7 DAS	10 DAS		Pod	Halum
T_1	*Metarhizium rileyi* (KK-Nr-1)	1×10^8 @ 5gm/l	12.84 (3.69)	5.28 (2.41)	2.54 (1.81)	69.84 (56.88)	5.18 (2.06)	1.52 (1.41)	1.22 (1.34)	65.62 (54.31)	24.28	28.68
T_2	*Bacillus thuringiensis* RARS TPT-C33 2%	1ml/L	13.62 (3.91)	8.78 (3.05)	6.26 (2.72)	48.74 (46.32)	5.84 (2.22)	3.06 (1.88)	2.98 (1.83)	46.48 (44.08)	18.42	25.52
T_3	Emamectin benzoate 5 SG		13.24 (3.71)	3.34 (1.98)	1.38 (1.41)	84.62 (69.06)	5.28 (2.18)	1.04 (1.25)	0.71 (1.11)	78.64 (63.72)	29.38	31.46
T_4	Untreated control		13.18 (3.63)	16.24 (3.99)	15.82 (3.94)	0.00 (0.00)	5.42 (2.22)	5.36 (2.28)	4.52 (2.19)	0.00 (0.00)	17.48	22.42
S Em±			**0.27**	**0.13**	**0.07**	**-**	**0.03**	**0.05**	**0.07**	**-**	**0.43**	**0.59**
CD (P=0.05)			**NS**	**0.34**	**0.16**	**-**	**NS**	**0.12**	**0.10**	**-**	**1.29**	**1.77**

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

TNAU

Results: Data revealed that population of groundnut leaf miner larvae/ 20 leaflets was minimum in Emamectin benzoate 5 SG @0.2gm/L (2.75 larvae/ 20leaflets) followed by *Metarhizium rileyi* KK-Nr-1 (1×10^8 spores/g) @ 5g/L (3.27 larvae/ 20leaflets) and *Bacillus thuringiensis* RARS TPT-C33 2% @ 1ml/L (3.52 larvae/ 20leaflets) while in control 7.03 larvae/ 20leaflets were observed on 7 days after spraying (Table 139). There was no significant difference in the plant damage due to *Spodoptera litura* in different treatments. Pod yield in Emamectin benzoate 5 SG @ 0.2gm/L (1957Kg/ha) was on par with yield in *M. rileyi* KK-Nr-1 (1×10^8 spores/g) @ 5g/L (1814Kg/ha) and *B. thuringiensis* RARS TPT-C33 2% @ 1ml/L (1765Kg/ha). CB ratio was maximum in Emamectin benzoate 5 SG @ 0.2gm/L (1:1.66) followed by *M.rileyi* KK-Nr-1 (1×10^8 spores/g) @ 5g/L (1:1.54) and *B. thuringiensis* RARS TPT-C33 2% @ 1ml/L (1:1.42).

Table 139. Effect of entomopathogens against leaf miner and tobacco caterpillar in groundnut

Treatments	No. of active leaf miner/20 leaflet*			% Plant damage due to *Spodoptera litura***			Pod yield kg/ha*	CB Ratio
	Pre treatment	7 DAS	14 DAS	Pre treatment	7 DAS	14 DAS		
T1: *Metarhiziumrileyi* KK-Nr-1 (1x10^8 spores/g) @ 5g/L	6.71 (2.49)	3.27 (1.79)[ab]	2.64 (1.62)[a]	24.45 (29.06)	23.67 (26.93)	23.23 (28.35)	1813.64 (42.57)[a]	1.54
T2: *Bacillus thuringiensis* RARS TPT-C33 2% @ 1ml/L	6.48 (2.45)	3.52 (1.87)[b]	2.37 (1.54)[a]	25.74 (30.01)	25.33 (29.55)	24.51 (29.13)	1765.23 (41.99)[a]	1.42
T3: Emamectin benzoate 5 SG @0.2gm/L	7.23 (2.59)	2.75 (1.66)[a]	2.28 (1.51)[a]	26.38 (30.28)	25.29 (29.68)	24.84 (29.35)	1957.15 (44.23)[a]	1.66
T4: Control	6.84 (2.54)	7.03 (2.65)[c]	3.62 (1.89)[b]	25.66 (29.73)	26.37 (30.44)	28.42 (31.62)	1538.72 (39.18)[b]	1.18
SEd±	**NS**	**0.093**	**0.096**	**NS**	**NS**	**NS**	**1.101**	
CD (P = 0.05)	**NS**	**0.195**	**0.201**	**NS**	**NS**	**NS**	**2.313**	

DAS – Days after spraying; Figures in parentheses are arcsine transformed values* *and square root transformed values*In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD Values are mean of five replications.

IV. 11. Biological Control of Mustard Pests

IV. 11.1. Evaluation of entomopathogens against mustard aphids

CAU, Pasighat

Crop and Variety: Mustard, PM-28

Spacing: 45×15 cm**; Plot size**: 3×3 m=9 m^2; **Treatments:** 03; **Replications:** 07; **Design:** RBD; **Season:** Winter, 2022-23; **Location:** Biocontrol field, CHF, Pasighat.

Treatment details:

T_1- *Beauveria bassiana* NBAIR Bb 5a (1 × 10^8 spores/g) @ 5g/L +Azadirachtin 1500 ppm @ 2 ml/L

T_2- Imidacloprid 17.8 SL @ 0.4ml/L

T_3- Control

Methodology and Observations

Spray schedule: Two sprays at 15 days interval when the pest reaches ETL

The data was statistically analyzed using suitable transformation.

No. of aphids per 10 cm twig from ten randomly selected five plants

No. of Coccinellids per five plants

Seed Yield

Results:

The data on the field efficacy of entomopathogens on incidence of mustard aphids is presented in the (Table 140). The data reveals that spraying of Imidacloprid 17.8 SL @ 0.4ml/L was found to be best treatment by reducing the aphids population and higher seed yield (5.80 aphids/10 cm twig and 9.50 q/ha yield) and significantly lower natural enemies (1.42 coccinellids/5 plants). Whereas the next best treatment was foliar application of *Beauveria bassiana* NBAIR Bb 5a (1 × 10^8 spores/g) @ 5g/L +Azadirachtin 1500 ppm @ 2 ml/L which resulted in 6.94 aphids/10 cm twig and 8.10 q/ha seed yield without having any detrimental effects on coccinellid predators (2.49/5 plants).

Table 140. Field efficacy of entomopathogens against mustard aphids

Treatments	No. of aphids per 10 cm twig			No. of Coccinellids per five plants			Yield data (q/ha)
	Before spray	After-I spray	After-II spray	Before spray	After-I spray	After-II spray	
T1 - *Beauveria bassiana* NBAIR Bb 5a (1 × 10^8 spores/g) @ 5g/L +Aza-dirachtin 1500 ppm @ 2 ml/L	9.53 (3.19)*	7.21 (2.55)	6.94 (2.50)	3.97 (2.13)	3.14 (1.78)	2.49 (1.58)	08.10 (2.93)
T2 - Imidacloprid 17.8 SL @ 0.4ml/L	9.20 (3.16)	6.80 (2.60)	5.80 (2.46)	4.35 (2.18)	2.73 (1.89)	1.42 (1.43)	09.50 (3.16)
T3 - Control	9.78 (3.17)	10.19 (3.37)	9.87 (3.31)	4.13 (2.17)	4.51 (2.29)	3.95 (2.11)	06.65 (2.66)
S. Em ±	0.03	0.12	0.13	0.01	0.13	0.11	0.07
C.D. at 5 %	NS	0.36	0.39	NS	0.41	0.34	0.21

*Figures in the parenthesis $\sqrt{x + 0.5}$ transformed values

Experimental plot view

Prdatory coccinellid feediing on aphids

Aphids incidence on Mustard

Pupa of predatory Syrphid on Mustard

Fig 43. Field trials against mustard aphids

SKUAST - Jammu

Number of treatments: 3; Number of replications: 7; Design: RBD

Results

Beauveria bassiana NBAIR Bb 5a @ 5 g/L + Azadirachtin 1500 ppm @ 2 ml/L (treatment 1) recorded significantly lowest number of aphids per 10 cm twig (49.23 aphids), while in untreated control it was 219.37 aphids. The number of coccinellids/ five plants was comparable with treatment 1 and the untreated control (2.876 and 2.705 coccinellids, respectively). Coccinellids number was significantly lower in treatment 2 (Imidacloprid 17.8 SL @ 0.4 ml/L) (Table 141).

Table 141. Effect of entomopathogens on mustard aphid and seed yield

Treatments	No. of aphids per 10 cm twig	No. of cocci-nellids per five plants	Seed yield (q/ha)
T_1 - *Beauveria bassiana* NBAIR Bb 5a (1 x 10^8 spores/g) @ 5 g/L + Azadirachtin 1500 ppm @ 2 ml/L	49.23	2.876	17.23
T_2 - Imidacloprid 17.8 SL @ 0.4 ml/L	63.71	0.867	15.75
T_3 - Untreated Control	219.37	2.705	12.54
C.D. at 5%	**1.872**	**0.541**	**0.756**

IV. 12. Biological Control of Sesame Pests

SKUAST - Jammu

IV. 12.1. Management of stem rot *Macrophomina phaseolina* in sesame using biocontrol agents

Number of treatments: 3;Number of replications: 7 Design: RBD

Results

Pseudomonas fluorescens NBAIR-PFDWD soil application @ 5 kg/ha (Treatment 1) recorded significantly lowest stem rot incidence followed by Carbendazim seed treatment @ 1 g/kg seed + carbendazim soil drenching @ 1 g/L (Treatment 2), while in untreated control it was the highest (35.34%) at 60 days after sowing. The root length and shoot length also varied. The seed yield was also highest in treatment 1. (Table 142).

Fig 44. field trials on sesame

Table 142. Effect of biocontrol agents on stem rot of sesame

Treatments	Germi-nation (%)	Root length (cm)	Shoot length (cm)	Stem rot inci-dence (%)		Yield (q/ha)	C:B ratio
				30 DAS	60 DAS		
T_1 - *Pseudomonas fluorescens* NBAIR-PF-DWD soil application @ 5 kg/ha	80.90	25.45	65.86	9.50 (17.95)	8.75 (17.21)	5.57	1 : 3.34
T_2 - Carbendazim seed treatment @ 1 g/kg seed + carbendazim soil drenching @ 1 g/L	78.60	24.78	60.94	16.60 (24.04)	15.80 (23.42)	4.38	1 : 2.56
T_3 - Carbendazim seed treatment @ 1 g/kg seed + carbendazim soil drenching @ 1 g/L	65.20	22.49	59.53	33.60 (35.43)	35.34 (36.48)	2.54	1 : 1.32
C.D. at 5%	**3.09**	**1.08**	**1.80**	**(3.07)**	**(2.86)**	**1.414**	**-**

FRUIT CROPS

IV. 13. Biological Control of Banana Pests

KAU, Thrissur

IV. 13.1. Evaluation of entomopathogens against banana pseudostem weevil, *Odoiporous longicollis*

The experiment to evaluate entomopathogens against banana pseudostem weevil, *Odoiporous longicollis* was laid out at Banana Research Station, Kannara. The experiment is in progress. The results will be presented after the completion of experiment.

Design: RBD Treatments: 3 Replications: 7

Plot size/replication: $50m^2$

Treatments:

T_1: Sucker treatment with talc formulation of *Beauveria bassiana* NBAIR Bb5a @ 20g/L + Soil drenching with NBAIR Bb5a @ 20g/L + Applicationof NBAIR Bb5a capsules in the leaf axils at 5,6 and 7 MAP + Applicationof NBAIR Bb5a capsules into the bore holes

T_2 : KAU POP recommendation

T_3: Control

Fig 45. View of experimental plot to evaluate entomopathogens against pseudostem weevil, *Odoiporous longicollis* at BRS, Kannara

IV. 14. Biological Control of Mango Pests

AAU, Anand

IV. 14.1. Large scale demonstration on bio-intensive management of mango hopper

T_1 BIPM module

1. 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 the month of 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

Results:

In all five locations, a varied population of mango hopper was noticed during off-season and flowering periods presented in Table 143. During the off-season, the highest population of mango hoppers was recorded in Nakhtrana (9.68/sweep) and the lowest population was recorded in the Dhangdhra (6.58/sweep). The BIPM module comprising microbial biopesticide *Metarhizium anisopliae* was found effective in reducing the mango hopper population. BIPM module recoded the lowest population in Dhangdhra (5.31/twig), Talala (6.79/twig) and Valsad (6.95/twig).However, in Nakhtrana chemical module (5.80/twig) recorded a lower population . The results of the large-scale demonstration highlight the successful biointensive management of mango hopper with microbial biopesticide *Metarhizium anisopliae* (NBAIR Ma-4) 1% WP.

Table 143. Efficacy of different modules on mango hopper population at different locations

Modules	Valsad		Talala		Dhangdhra		Navsari		Nakhatrana	
	Off season (mango hoppers / sweep)	Flowering (No. of Mango hoppers/ twig)	Off season (mango hoppers / sweep)	Flowering (No. of Mango hoppers/ twig)	Off season (mango hoppers / sweep)	Flowering (No. of Mango hoppers/ twig)	Off season (mango hoppers / sweep)	Flowering (No. of Mango hoppers/ twig)	Off season (mango hoppers / sweep)	Flowering (No. of Mango hoppers/ twig)
BIPM	2.98 (8.38)	2.73a (6.95)	2.91 (7.97)	2.70a (6.79)	2.97 (8.32)	2.41a (5.31)	2.81 (7.40)	2.78 (7.23)	3.19 (9.68)	2.86b (7.68)
Chemical	2.98 (8.38)	3.06b (8.86)	2.94 (8.14)	3.02b (8.62)	2.66 (6.58)	2.72b (6.90)	2.78 (7.23)	2.72 (6.90)	2.75 (7.06)	2.51a (5.80)
S. Em ± (T)	0.21	0.05	0.19	0.05	0.09	0.05	0.23	0.11	0.10	0.05
C.D. at 5 % T	NS	0.14	NS	0.14	0.28	0.13	NS	NS	0.29	0.15
C. V. (%)	10.48	9.83	8.90	9.87	10.76	10.53	10.09	10.73	10.57	11.60

Note: * Figures are √x + 0.5 transformed values whereas those in parentheses are retransformed values **NS**: Non-significant

IV. 15. Biological Control of Apple Pests

DrYSPUHF

IV. 15.1. Demonstration on 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 12 apple (cv Royal Delicious) orchards in Shimla, Kulluand Kinnaur districts covering an area of 5ha. (Table 144). *Metarhizium anisopliae* (10^8 conidia/g) was applied @ 30g/ tree basin mixed in well rotten farm yard manure (FYM). Chemical treatment comprising of chlorpyriphos (0.06%) was also maintained for comparison.

Table 144. Detail locations of the demonstrations :

Sl. No.	Location	Number of orchards	Mortality (%)
1	Kalpa, district- Kinnaur	3	70.66±2.23
2	Jubbal, district-Shimla	2	65.4±1.95
3	Bhunter (Kullu)	2	71.60±1.23
4	Kotkhai, district Shimla	3	66.6±1.29
5	Rohru district Shimla	2	63.6±0.70
	Mean±S.E (m)		67.57±1.53
6	Control	2	89.3±1.20
	Total	**12**	

Metarhizium anisopliae treatment resulted in 67.57 per cent mortality of the apple root borer grubs in different orchards, while in chlorpyriphos (0.06%) treated plants the grub mortality was 89.3 per cent. Farmers saved about Rs 12000/- per hectare by avoiding/reducing pesticide applications

SKUAST, Srinagar

IV. 15.2. Demonstration of Biointensive pest management module for codling moth, *Cydia pomonella* infesting apple in Ladakh (SKUAST -K)

The experiment was conducted in three villages of Kargil to study the impact of BIPM apple orchards as compared to non-BIPM orchards. Besides, a separate control was maintained to quantify the fruit damage, trap catch and yield. In non-BIPM plots, two sprays of chlorpriphos @1ml/liter were sprayed on the apple block at Minji,Whereas, no treatment was applied in the control plots. The BIPM plots were sprayed three times with *Baciliius thuringensis* @ 2ml/liter of water at complete petal fall, fruits let stage and last spray at fruit formation-1. The pheromone baited traps were installed at the biofix of the pest which was found on 10th of May. The trunk banding was done twice in the treated apple block in the last week of June and another during the last week of July. The *cydia* granulosis virus was sprayed in the treated blocks during first week of July. Data on per cent fruit damage, trap catch and yield was calculated in both BIPM and non-BIPM apple block using ANOVA followed by Tukey's test.

All the treatments differed significantly with respect to fruit damage, trap catch, per cent fruit drop and yield. Overall the per cent fruit damage in treated apple blocks varied from 10.50 to 17.5 %. While in the control apple block, fruit damage was observed to a tonne of 58.50%. The per cent reduction over control was highest in BIPM orchard blocks as compared to non-BIPM orchard blocks. The data on the per cent fruit drop was lowest in BIPM plots as compared to non-BIPM plots and highest fruit drop of 50.00% was observed in control plots. Both BIPM and non-BIPM treated plots showed significant yield as compared to control plots and trap catch was also lowest in BIPM treated plots revealed less fruit damage, fruit drop and trap catch, respectively. Analysis of the data for yield in Table-145 indicated highest yield in BIPM plots as compared to non- BIPM and control plots, respectively at (P=0.05%).

Table 145. Biointensive pest management module for codling moth, *Cydia pomonella* infesting apple in Ladakh

Treatments /Locations	Fruit damage (%)	Reduction over control (%)	Trap ctach	Fruit drop (%)	Yield/tree (Boxes)	C:B
T1 BIPM Saliskoot	10.5±1.75[b]	82.12	6±0.57[b]	5±0.57[b]	10±1.52[b]	5.33
T2 Minji	17.5±3.77[b]	70.21	8 .33±3.33[b]	20±4.04[b]	4±1.0[b]	2.66
T3 Trespone Control	58.5±7.11[a]	-	18±1.15[a]	50±5.77[a]	1±0.57 [b]	0.80
C.D(0.05)	0.001		0.014	0.001	0.003	

✦ Means followed by different letters in the same columns are significantly different by Tukey's test (P<0.01). Means followed are the Standard error of the respective treatments.The treatments with the same alphabetical letter are significantly different

SKUAST, Srinagar

IV. 15.3. Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite, Panonychus *ulmi* and two spotted spider mite on apple.

European red mite: Two releases of anthocorid bugs @ 200 (T1) and 400 (T2) /plant were made during 2022, and the mean population of ERM$^{-\text{ leaf}}$ was recorded as 7.3.40 (T1), 6.50 (T2), 1.30 (T3, Fenazaquin) and 11.5(T4, Untreated check) was found to be statistically significant (P= ≤ 0.001). Per cent reduction in population of European red mite over untreated control was 30.43 and 43.47.89 per cent respectively (Table 146) . The data was subjected ANOVA.

Two spotted spider mite: The anthocorid bug having high predatory potential against two spotted spider mite than the ERM.Mean population of TSSM $^{-\text{ leaf}}$ after one week was recorded as 2.95(T1, @ 200), 2.75(T2 @ 400), 1.25(T3, Fenazaquin) and 8.00 (T4, Untreated check) respectively (Table 147). The per cent reduction in the mite population over untreated control was recorded as 63.12 (T1), 65.62(T2) and 84.37 (T3) under field conditions

The recommended acaricide *i.e.,*Fenazaquin 40 EC @ 0.4 ml^{-1} was found superior over all other treatments.

Table 146. Impact of field releases of anthocorid bug, *Blaptostethus pallescens* against European red mite, *Panonychus ulmi* in high density apple in Kashmir during 2022

Treatment	No. of mites/ leaf		Mean population	% reduction in pop. over control
	3rd day after treatment	7th day after treatment		
200 bugs/plant(T1)	9.5±0.28[a]	6.5±0.76[b]	7.3±0.88[ab]	30.43
400bugs/ plant (T2)	8±1.52[a]	5±0.57[bc]	6.5±1.60[ab]	43.47
Fenazaquin @ 0.4 ml/lit. (T3)	2±0.57[b]	1.5±0.28[c]	1.3±0.35[b]	88.69
Untreated Check (T4)	10.5±0.76[a]	12.5±1.60[a]	11.5±2.02[a]	-
CD(0.05)	0.20	0.19	0.19	

Means followed by different letters in the same columns are significantly different by Tukey's test (P<0.01).Means followed ± are the Standard error of the respective treatments.The treatments with the same alphabetical letter are significantly different

Table 147. Impact of field releases of anthocorid bug, *Blaptostethus pallescens* against Two spotted spider mite, *Tetranychus urticae* in High density apple in Kashmir during 2022

Treatment	No. of mites/ leaf		Mean population	% reduction in pop. over control
	3rd day after treatment	7th day after treatment		
200 bugs/plant(T1)	2.4±0.87[ab]	3.5±0.86[b]	2.95±0.57[b]	63.12
400bugs/ plant (T2)	3.5±1.32[ab]	1 ±0[b]	2.75±0.25[b]	65.62
Fenazaquin @ 0.4 ml/lit. (T3)	1±0.01[b]	1.5±0.28[b]	1.25±0.14[b]	84.37
Untreated Check (T4)	7±1.52[a]	9±2.08[a]	8±0.57[a]	-
CD (0.05)	0.17	0.19	0.14	3.88

Means followed by different letters in the same columns are significantly different by Tukey's test ($P<0.01$).Means followed ± are the Standard error of the respective treatments.

IV. 16.Biological Control of Citrus Pests

DRYSRHU

IV. 16.1. Evaluation of different isolates of entomopathogenic fungi against citrus thrips

Centres: Tirupati

Status: New

Duration: 3 years, **Start date**: 2020

Objectives: To study the effect of different isolates of entomopathogenic fungi against citrus thrips

Methodology:

Experimental material: Existing orchard with 6 x 6m spacing.

Age of plants:8 years (Tirupati)

Design: RBD

Replications:5

Plants/replication: 3

Variety: Sathgudi

Observations: The per cent leaf infestation due to thrips on foliage at 0 days (pre count) and 3, 7 and 14 days after second spray and the percent infested fruits will be counted. The observed data for per cent thrips infestation on leaf and fruits infestation will be analysed statistically and the values will be converted into arc sine transformed values. The yield data will be recorded and expressed into tonnes/ha.

Time of spray**:** First spray at the peak activity of the pest and second at 14 days after first spray for thrips damaging leaf and in case of thrips, treatments should be initiated immediately after fruit set (10 days after flowering)

Results:Among the three entomopathogens evaluated, *Lecanicilium lecanii* @ 5g/L was found effective with least infestation by thrips on fruits (8.00%) as compared to *Beauveria bassiana* @ 5g/L (8.20%) and *Metarhizium anisopliae* @ 5g/L(9.35%) where the former and latter two treatments were on par with each other. Highest infestation was recorded in control with 16.15% fruits infested. Acephate treated trees recorded lowest damage by thrips on fruits (7.55%). Though T_4i.e.acephate produced higher fruit of 15.40 t/ha but it was on par with T1*(Beauveria bassiana*- 14.80 t/ha) and T3*(Lecanicilium lecanii*-14.00t/ha) and lower yield was noticed in control (9. 61 t/ha)

Table 148. Efficacy of entomopathogens against thrips infesting sweet orange

Treatments	Fruits infestation (%)	No. of fruits/tree	Yield (t/ha)
T_1:*Beauveria bassiana* (NBAIR Strain) @ 5g/Litre	8.20 (16.60)*	109.82	14.80
T_2: *Metarhizium anisopliae* (NBAIR Strain) @ 5g/Litre	9.35 (17.72)	101.04	12.70
T_3:*Lecanicilium lecanii* (NBAIR Strain) @ 5g/Litre	8.00 (16.41)	103.63	14.00
T_4:Local check (Acephate 75SP @ 0.1%)	7.55 (15.81)	117.50	15.40
T5: Control	16.15(23.68)	94.7	9.61
SE (m±)	0.61	1.08	0.81
CD at 5%	1.89	3.56	2.34

* Figures in parentheses angular transformed values

IV. 16.2. Evaluation of different isolates of entomopathogenic fungi against citrus Rust and Green mites

Centres: Tirupati

Status: New

Duration: 3 years, **Start date**: 2020

Objectives: To study the effect of different isolates of entomopathogenic fungi against citrus Rust and Green mites

Methodology:

Experimental material: Existing orchard with 6 x 6m spacing

Treatments should be given during active period of the pest twice at 15 days interval

Design: RBD

Replications: 4

Plant/replication: 2

Variety: Sathgudi

Observations: The population counts of mites before and 3, 7 and 14 days after treatment was recorded. In case of rust mites, observation on infested fruits (%) before harvest was noted and the yield data was expressed into tonnes/ha.The observed data for population counts on leaf and fruits infestation was analysed statistically and the values will be converted into square root and arc sine transformed values, respectively.

Results: Among the three entomopathogens evaluated, *Beauveria bassiana* @ 5g/L was found effective with lower infestation by rust mites on fruits (6.70%) while least infestation was recorded in propargite 57EC with 4.85%. With respect to green mites infestation on fruits, *Beauveria bassiana* @ 5g/L (7.55%) showed lower damage among entomopathogens tested. The standard check acaricide, propargite 57EC showed least damage of green mites damage i.e. 5.20%. The yield data showed that though T4 produced higher yield of 17.08t/ha but it was on par with T_1 (17.06t/ha) and minimum yield was recorded in control (12.87t/ha).

Table 149. Efficacy of entomopathogens against mites infesting sweet orange

Treatments	Fruits infestation		No. of fruits/tree	Yield (t/ ha)
	rust mites (%)	green mites (%)		
T :*Beauveria bassiana* (NBAIR Strain) @ 5g/Litre	6.70 (14.96)*	7.55 (15.81)*	220.53	17.06
T^1:*Metarhizium anisopliae* (NBAIR Strain) @ 5g/Litre	9.35 (17.72)	10.50 (18.83)	207.00	16.03
T^2:*Lecanicilium lecanii* (NBAIR Strain) @ 5g/Litre	8.20 (16.60)	9.85 (18.25)	185. 20	14.75
T^3:Local check (Propargite 57EC @ 0.1%)	4.85 (12.69)	5.20 (13.16)	216.99	17.08
$T^4$5: Control	17.50 (24.71)	15.70 (23.33)	158.34	12.87
SE (m±)	1.11	0.85	1.16	1.90
CD at 5%	3.38	2.59	3.52	5.77
CV at 5%	9.17	10.04	7.45	12.00

*Figures in parentheses angular transformed values

IV. 17. Biological Control of Litchi Pests

PAU, Ludhiana

IV. 17.1. Bio-intensive management of litchi fruit borer, *Conopomorpha sinensis* in litchi

The experiment was conducted during *Kharif*, 2022 at PAU Fruit Research Station, Gangian (Hoshiarpur) in collaboration with Scientists from the Department of Fruit Science, PAU Ludhiana and Fruit Research Station, Gangian. The area was divided into three blocks representing three treatments, viz. BIPM, farmer's practice and untreated control. Each block was further divided into 10 units (each unit representing one replication). The observations were recorded by collecting 100 fruits from each unit and per cent damage was worked out based on total and infested fruits. Fruit yield was recorded on a tree basis and converted to quintals per acre.

Treatments

1. **BIPM**
   - Ploughing in orchard during March-April
   - Regular clean cultivation throughout the year
   - Regular collection and destruction of fallen infested fruits during May-June
   - Releases of *T. embryophagum* @ 4000 parasitized eggs per tree 6 times at 7-10 days intervals starting from fruit initiation to colour break stage
2. **Farmer's practice (chemical control)** – 2 sprays of quinalphos 25 EC @ 2 ml/litre of water and 1 spray of Fenvelarate 20 EC @ 2.5 ml/ litre of water
3. **Untreated control**

The fruit damage (10.90 %) in BIPM practices (involving ploughing in the orchard during March-April, regular clean cultivation, regular collection and destruction of fallen infested fruits during May-June and releases of *T. embryophagum* @ 4000 parasitized eggs per tree 6 times at 7-10 days interval starting from fruit initiation to colour break stage) was not significantly different from farmer's practice, i.e. chemical control (9.80 %). However, significantly higher damage was recorded in the untreated control (30.40%). The reduction in fruit damage over untreated control was 64.14 and 67.76 per cent in BIPM and chemical control, respectively (Table 150). The yield in BIPM (65.23 q/acre) was also at par with the farmer's practice (66.82 q/acre). However, the lowest yield was recorded in the untreated control (43.13 q/acre).

Table 150. Bio-intensive management of litchi fruit borer, *Conopomorpha sinensis* in litchi

Treatments	Per cent infested fruits (%)	% reduction over control	Marketable yield (q/acre)
BIPM	10.90 (19.12)	64.14	65.23
Farmer's Practice (chemical control)	9.80 (18.11)	67.76	66.82
Untreated control	30.40 (33.41)	-	43.13
CD (p=0.05)	(2.36)	-	5.75
CV (%)	10.67	-	10.48

Figures in parentheses are arc sine transformed values

Fig 46. Field release of *T. embryophagum* in litchi

PLANTATION CROPS

IV. 18. Biological Control of Coconut Pests

IV. 18.1. Surveillance of rugose spiraling whitefly in coconut and population of natural biocontrol agents

ICAR-CPCRI, Kasaragod: Population dynamics of two exotic whiteflies *viz.,* rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* and Bondar's nesting whitefly (BNW), *Paraleyrodes bondari* as well as the parasitism by *Encarsia guadeloupae* on RSW are presented in Fig 47 and Fig 48, respectively

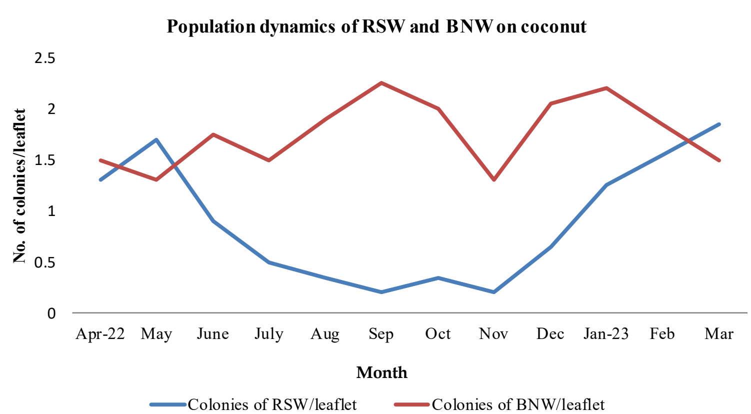


Fig. 47. Population dynamics of RSW and BNW on Kalparaksha palms at Kayamkulam

RSW population ranged from 0.25 to 1.75 live colonies per leaflet whereas BNW population ranged from 1.25 to 2.25 live colonies per leaflet. BNW is prevalent in higher population range than RSW, which has wider range values. Parasitism by *E. guadeloupae* on RSW ranged from 20% to 42.5% synchronizing with elevated RSW population. Weather factors and parasitism play a major role in population regulation of exotic whiteflies in coconut.

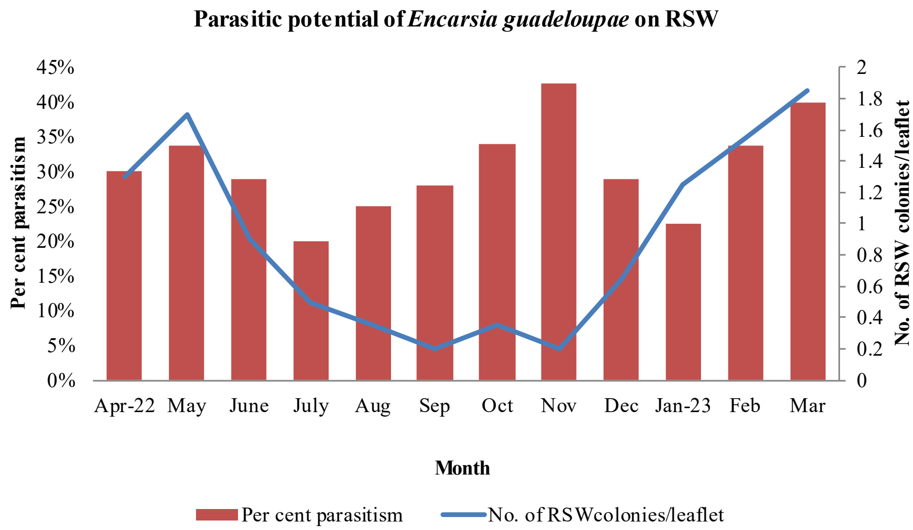


Fig 48. Parasitic potential of *Encarsia guadeloupae* on RSW

IV. 18.2. Biological suppression of rugose spiraling whitefly in coconut

RARS, Anakapalle: Per cent reduction in rugose spiraling whitefly intensity was maximum (57.41%) with foliar apllication of *Isaria fumosorosea* NBAIR Pfu5 @ 5 g/L (two sprays) and augmentation of *Encarsia guadeloupae* (T1). This results followed by foliar application of *Isaria fumosorosea* NBAIR Pfu5@ 5 g/L and augmentation of predator, *Apertochrysa astur* result (50.81%) and application of neem formulation 10000 ppm @ 5 ml/L two times (23.57 %) reduction of RSW infestation (Table 151).

Table 151. Efficacy of entomopathogenic fungi, *Isaria fumosorosea* in management of rugose spiraling whitefly

Location	Before Spray			After first Spray		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	62.24	43.25	22.3	26.62	11.67	14.22	18.42	6.23	38.45	57.41
T_2	59.67	41.33	26.13	31.43	12.50	16.89	20.33	6.88	23.95	50.81
T_3	65.33	46.67	47.5	38.67	28.33	22.5	35.67	20.92	17.14	23.57

*T1: Spraying of *Isaria fumosorosea* (Pfu-5) at 5 ml/L + parasitoid, *Encarsia guadeloupae*; T2: Spraying of *Isaria fumosorosea* (Pfu-5) + predator, *Apertochrysa astur*; T3: Spraying of neem formulation 10000 ppm at 5 ml/L

ICAR-CPCRI, Kayamkulam: Bio-suppression of the exotic rugose spiraling whitefly, *Aleurodicusrugioperculatus* using the entomopathogen, *Isaria fumosorosea* (ICAR-NBAIR Pfu-5), neem oil (0.5%) and conservation biological control (Conservation of parasitoid, *Encarsia guadeloupae*) is presented in

Table 152. RSW population was found to be very low ranging from 0.29 to 0.7 live colonies per leaflet as pre-treatment count. All treatments were found effective in pest regulation and are non-significant. Conservation biological control was found to be equally effective as that of palms sprayed with *I. fumosorosea* as well as neem oil. There was an increase in pest population 60 days after treatment, and the least observed in palms sprayed with neem oil. Parasitism by *Encarsia guadeloupae* was found to be ranging from 21% to 27% in all treated palms.

Table 152. Biological suppression of rugose spiraling whitefly

Treatments	RSW population (No. of colonies / leaflet)*					Parasitism (%)
	Pre-treatment	After 15 days	After 45 days	After 60 days	Reduction (%)	
T1: Isariafumosorosea (5g /L)	0.57 (0.69)	0.30 (0.25)	0.05 (0.10)	1.53 (0.72)	-168.33	21.29
Neem oil (0.5%)	0.54 (0.73)	0.50 (0.32)	0.50 (0.32)	0.57 (0.24)	-6.67	27.17
Conservation biological control	0.29 (0.39)	0.96 (0.52)	0.61 (0.38)	0.64 (0.19)	-122.73	25.49
CD (P=0.05)	NS	NS	NS	NS	-	-

*Values in parentheses are square root transformed values

DRYSRHU, Ambajipeta: The first spray was initiated on second week or January, 2023 at Ganagalakurru Agraharam village of Ambajipeta mandal and subsequent spray at 15 days interval. Data on survival of various stages of whitefly population were transformed into √x+0.5 values before subjecting to analysis of variance (Table 153). The experiment was carried out in 5-7 years old Godavari ganga variety and with low to medium incidence of RSW. There was no significant difference in various stages of RSW in the pre-treatment count (Table 153). Fifteen days after treatment imposition, lowest number of nymphs were recorded in neem oil spray and *I. fumosorosea* treatment (1.62 and 3.54 nymphs, respectively). A high number of 13.42 nymphs per leaflet were observed in Control. After 15 days after second spray, lowest number of nymphs were recorded in neem oil and *I. fumosorosea* treatments (0.98 and 1.72 nymphs). The lowest number of RSW infested leaflets /leaf was observed (intensity) in neem oil treatment (Table 154).

Table 153. RSW population in various treatments before treatments imposition and 15 days after first spray

Treatments	Leaves infested with RSW/ palm (Incidence %)**	RSW infested leaflets /leaf (from 4 sample leaves/palm (Intensity %) **	Number of live population/ leaflet			Para-sitized nymphs / pupae	Predator *A.astur*	Spiders
			Egg	Nymph	Adult			
T_1 - *I. fumosorosea* spray (5g / L)	86.23 (68.46)	75.90 (60.96)	6.03 (2.53)	7.42 (2.70)	8.34 (2.89)	2.89 (1.83)	1.75 (1.43)	1.40 (1.21)
T_2- Neem oil spray	83.19 (66.54)	74.83 (60.15)	5.25 (2.37)	7.71 (2.80)	8.19 (2.76)	2.74 (1.78)	1.97 (1.46)	1.90 (1.43)
T_3- Control	84.99 (67.41)	75.10 (60.34)	5.40 (2.42)	9.17 (3.05)	11.90 (3.30)	3.30 (1.92)	2.05 (1.53)	1.60 (1.31)

SEm	-	-	-	-	-	-	-	-
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS
RSW population in various treatments 15 days after first spray imposition								
T_1 - *I. fumosorosea* spray (5g/L)	80.91 (64.69)	64.18 (53.43)	3.54 (1.89)	3.21 (1.74)	7.38 (2.74)	4.16 (2.14)	2.53 (1.73)	0.80 (1.04)
T_2- Neem oil spray	67.69 (55.83)	53.90 (47.29)	1.62 (1.37)	2.27 (1.58)	6.83 (2.67)	3.03 (1.86)	1.68 (1.46)	0.40 (0.89)
T_3- Control	86.45 (68.59)	80.02 (63.83)	13.42 (3.71)	17.43 (4.22)	16.75 (4.11)	5.37 (2.39)	3.25 (1.92)	1.90 (1.49)
SEm	1.79	1.81	0.17	0.24	0.19	0.11	0.07	0.14
CD (5%)	5.32	5.39	0.52	0.72	0.57	0.35	0.19	0.42

** Fig in parenthesis are arc sign transformed values; Fig in parenthesis are √x+0.5 transformed values

Table 154. RSW population in various treatments 15 days after second spray

Treatments	Leaves infested with RSW/ palm (Incidence %)**	RSW infested leaflets /leaf (from 4 sample leaves/palm (Intensity %) **	Number of live population/ leaflet			Parasitized nymphs / pupae	Predator *A.astur*	Spiders
			Egg	Nymph	Adult			
T_1 - *I. fumosorosea* spray (5g/L)	71.45 (58.30)	50.45 (45.25)	1.72 (1.44)	2.09 (1.52)	3.68 (1.96)	5.35 (2.36)	3.74 (2.02)	0.60 (0.97)
T_2- Neem oil spray	57.75 (49.52)	48.30 (44.01)	0.98 (1.17)	1.70 (1.41)	2.25 (1.55)	3.14 (1.83)	2.22 (1.64)	0.20 (0.81)
T_3- Control	88.62 (70.66)	82.55 (65.85)	16.95 (4.13)	20.27 (4.53)	22.45 (4.77)	5.85 (2.47)	4.10 (2.09)	2.20 (1.58)
SEm	1.68	1.96	0.16	0.15	0.16	0.17	0.12	0.10
CD (5%)	5.01	5.85	0.47	0.46	0.48	0.52	0.37	0.31

** Fig in parenthesis are arc sign transformed values; Fig in parenthesis are √x+0.5 transformed values

IV. 18.3. Large scale suppression of rugose spiraling whitefly using parasitoid *Encarsia guadeloupae* and *Apertochyrsa astur.*

TNAU, Coimbatore: Bio-intensive integrated pest management (BIPM) module ie., *Encarsia guadeloupae* natural conservation + Release of *Apertochyrsa astur* eggs @ 1000/ha + Yellow sticky traps @ 20/ha was demonstrated in Anaimalai Block, Coimbatore. In BIPM field, there was 75.31 % reduction in the population of rugose spiraling whitefly while in control plot there was 41.71 % reduction in RSW population after six months. In case of Bondars nesting whitefly, 66.24 and 38.29 % reduction was observed in BIPM module and control respectively. *Encarsia guadeloupae* parasitisation was increased to the tune of 51.92 % in BIPM module. There was 56.86 and 38.14 % increase in the population of *Apertochyrs aastur* in BIPM module and control respectively (Tables 155-157).

Table 155. Effect of BIPM module of rugose spiraling whitefly and Bondars nesting whitefly in coconut in Coimbatore

Treatments	Population of RSW/leaflet*				Population of BNW/leaflet*			
	Pre treat ment	Two months	Four months	Six months	Pre treat ment	Two months	Four months	Six months
BIPM Module	13.57 (3.57)	9.78 (3.12)[a]	6.85(2.61)[a]	3.35(1.82)[a]	16.35 (3.91)	11.64 (3.41)[a]	8.35 (2.89)[a]	5.52 (2.34)[a]

Control	15.92 (3.91)	13.71 (3.69)[b]	11.42 (3.37)[b]	9.28 (3.04)[b]	15.28 (3.81)	12.43 (3.52)[b]	10.79 (3.28)[b]	9.43 (3.06)[b]
SEd	NS	0.174	0.129	0.141	NS	0.051	0.122	0.130
CD (P = 0.05)	NS	0.366	0.271	0.296	NS	0.108	0.256	0.274

Figures in parentheses are arcsine transformed values* *and square root transformed values*; In a column means followed by same letter(s) are not significantly different (p=0.05) by LSD. Values are mean of seven replications.

Table 156. Effect of BIPM module of natural enemies of whiteflies in coconut in Coimbatore

Treatments	*Encarsia guadeloupae* parasitisation (%) **				*Apertochrys aastur* (Grub/10 leaflets)*				RSW trapped in yellow sticky trap in 180 days (nos/ trap) *
	Pre treat ment	Two months	Four months	Six months	Pre treat ment	Two months	Four months	Six months	
BIPM Module	34.71 (35.79)	40.05 (39.26)[a]	47.36 (43.49)[a]	52.73 (46.57)[a]	10.43 (3.14)	12.36 (3.51)[a]	14.43 (3.79)[a]	16.36 (4.04)[a]	2683 (51.79)[a]
Control	35.07 (36.04)	37.85 (37.97)[b]	40.74 (39.65)[b]	42.67 (40.78)[b]	9.36 (2.97)	11.29 (3.36)[b]	12.07 (3.47)[b]	12.93 (3.58)[b]	0 (0.71)[b]
SEd	NS	0.475	1.075	0.509	NS	0.038	0.088	0.107	0.489
CD (P = 0.05)	NS	0.998	2.257	1.070	NS	0.081	0.184	0.224	1.026

Figures in parentheses are arcsine transformed values* *and square root transformed values*In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD Values are mean of seven replications

Table 157. Effect of BIPM module on whiteflies and their natural enemies in coconut in Coimbatore

Treat-ments	Reduction in population of RSW from pre - treatment count (%)			Reduction in population of BNW from pre - treatment count (%)			Increase in *Encarsia guadelouape* parasitisation from pre - treatment count (%)			Increase in *Apertochrysa astur* grubs from pre - treatment count (%)		
	Two months	Four months	Six months	Two months	Four months	Six months	Two months	Four months	Six months	Two months	Four months	Six months
BIPM Module	27.93	49.52	75.31	28.81	48.93	66.24	15.38	36.44	51.92	18.50	38.35	56.86
Control	13.88	28.27	41.71	18.65	29.38	38.29	7.93	16.17	21.67	20.62	28.95	38.14

IV. 18.4. Area-wide demonstration of biological suppression of black headed caterpillar using *Goniozus nephantidis* and *Bracon brevicornis*

ICAR-CPCRI, Kayamkulam: Regular monitoring on the incidence and reduction (%) of black headed caterpillar, *Opisina arenosella* in Kerala (table 158). Systematic release of stage specific parasitoids (*Goniozus nephantidis* & *Bracon brevicornis*) could reduce the pest incidence from 30.6% to 0.6% in a period of three years. Percentage reduction of pest population ranged from 62.7% to 98.0% in three years period with recoupment of palm health. Classic example of successful biological suppression of coconut black headed caterpillar.

Table 158. Incidence of black headed caterpillar over years after release of parastioids

Period	Pest Incidence (%)	Reduction (%)
October 2019	30.6	-
March 2020	11.4	62.7
August 2020	3.3	89.2
March 2021	1.1	96.4
August 2021	0.5	98.4
March 2022	0.7	97.7
August 2022	0.6	98.0

IV. 18.5. Converging biological suppression approaches for area-wide management of coconut rhinoceros beetle

ICAR-CPCRI, Kayamkulam: The damage caused by coconut rhinoceros beetle on spear leaf and fronds are assessed and the leaf damage after incorporation of *Metarhizium majus* in to breeding zone in Vallikunnam panchayat are presented in Table 159. Damage by coconut rhinoceros beetle on fronds and spear leaf after incorporation of *Metarhizium majus* in to the breeding sites was reduced 25.5% and 27.9%, respectively. Ease is field application and creation of mass awareness for the whole panchayat is the success of the programme which had greater penetration of the technology. Farmers are realizing the success of the area-wide field delivery of *M. majus* (Fig 49).

Table 159. Leaf damage by coconut rhinoceros beetle

Treatments (n=25)	Frond infested per palm (%)	Leaf damage (%)	Spear leaf damage (%)
Before treatment	4.19	21.5	40.8
After treatment	3.12	17.6	29.4*
Reduction (%)	25.5	18.1	27.9

*Significant t<0.05

Fig 49. Technological awareness and distribution of *Metarhizium majus*

VEGETABLE CROPS

IV. 19. Biological control of Tomato Pests

IV.19.1. Demonstration on bio-intensive management of insect pests of tomato (YSPUHF, Solan; SKUAST, Srinagar; AAU, Jorhat; PJTSAU, Hyderabad & CAU, Pasighat)

YSPUHF, Solan

Demonstration on the bio-intensive management of tomato pests was laid at three locations namely Karganoo, Narag and Deothi covering an area of 1ha. Bio-intensive Integrated Pest Management (BIPM) module, targeting mainly *Tuta absoluta, Helicoverpa armigera* and sucking pests, comprised of spraying of *Lecanicillium lecanii* (5g/L of 10^8 conidia/g), pheromone trap (PCI)@ 20/ha, six releases of *Trichogramma achaeae* and *T. chilonis* @ 50000/ha, sprays of azadirachtin 1500ppm @ 2ml/L. For comparison, chemical plots where 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* from mid-July till the final harvest of the crop i.e. mid-September. Observations on the number of mines per leaf, number of infested fruits were recorded on 100 randomly selected plants per plot. Yield data at each picking were recorded and pooled to get the total yield, which were extrapolated to get yield per hectare. The data were compared by t-test and the results of the experiment are presented in Tables 160 and 161.

Incidence of *T. absoluta*:

The number of mines by *Tuta absoluta* was recorded in the second week of July were statistically on par in both the plots and varied from 0.53 to 0.76 mines/leaf. Seasonally the mine density remained nearly same in both the plots and varied from 0.53 to 0.93 mines per leaf in BIPM plots and 0.76 to 1.03 mines per leaf in chemical plots (Table 160).

Table 160.*Tuta* infestation on tomato leaves

Treatment	Mines/leaf on indicated weeks			
	July II	July IV	August II	August IV
BIPM	0.53 ± 0.54a	0.83 ± 0.57	0.93 ± 0.51	0.96± 0.07
Chemical control	0.76 ± 0.12a	1.03 ± 0.12	0.83 ± 0.16	1.03 ± 0.07
t-value	-1.7565	-1.4457	0.4370	-0.6060
P<0.05	0.0960	0.1654	0.6672	0.5520

Similarly, the fruit infestation in the BIPM and Chemical plots remained almost same throughout the season and varied from 2.88 to 3.85 per cent in BIPM plots and 2.72 to 3.64 per cent in chemical plots (Table 160). The yield recorded in BIPM plots (32.67t/ha) was also statistically on par with that recorded in chemical treated plots (31.46t/ha).

Table 161. *Tuta* infestation on tomato fruit

Treatment	Mines/leaf on indicated weeks					Yield(t/ha)
	July II	July IV	August II	August IV	September	
BIPM	3.10±0.23	3.10±0.23	3.85±0.19	2.88±0.15	2.92±0.15	32.67±1.20
Chemical control	2.72±0.13	2.76±0.15	3.64±0.14	2.75±0.13	2.86±0.14	31.46±0.55
t-value	1.3808	1.2017	0.8662	0.6292	0.2897	0.9114
P<0.05	0.1842	0.2450	0.3977	0.5370	0.7753	0.3741

The incidence of *H. armigera* persisted throughout the cropping season, but its population was very low.

SKUAST, Srinagar

BIPM plots showed significantly less fruit damage as compared to non-BIPM plots and was found statistically significant (P= ≤ 0.001). Per cent reduction in fruit borer damage over untreated control was 80.00% in BIPM and 40.00 % in non-BIPM plots, respectively (Table 162). Whereas, the % fruit damage in BIPM plots was 2.00 % and the highest fruit damage of 10.00 % was observed in the control treatment. The highest yield of tomato (24500 kgs/ ha) was observed in BIPM plots and the control plots resulted (8800 kgs/ha). The C: B ratio is higher in BIPM plots as compared to control and non-BIPM plots respectively, and were found significant at (P= ≤ 0.001).

Table162. Demonstration of bio intensive pest management practices for the management of insect pests of tomato

Treatments /Locations	Fruit damage (%)	Reduction over control(%)	Aphids/leaf	Yield/ha (Kgs)	Yield reduction over treatment	C:B
T1: BIPM Srinagar	2±0.57[b]	80.00	0.2±0.05[a]	24500±763.7[b]	64.08	2.72
T2 : Harwan	6±1.15[ab]	40.00	0.33±0.13[a]	20785±2968.5[a]	57.66	2.30
T3: Control	10±2.08[a]	-	0.5±0.1 [a]	8800±1665.3[a]		1.00
C.D(0.05)	0.020		0.194	4.230		

Means followed by different letters in the same columns are significantly different by Tukey's test (P<0.01). Means followed ± are the Standard error of the respective treatments.The treatments with the same alphabetical letter are significantly different

AAU, Jorhat

The trial was undertaken in Bhahphala, Jorhat and Maharichuck, Majuli with Namdhari F1 hybrid. The fruit borer damage was reduced to 72.17% in BIPM Plot against 78.71% in chemical treated plots. There was no significant difference in between yield of BIPM (6785 kg/ha) and chemical treated plots (7164 kg/ha) with B:C ratio 1:2.86 and 1:3.48, respectively.

PJTSAU, Hyderabad

The trial was conducted in Mankhal Village, Maheshwaram Mandal in farmer's field. BIPM plots recorded 1.83 mined leaves/plant, 2.50 mirids/plant, 5.75% fruit damage and 738 kg/plot as yield which was higher than control plot (2.71 mined leaves/plot, 3.02 mirids/plant, 12.5% fruit damage and 267 kg/plot yield) but lower than Farmers' practices plot (1.48 mined leaves/plot, 1.96 mirids/plant, 3.75% fruit damage and 960 kg/plot yield). Benefit: cost ratio was1.98 in BIPM package and 1.58 in Farmers' practices.

CAU, Pasighat

The trial was conducted during *rabi* 2022-23 in farmers field at Jampani, Jorkong and Namsimg villages, East Siang district in 1 ha area with Arka Rakshak variety. Results revealed, there was no significant differences recorded between BIPM and POP (Chemical control) modules except for the coccinellid beetles which are found highest in BIPM module (1.62/plant). However, the POP module recorded comparatively lower incidence of fruit borers (0.70 larvae/plant) and the level fruit damage was 4.70 %. The yield recorded in BIPM (13.60 q/ha) was statistically on par with the POP module (14.40 q/ha). However, C:B ratio was higher in BIPM module 1.86 as compared to 1.35 against POP module.

IV. 19.2. Large scale field trials for the management of *Helicoverpa armigera* on Tomato(MPUAT)

The trial was conducted during *rabi* 2022-23 in farmers field at Pilader and Bovas (Jaisamand) with three treatments as detailed below.

T1 = BIPM

- Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds.
- Azadirachtin 1500 ppm @ 2 ml/lit.
- Raising of marigold as trap crop
- Spraying of *Lecanicillium lecanii* NBAIR VI-8 (1×10^8spores/g) @ 5g/L and installation of yellow sticky trap @50 number/ha for sucking pests
- Release of *Trichogramma chilonis* @ 50,000/ha per release (6 releases) from flower initiation stage at weekly intervals for fruit borer
- *Trichogramma achaeae* @ 50,000/ ha per release (6 releases) for pinworm
- Installation of Pheromone traps @ 20/ha against fruit borer and pinworm
- *Beauveria bassiana* @ $1x10^8$ conidia /g, @ 5g/lt – 2 sprays at 15 days interval
- Spray of HaNPV ($1.5x10^{12}$ POBS/ha) twice during the peak flowering and at fruit setting stage at 15 days interval.
- *Bacillus thuringiensis* @ 1kg/ha^{-1} two times during season at 15 days interval

T2 = Chemical control

- Spinosad 45 SC @ 0.25 ml/l

T3 = Untreated Control

Results revealed 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. The highest fruit damage (46.18%) and larval population (5.47 larvae/ plant) was found in untreated control followed by BIPM package and Chemical control. BIPM package was equally effective as chemical control against *H. armigera*. Chemical control module recorded the highest yield (14.92 t/ha) which was at par with the yield recorded in BIPM package (13.0 t/ha). Significantly, low yield was recorded in untreated control (6.84 t/ha). It could be concluded that BIPM package had promising results in minimizing the pest damage with higher yield.

IV. 19.3. Evaluation of predatory mite, *N. longispinosus* for the management of spider mite, *T. urticae* in tomato under polyhouse(YSPUHF, Solan)

Results revealed the release of predatory mite, *N. longispinosus* @ 10 per plant (T_1) resulted lowest (1.33 mite per cm^2/leaf) which was statistically at par with T_2 (3 releases of an anthocorid predator *B. pallescens* @ 20 per plant at weekly interval), T_3 (Spiromesifen 240 SC @100 g.a.i.ha^{-1}at 15 days interval) and differed statistically with T_4 (Control). Similarly, the per cent leaf damage was lowest (6.66 %) with release of predatory mite, *N. longispinosus* @ 10 per plant (T_1) which was statistically at par with T_2 and differed with T_3. Per cent reduction in mite population was also highest (88.24%) withT_1(Release of predatory mite, *N. longispinosus* @ 10 per plant).The yield (450.83 q/ha) recorded with T_1 was statistically at par with T_2(*B. pallescens* @ 20 per plant) and T3 (Spiromesifen). However, yield recorded with spiromesifen was maximum (468.83 q/ha) among all the treatments with per cent reduction in leaf damage was 88.24 % (Table 163).

Table 163. Effect of predatory mite, *N. longispinosus* for the management of spider mite, *T. urticae* in tomato under polyhouse

Treatment	Population of mite per cm^2 per leaf		Per cent leaf damage (%)		Per cent pest reduction over control (%)	Yield (Kg/ha)	Increase in yield over Control (%)
	Pretreatment Count	Post treatment Count	Pre treatment	Post treatment			
T1 *N. longispinosus* @10 per plant; 3 releases of predatory mite at weekly interval	2.83 (1.95)	1.33 (1.48)	12.50 (20.60)	6.66 (14.75)	88.24	450.83	70.65

T_2 *B. pallescens* @ 20 per plant; 3 releases of predatory mite at weekly interval	3.16 (2.03)	1.50 (1.55)	13.33 (21.33)	9.17 (17.12)	83.81	431.66	63.40
T_{3-} Spiromesifen 240 SC @100 g.a.i.ha^{-1}at 15 days interval	3.33 (2.06)	0.83 (1.34)	15.83 (23.41)	2.50 (6.46)	95.58	468.83	77.47
T_{4-} Control	3.33 (2.04)	14.17 (3.88)	14.17 (21.96)	56.66 (48.86)	-	264.17	-
CD	NS	0.35	NS	6.31	-	62.71	-
S.Em	0.13	0.12	0.97	2.07	-	20.62	-

IV. 20. Biological control of Brinjal Pests

IV. 20.1. Demonstration of bio intensive management practices for the management of fruit and shoot borer in brinjal (KAU, Vellayani; TNAU, Coimbatore & PJTSAU, Hyderabad)

KAU, Vellayani

The experiment was laid out in December 2022 at Kakkamoola, under Kalliyoor Krishi bhavan in an area of 50 cents (0.2ha). Experiment was laid out in RBD with 2 treatments replicated 14 times.The treatments were,

T1: BIPM Module

- Use of pheromone traps for mass trapping @30/ha against fruit borer (Sun Agro's product)
- Release of *Trichogramma chilonis* @ 100,000/release against brinjal fruit and shoot borer, 10-12 releases to be made at 30 days after transplanting & need based spray of *Bacillus thuringiensis* (NBAIRBtG4) 2ml/L
- *Lecanicillium lecanii*Vl 8(1 x 10^8 spores/ ml @ 5g/L) for sucking pests.
- *Heterorhabditis indica* NBAIR H38 @ 2.5 10^9 IJs ha-1

T2 = POP Recommendation – removal of affected shoots and spraying chlorantraniliprole 18.5 Sc @ 30ai/ha (2ml/100 L)

Results revealed BIPM package was equally good as KAU PoP as the number of shoots damaged were on par and there was no significant variation in yield among the two treatments. However, there was no damage at all during the later part of the experiment in plots treated with chlorantraniliprole 18.5 SC @ 30 ai/ha (2ml/100 L)- KAU PoP.

TNAU, Coimbatore

The fruit damage in brinjal due to *Leucinodes orbonalis* was significantly low (24.41%) in plots sprayed with pesticides followed by 30.65 per cent fruit damage in BIPM plots (*Bacillus thuringiensis* (NBAIR BtG4) 2ml/L (two rounds of spray) + *Lecanicillium lecanii* (one round of spray) + *Trichogramma chilonis* (8 releases) + Pheromone traps @20/ha). In the control plot, fruit damage was 52.68 per cent. The marketable fruit yield was 14822Kg/ha in BIPM plots while in control plots the yield was 10975Kg/ha. The cost benefit ratio realized in BIPM was 1:3.156 as against 1:3.315 in insecticides treated plots (Table 164).

Table 164. Bio-intensive insect management in brinjal

Treatments	Pretreatment damage %	Fruit damage %	% decrease over control	Yield Kg/ha (Marketable fruits)	% increase over control	CB ratio
T1: BIPM – Module	43.46 (41.16)	30.65 (33.61)[b]	41.81	14822 (121.65)[a]	35.05	3.156

T2: Insecticide	42.89 (40.78)	24.41 (29.59)[a]	53.67	15592 (124.69)[a]	42.07	3.315
T3: Control	45.23 (42.15)	52.68 (46.54)[c]	-	10975 (104.62)[b]	-	2.347
SEd	-	0.439	-	2.78	-	-
CD(P=0.05)	-	0.921	-	5.838	-	-

Values are mean of ten replications
Figures in parentheses are arcsine transformed values
In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD

PJTSAU, Hyderabad

The trial was laid out during January, 2022 with brinjal variety Gulabi with following treatments

T1 = BIPM

For sucking pests

Beauveria bassiana NBAIR strain Bb 5a @ 10^8 conidia/ ml @ 5ml/L

Neem oil 1500 ppm @ 5ml/L

Lecanicillium lecanii (NBAIR strainVL8) 10^8 spores/ml @ 5ml/L

For shoot and fruit borer

Release of *Trichogramma pretiosum* @100,000/ha, 8-10 releases at weekly interval from a month after sowing.

Bacillus thuringiensis NBAII *Bt* G42%

Pheromone traps @ 10/acre

T2: Chemical control

For sucking pests – Imidacloprid @ 0.5 ml/L

For BSFB- Flubendiamide - 0.3-0.5ml/L

T3: Untreated control

Results revealed BIPM package recorded lesser leafhopper incidence (4.90/plant) and was on par with the farmers' practices (3.93/plant) while control recorded higher leafhopper incidence (8.24/plant). Effect of shoot and fruit borer was also lesser in the BIPM and Farmer's plots compared to control. BIPM plots recorded 16.84% damage of shoots and 13.9% fruit damage (Table 165), while Farmers' practices recorded 12.19 and 10.90 % damage of shoots and fruits respectively, while untreated control registered maximum shoot and fruit damage (25.75 and 35.40 %). Yield was higher in farmer's practice 78.66q/acre, while in BIPM package it was 51.38q/acre, untreated control it was least 24.56q/acre.

Table 165. Impact of BIPM package on pests in brinjal

Treatment	Leafhopper incidence (Mean no/3 leaves in a plant)	Incidence of Shoot and fruit borer (Mean of 7 quadrats)		Yield (q/acre)	Gross returns (Rs.)	Costs (Rs.)	Benefit: cost ratio
		Shoot damage (%)	Fruit damage (%)				
BIPM package	4.90 (2.21)[a]	16.84 (4.10)[b]	13.9 (3.73)[b]	39.38	55132.00	Rs.12000	3.59
Farmers' Practices	3.93 (1.98)[a]	12.19 (3.48)[a]	10.9 (3.29)[a]	45.99	64386.00	Rs.13000	3.95

Untreated control	8.24 (2.84)^b	25.72 (5.07)^c	35.4 (5.95)^c	14.25	19,950.00	-	-
CD (5%)	0.33	0.29	0.21	6.71			
CV	11.98	11.88	4.25	11.28			

Sale price of Brinjal: Rs.1400/q

IV. 20.2. Large scale field trials for the management of brinjal shoot and fruit borer *Leucinodes orbonalis* on Brinjal (MPUAT)

The trial was conducted during *rabi* 2022-23 in farmers field at Pilader and Oda (Jaisamand) with five treatments as detailed below.

T_1 = *Beauveria bassiana* @ 1x10^8 conidia /g, @ 5g/lt – 2 sprays at 15 days interval

T_2 = *Bacillus thuringiensis* @ 1kg/ha two times during season at 15 days interval

T_3 = Neem oil (Azadirachtin 1500 ppm) @ 5 ml/lit. 2 sprays at 15 days interval

T_4 = Spinosad @ 0.32ml/ lit. 2 sprays at 15 days interval

T_5 = Untreated Control

Results revealed minimum shoot infestation was found in Spinosad (13.32) followed by *Bacillus thuringiensis* (14.67), Neem oil (16.16) and *Beauveria bassiana* (17.37) in comparison to untreated control (21.46). The minimum fruit infestation also found in same treatments as that of shoot infestation. Significantly, low yield was recorded in untreated control (9.58 t/h). It could be concluded that biopesticides had promising results in minimizing the pest damage with higher yield.

IV.20.3. Evaluation of entomopathogens against *Myllocerous subfasciatus* on brinjal (ICAR-IIHR, Bengaluru)

Among the treatments, the entomopathogenic nematode *Heterorhabditis indica* @ 2.5 10^9 IJs ha^{-1} was significantly superior over other treatments with 1.01mean adults per plant(Table 166). Destructive sampling also showed similar results with minimum number of grubs per plant in *H. indica* treatment. Entomopathogenic nematode (EPN) *H. indica* was on par with the chemical control in minimizing the ash weevil population in brinjal. Since ash weevil grubs are subterranean in nature EPNs are effective in managing this pest.

Table 166. Evaluation of entomopathogens against ash weevil, *Myllocerus subfasciatus* in brinjal

	Treatment Details	Mean number of adults per plant					Destructive sampling (Mean no. of grubs per plant)	Marketable yield (t/ha)
		Pre-count	I Fort-night	II Fort-night	III Fort-night	Pooled		
T1	*M. anisopliae* oil formulation IIHR Strain @5 ml/L	4 (2.11)	3.53 (2.00)	4.03 (2.12)	3.3 (1.94)	3.62 (2.02)	10 (3.24)	9.27 (3.13)
T2	*B. bassiana* IIHR Strain-WP formulation @ 5 g/L	4.13 (2.14)	3.23 (1.92)	3.23 (1.92)	2.7 (1.78)	3.05 (1.88)	10.5 (3.3)	10 (3.24)
T3	*M. anisopliae* NBAIR Ma4WP formulation @ 5 g/L @ 5g/L	3.7 (2.04)	3.36 (1.96)	3.6 (2.02)	2.76 (1.80)	3.24 (19.3)	11 (3.39)	9.94 (3.21)

T4	*B. bassiana* NBAIR Bb-5aWP formulation @ 5 g/L	3.56 (2.01)	3.2 (1.91)	3.56 (2.00)	3.2 (1.91)	3.32 (1.95)	11.,5 (3.32)	8.61 (3.02)
T5	*H. indica* NBAIR H38 @ 2.5 ×10⁹ IJs ha⁻¹	4.33 (2.19)	1.13 (1.27)	0.93 (1.18)	0.96 (1.20)	1.01 (1.22)	5 (2.34)	1.77 (3.63)
T6	Chlorpyriphos 2 ml /L	3.2 (1.91)	0.93 (1.18)	1.23 (1.31)	1.6 (1.29)	1.11 (1.26)	6.5 (2.64)	12.11 (3.54)
T7	T7: Untreated control	4.33 (2.19)	4.33 (2.19)	4.53 (2.23)	5.23 (2.39)	4.7 (2.27)	13.5 (3.74)	5.88 (2.52)
	CD@0.05%	0.37	0.38	0.35	0.27	0.16	0.38	0.57
	CV	0.04	0.21	0.22	0.23	0.22	0.15	0.11

IV. 20.4. Evaluation of entomopathogens against *Henosepilachna* (*Epilachna) vigintioctopunctata* on Brinjal (CAU, Pasighat)

The data pertaining to field efficacy of entomopathogens against incidence and infestation of *Henosepilachna* (*Epilachna) vigintioctopunctata* on brinjal is presented in Table 167 and 168**.** Among the biopesticides, *Metarhizium anisopliae* IIHR Strain oil formulation (1x10^8 spores/ml)@5 ml/L was the best treatment in reduction of hadda beetle incidence (3.21 beetles/plant) and infestation (4.95 % defoliation) on brinjal with higher yield registering 30.20q/ha. It was closely followed by *Beauveria bassiana* NBAIR Bb-5a (1x10^8 spores/g) WP formulation @ 5 g/L (3.81/beetle plant, 5.47 % defoliation and 29.80 q/ha yield) and *Metarhizium anisopliae* NBAIR Ma4 (1x10^8 spores/g) WP formulation @5 g/L (3.81 beetles plant, 5.70 % defoliation and 29.50 t/ha yield).

Table 167. Field efficacy of entomopathogens against *Henosepilachna (Epilachna) vigintioctopunctata* on Brinjal

Treatments	Mean number of Hadda beetles/plant				Pooled
	Beforespray	After Ispray	AfterIIspray	After IIIs-pray	
T_{1-}*M. anisopliae* IIHR Strain oil formulation (1x10^8 spores/ml)@5 ml/L	4.08 (2.12)*	2.65 (1.76)	3.78 (2.04)	3.20 (1.91)	3.21 (1.91)
T_2_*B. bassiana* IIHR Strain (1x10^8 spores/g) WP formulation @5 g/L	4.01 (2.10)	4.15 (2.14)	5.58 (2.45)	5.01 (2.34)	4.92 (2.31)
T_{3-}*M. anisopliae* NBAIR Ma4 (1x10^8 spores/g) WP formulation @5 g/L	3.85 (2.07)	3.38 (1.93)	4.93 (2.32)	4.56 (2.24)	4.29 (2.16)
T_{4-}*B. bassiana* NBAIR Bb-5a (1x10^8 spores/g) WP formulation @5 g/L	4.33 (2.17)	3.74 (2.03)	4.19 (2.14)	3.50 (1.98)	3.81 (2.07)
T_5 - *Heterorhabditis indica* NBAIR H38@ 2.5 10^9 IJs ha^{-1}	3.92 (2.09)	4.39 (2.18)	5.15 (2.37)	4.91 (2.32)	4.82 (2.28)
T_6 - Chlorpyriphos 2 ml/L	4.63 (2.26)	2.34 (1.66)	2.22 (1.64)	2.04 (1.58)	2.20 (1.62)
T_7 – Untreated control	4.51 (2.22)	5.83 (2.51)	6.42 (2.62)	5.52 (2.45)	5.93 (2.53)
S. Em ±	0.10	0.21	0.19	0.17	0.20
C.D. at 5 %	NS	0.63	0.57	0.51	0.62

*Figures in the parenthesis are √x + 0.5 transformed values

Table 168. Field efficacy of entomopathogens against *Henosepilachna (Epilachna) vigintioctopunctata* infestation on Brinjal

Treatments	Percent defoliation by Grubs & Adults of Hadda beetle on Brinjal				Pooled	Yield (q/ha)
	Before-spray	After I spray	After II spray	After III Spray		
T_{1}-*M. anisopliae* IIHR Strain oil formulation (1x10^8 spores/ml)@ 5 ml/L	8.05 (16.44)*	4.90 (12.76)	5.85 (13.90)	4.10 (11.62)	4.95 (12.69)	30.20 (5.54)
T_{2}-*B. bassiana* IIHR Strain (1x10^8 spores/g) WP formulation @ 5 g/L	8.10 (16.51)	6.10 (14.28)	7.50 (15.89)	6.90 (15.20)	6.83 (15.06)	27.20 (5.26)
T_{3}-*M.anisopliae* NBAIR Ma4 (1x10^8 spores/g) WP formulation @ 5 g/L	8.01 (16.40)	5.15 (13.05)	6.75 (15.01)	5.23 (13.19)	5.70 (13.71)	29.50 (5.47)
T_{4}-*B. bassiana* NBAIR Bb-5a (1x10^8 spores/g) WPformulation @ 5 g/L	7.39 (15.74)	5.10 (13.03)	6.40 (14.60)	4.92 (12.77)	5.47 (13.42)	29.80 (5.50)
T_{5} - *Heterorhabditis indica* NBAIR H38 @ 2.5 10^9 IJs ha^{-1}	7.98 (16.38)	5.60 (13.64)	6.88 (15.18)	5.44 (13.51)	5.98 (14.09)	28.50 (5.38)
T_{6} - Chlorpyriphos 2 ml/L	8.00 (16.41)	4.18 (11.74)	4.96 (12.75)	3.86 (11.27)	4.34 (11.80)	32.30 (5.72)
T_{7} – Untreated control	7.80 (16.19)	12.87 (21.00)	15.98 (23.24)	11.23 (19.53)	13.36 (21.43)	25.30 (5.07)
S. Em ±	0.70	0.77	0.83	0.76	1.24	0.20
C.D. at 5 %	NS	2.38	2.57	2.36	3.81	0.63

*Figures in the parenthesis are Arc sine transformed values

IV. 21. Biological control of Chilli Pests

IV. 21.1. Evaluation of entomopathogens against sucking pests of chilli (thrips, aphids and Whitefly*)* (MPKV, Pune; ICAR-IIHR Bengaluru; HRS, Ambajipeta; PJTSAU, Hyderabad & CAU, Pasighat)

MPKV, Pune

The trial was laid out at the research farm of Agril. Entomology Section, College of Agriculture, Pune. Chilli seedlings of variety 'AK-47' were transplanted on 02/12/2022 in plot size 5.00 x 4.00 m with 60 x 45 cm spacing in Randomized Block Design with four treatments replicated five times.

Data in Table 169 revealed that, pre-count thrips population was non-significant indicating homogenous distribution of the pest (14.00-15.35 thrips/4 leaves/plant) in different treatment plots. The five sprays of oil based formulation of *M. anisopliae* IIHR Strain (1x10^8 spores/g) @ 5 g/lit at weekly interval found significantly superior in suppressing thrips population (6.47 thrips/4 leaves/plant and 75.64% reduction) with highest yield of green chilli (110.69 q/ha) and highest B:C ratio (1:3.24) however, it was at par with POP Recommendation (Imidacloprid 17.8 % SL) @ 0.3 ml/lit and powder formulation of *B.bassiana* NBAIR Bb5a (1x10^8 spores/g) @ 5 g/lit recorded 6.54 and 7.94 thrips/4 leaves/plant with 108.97 and 104.23 q/ha yield of green chilli and 3.18 and 3.05 BC ratio, respectively(Table 170).

In respect of whitefly population, data was non-significant indicating homogenous distribution of the pest (9.55-9.60 whiteflies/4 leaves/plant) in different treatment plots. The surviving population of whiteflies showed that five sprays of powder formulation of *B. bassiana* NBAIR Bb5a (1x10^{8}spores/g) @ 5 g/lit at weekly interval found superior over other treatments and recorded 4.00 white flies/4 leaves/plant (83.43 % reduction) however, POP recommendation (Imidacloprid 17.8 % SL) @ 0.3 ml/lit recorded least population of whitefly (2.70 whiteflies/ 4 leaves/plant) with highest per cent reduction (88.89%). The next best treatment was oil-based formulationof *M. anisopliae* IIHR Strain (1x10^8 spores/g) @ 5 g/lit which recorded 6.24 whiteflies/4 leaves/plant.

ICAR-IIHR, Bengaluru

Different entomopathogens were evaluated against chili thrips, *Thrips parvispinus*. Among the entomopathogens evaluated, *Bacillus albus* NBAIR-BATP @ 20ml/L was significantly superior over other entomopathogens. The Mean number of thrips per plant observed was 8.66 in *B. albus*, compared to the untreated control (28.71 thrips per plant)(Table 171).

HRS, Ambajipeta

The experiment was carried out in tribal village, Iralapalli of Rampachodavaram mandal in Alluri Sitrarama Raju district. The results revealed that after third and fourth spray, imidacloprid treatment recorded 2.58 thrips per flower per plant. The bio pesticide treatments, oil based formulation of *Metarhizium anisopliae* and powder based formulation *Beauveria bassiana* also recorded low thrips population *i.e.,* 4.91,5.41 and 3.74, 3.88 thrips per flower respectively after third and fourth sprays. Both biopesticide treatments are statistically at par. In untreated control block the maximum population of thrips ranging from 10.86 to 21.86 was recorded (Table 172).

PJTSAU, Hyderabad

Results revealed that after five sprays the population of *Scirtothrips dorsalis* was lesser (2.19/leaf) in the chemical treated plots at 3 days after spraying, followed by IIHR oil-based formulation of *Metarhizium* (3.13/leaf) and *Beauveria bassiana* (2.99/leaf) and by the 7th day, all the treatments recorded almost same no. of thrips(Table 173). No significant difference was found among the treatments with respect to yield.

Table 169. Cumulative efficacy of entomopathogen against pests of chilli after five sprays

Treatment	Dose (gm or ml/ lit)	Thrips population/4 leaves /plant				Reduction over control (%)	White fly population/4 leaves / plant				Reduction over control (%)	Yield (q/ha)	B:C ratio
		Pre count 3 DAS	Post count				Pre count 3 DAS	Post count					
			7 DAS	Cumulative Mean				7 DAS	Cumulative Mean				
T1: Oil based formulation of *M. anisopliae* IIHR Strain (1x10^8 spores/g)	5	14.00 (3.80)	10.35 (3.29)	2.60 (1.75)	6.47 (2.64)	75.64	9.55 (3.17)	8.70 (3.02)	3.80 (2.05)	6.24 (2.60)	74.33	110.69	3.24
T2: Powder formulation *B. bassiana* NBAIR Bb5a (1x10^8spores/g)	5	15.35 (3.97)	11.00 (3.39)	4.90 (2.32)	7.94 (2.91)	70.09	9.50 (3.09)	6.95 (2.72)	1.05 (1.19)	4.00 (2.12)	83.43	104.23	3.05
T3: POP Recommendation (Imidacloprid 17.8 % SL)	0.3	14.60 (3.90)	8.84 (3.14)	4.25 (2.18)	6.54 (2.65)	75.36	9.60 (3.18)	4.55 (2.21)	0.85 (1.15)	2.70 (1.79)	88.89	108.97	3.18
T4: Untreated Control	-	14.30 (3.83)	24.95 (5.04)	28.15 (5.35)	26.55 (5.20)	-	9.35 (3.12)	20.25 (4.55)	28.35 (5.37)	24.30 (4.98)	-	78.94	2.38
SE±		0.12	0.05	0.16	0.14		0.34	0.14	0.19	0.13		3.63	-
CD at 5%		N.S.	0.14	0.48	0.42		NS	0.42	0.58	0.39		12.34	

*Figures in parenthesis are √x+0.5 transformed values

Table 170. Cost and Economics

Treatment	Cost of Insecti-cidesRs.	Labour cost Rs	Total cost of appli-cation Rs	Cost of Culti-vation Rs	Total cost of cultiva-tion Rs	Yield (q/ha)	Rate Rs/q	Gross returns Rs.	Net return Rs.	B: C ratio
T1: Oil based formulation of *M. anisopliae* IIHR Strain (1x10^8 spores/g)	2000	1400	3400	116210	119610	110.69	3500	387415	267805	3.24
T2: Powder for-mulation *B. bassi-ana* NBAIR Bb5a (1x10^{8}spores/g)	200	1400	3400	116210	119610	104.23	3500	364805	245195	3.05

Table 171. Evaluation of different entomopathogens against thrips, *Thrips parvispinus* in chilli

	Treatment details	Mean number of thrips/plants									
		Pre count	First Spray		Second spray		Third spray		Fourth spray		Pooled
			3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	
T1	*M. anisopliae* IIHR Strain @5ml /L	19.85 (4.50)	17.53 (4.24)	18.41 (4.34)	18.7 (4.37)	18.17 (4.30)	18.62 (4.6)	20.53 (4.58)	19.44 (4.46)	18.96 (4.40)	18.79 (4.39)
T2	*M. anisopliae* NBAIR Ma4 (1x10^8 spores/g)@5 g/L	16.72 (4.14)	14.81 (3.9)	15.33 (3.97)	18.2 (4.32)	13.70 (3.75)	16.27 (4.09)	15.97 (4.05)	17.09 (4.19)	14.81 (3.90)	15.77 (4.03)
T3	*B. bassiana* NBAIR Bb5a (1x10^{8}spores/g) @ 5 g/ L	16.00 (4.05)	16.00 (4.05)	16.25 (4.08)	16.00 (4.05)	14.53 (3.85)	16.00 (4.05)	17.19 (4.0)	16.97 (4.17)	16.00 (4.05)	16.12 (4.07)
T4	*L. lecanii* NBAIR Vl8 @ (1x10^{8}spores/g) @5g/L	17.11 (4.19)	17.11 (4.19)	18.16 (4.31)	18.14 (4.31)	18.28 (4.32)	18.14 (4.30)	17.11 (4.19)	18.24 (4.32)	17.11 (4.19)	17.78 (4.27)
T5	*P. fluorescens* NBAIR-PF-DWD 10g/L	15.78 (4.02)	15.78 (4.02)	17.81 (4.27)	15.78 (4.02)	15.99 (4.05)	15.97 (4.04)	15.78 (4.02)	17.17 (4.20)	15.78 (4.02)	16.25 (4.09)
T6	*B. albus* NBAIR-BATP 20ml/L	14.42 (3.85)	8.23 (2.94)	8.37 (2.97)	9.35 (3.13)	9.13 (3.09)	8.65 (3.01)	8.55 (3.08)	8.31 (2.94)	8.23 (2.94)	8.66 (3.02)
T7	Fipronil @ 1mL/L	15.08 (3.95)	3.78 (2.05)	4.06 (2.12)	4 (2.11)	3.90 (2.08)	4.41 (2.20)	3.97 (2.28)	5.08 (2.35)	3.78 (2.05)	4.22 (2.17)
T8	Control	14.4 (3.82)	24.92 (4.96)	25.66 (5.05)	26.11 (5.9)	35.86 (6.00)	35.08 (5.95)	28.56 (5.32)	28.56 (5.34)	24.92 (4.96)	28.71 (5.39)
	CD @0.05%	NS	0.8	0.64	0.69	1.12	0.51	0.66	0.62	0.75	0.9
	CV	0.05	0.20	0.23	0.23	0.28	0.27	0.23	0.23	0.23	0.24

Table 172. Field evaluation of entomopathogens against sucking pests of chilli

Treatments	Dosage	Average number of thrips per flower per plant 7 days after spray				
		Pre count*	After 1st spray	After 2nd spray	After 3rd spray	After 4th spray
T_1- Oil based formulation of *M. anisopliae* IIHR Strain (1x10[8] spores/g)	5 ml/l	12.35 (3.55)	8.65 (2.99)	6.25 (2.58)	4.91 (2.31)	3.74 (2.04)
T_2- Powder formulation *B. bassiana* NBAIR Bb5a (1x10[8]spores/g)	5 g/ l	12.16 (3.54)	8.79 (3.02)	7.06 (2.73)	5.41 (2.39)	3.88 (1.95)
T_3- Imidacloprid	0.3ml/l	12.44 (3.56)	6.62 (2.62)	5.10 (2.31)	3.32 (1.93)	2.58 (1.71)
T_4- Untreated control	-	10.89 (3.32)	15.79 (4.06)	16.13 (4.07)	20.81 (4.62)	21.86 (4.71)
SEm	-	-	0.14	0.11	0.09	0.14
CD (5%)	-	-	0.39	0.31	0.28	0.42

*Fig in parenthesis are √x+0.5 transformed values.

Table 173. Evaluation of entomopathogens against sucking pests of chilli (thrips, aphids and Whitefly) using oil-based formulation of Metarhizium anisopliae.

Treatments	Population of thrips (no./leaf)						Yield (q/acre)
	First spray		Second spray				
	Pre count	3 DAS	7 DAS	Pre count	3 DAS	7 DAS	
T1:Oil based formulationof *M. anisopliae* IIHR Strain (1x10 8 spores/g) @ 5ml /L	3.40 (1.84)	3.13 (1.77) b	3.40 (1.84)	4.05 (2.00)	4.03 (1.99) b	4.14 (2.02)	5.44
T2: Powder formulation *B. bassiana* NBAIR *Bb*5a (1x10 8 spores/g) @ 5g/L	3.40 (1.84)	2.99 (1.73) b	3.55 (1.88)	3.54 (1.87)	3.24 (1.79) ab	3.88 (1.96)	6.02
3: POP Recommendation (Fipronil @ 2.0 ml/L or Spirotetramat 0.2 g/L)	3.89 (1.96)	2.19 (1.48) a	3.89 (1.96)	3.49 (1.86)	2.45 (1.56) a	3.45 (1.85)	6.01
T4. Untreated control	3.22 (1.83)	5.45 (2.33) c	3.22 (1.87)	3.78 (1.93)	4.23 (2.05) b	4.23 (2.05)	2.84
CD (0.05)	NS	0.12	NS	NS	0.24	NS	NS
CV	5.48	5.15	6.15	12.33	11.56	11.19	11.68

CAU, Pasighat

The trial was laid out during 2022. Chilli seedlings of variety ‘Arka Tejaswi’ were transplanted in plot size 3x 3m with 60 x 45 cm spacing in Randomized Block Design with four treatments replicated five times. The data of the field efficacy of entomopathogens against thrips in chilli is presented in (Table 174).The oilbased formulation of *M. anisopliae* IIHR Strain (1x10[8] spores/g) @5ml/L (8.65 thrips/plant), it was found statistically significant with powder formulation *Beauveria bassiana* NBAIR Bb5a (1x10[8] spores/g) @5 g/ L (8.65 thrips/plant). However, the farmers practice recorded the lowest number of thrips *i.e.*7.90 per plant, among all the treatments. Due to higher pest incidence in untreated control (14.89 thrips/plant), it was recorded with the poor yield (09.27 q/ha) significantly lower than remaining treatments.

Table 174. Field efficacy of entomopathogens against thrips in chilli

Treatments	Mean No. of thrips/plant						Pooled	Yield (q/ha)
	Before spray	After-I spray	After-II spray	After-III spray	After-IV spray	After-V Spray		
T1 - Oil based formulation of *M. anisopliae* IIHR Strain (1x10^8 spores/g) @ 5ml /L	12.80 (3.65)	9.60 (3.17)	8.01 (2.91)	9.98 (3.23)	8.50 (2.99)	7.15 (2.75)	8.65 (3.01)	15.10 (3.95)
T2 - Powder formulation of *Beauveria bassiana* NBAIR Bb5a (1x10^8 spores/g) @ 5 g/ L	12.50 (3.60)	9.92 (3.22)	8.80 (3.04)	10.03 (3.24)	9.60 (3.17)	8.35 (2.97)	9.34 (3.10)	14.30 (3.82)
T3 - Imidacloprid @0.3ml/L	13.10 (3.69)	8.50 (2.99)	7.50 (2.82)	9.20 (3.11)	7.80 (2.87)	6.50 (2.63)	7.90 (2.88)	16.52 (4.12)
T4 - Control	13.01 (3.68)	15.30 (2.99)	16.13 (4.07)	16.50 (4.11)	14.02 (3.80)	12.50 (3.59)	14.89 (3.92)	09.27 (3.13)
S. Em ±	0.04	0.11	0.14	0.13	0.10	0.14	0.17	0.04
C.D. 5 %	NS	0.34	0.42	0.40	0.29	0.44	0.51	0.12

IV. 21.2. Effect of ICAR NBAIR promising entomopathogen strains against South East Asian thrips, *Thrips parvispinus* in chilli(PJTSAU, Hyderabad)

Results revealed that all the biopesticide formulations were on par in bringing down the population of thrips on flowers and they were on par with each other and with the chemical treatment. Population of thrips ranged from 13.14 -16.23/flower in the treatments before the spray and this decreased to 3.19-3.59 thrips/flower at 3 days after the first spray, while untreated control recorded 11.42 thrips/flower. At 4 days after spray, biopesticide treatments recorded population between7.56 and 8.70 thrips/flower and they were on par with the acetamiprid treatment (9.25thrips/flower), while untreated control registered maximum population (13.28 thrips/flower) (Table 175).

Table 175. Evaluation of entomopathogens against South East Asian thrips on chilli

Treatments	Population of thrips (no./flower)*			Yield (q/acre)
	Pre count	3 DAS	7 DAS	
T1: *B. bassiana* Bb 5a (1x10^8 spores/g) @ 5g /L	14.09 (3.42)	3.59 (2.02)[a]	7.70 (2.77)[a]	20.09[a]
T2: *L. lecanii* Vl8 (1x10^8 spores/g) @ 5g /L	15.23 (4.02)	3.39 (1.97)[a]	8.70 (2.94)[a]	21.45[a]
T3: *B. albus* NBAIR BATP 10g/L	15.12 (3.87)	3.49 (1.99)[a]	8.51 (2.91)[a]	20.98[a]
T4 : *P. fluorescens* PfDWD 10g/L	14.44 (3.56)	3.98 (2.11)[a]	7.56 (2.74)[a]	21.45[a]
T5 Chemical control (Acetamiprid 0.2g/L)	13.14 (3.63)	3.19 (1.92)[a]	9.25 (3.04)[a]	21.78[a]
T6. Untreated control	13.28 (3.65)	11.42 (3.45)[b]	13.25 (3.64)[b]	6.67[b]
CD (0.05)	NS	0.2	0.29	2.09

* Mean of three sprays

IV.21.3. Incidence of *Thrips parvispinus* Karny on chilli and preliminary studies on efficacy of entomopathogenic fungi (UAS, Raichur)

The preliminary studies on efficacy of entomopathogenic fungi indicated that the combined effect of *B. bassiana* (ICAR-NBAIR-Bb5a) and *I. fumosorosea* (ICAR-NBAIR-Pfu 5) recorded lowest LC_{50} value of 4.22 × 10^8 spores per ml and combined effect of *B. bassiana* (ICAR-NBAIR-Bb5a) and *L. lecanii* (ICAR-NBAIR-VL-l8) (4.32 ×10^8 spores per ml) followed by sole treatment of *I. fumosorosea* (ICAR-NBAIR-Pfu 5) (5.11 ×10^8 spores/ml) and *B. bassiana* (ICAR-NBAIR-Bb5a) (6.2 × 10^8 spores/ml), respectively. Minimum lethal time recorded in combined effect of *B. bassiana* (ICAR-NBAIR-Bb5a) and *I. fumosorosea* (ICAR-NBAIR-Pfu 5) which recorded 5.81 days and combined effect of *B. bassiana* (ICAR-NBAIR-Bb5a) and *L. lecanii* (ICAR-NBAIR-VL-l8) recorded 6.27 days followed by sole treatment of *I. fumosorosea* (ICAR-NBAIR-Pfu 5) (8.10 days) and *B. bassiana* (ICAR-NBAIR-Bb5a) (8.56 days), respectively. *B. bassiana* and *I. fumosorosea* are promising biocontrol agent that could be used as alternative to chemical insecticide for controlling chili black thrips (Table 176 and 177).

Table 176. LC_{50} values of different entomopathogenic fungiagainst chilli black thrips

Sl. No.	Strains	LC_{50} (spores per ml)	Fiducial limit	Hetero-genity (χ^2)	Regression equation
1	*B. bassiana* (ICAR-NBAIR-Bb5a)	6.2 × 10^8	1.7 × 10^3 4.4 × 10^{10}	0.98	Y = 2.01+0.24X
2	*I. fumosorosea* (ICAR-NBAIR-Pfu 5)	5.11 × 10^8	4.3 × 10^3 6.4 × 10^9	2.50	Y= 1.50 +0.31X
3	*M. anisopliae* (ICAR-NBAIR-Ma4)	10.34 × 10^8	4.7 × 10^2 12.3 × 10^8	2.27	Y= 2.12 +0.23X
4	*L. lecanii*(ICAR-NBAIR-Vl8)	7.11 × 10^8	3.3 × 10^4 4.1 × 10^9	1.25	Y= 1.99+0.31X
5	*B. bassiana* (ICAR-NBAIR-Bb5a) × *I. fumosorosea* (ICAR-NBAIR-Pfu 5)	4.22 × 10^8	2.22 × 10^4 6.3 × 10^{10}	3.10	Y= 1.72 +0.30X
6	*B. bassiana* (ICAR-NBAIR-Bb5a) × *M. anisopliae* (ICAR-NBAIR-Ma4)	9.21 × 10^7	2.1 × 10^2 3.5 × 10^8	1.92	Y= 1.43 +0.28X
7	*B. bassiana* (ICAR-NBAIR-Bb5a) × *L. lecanii* (ICAR-NBAIR-Vl8)	4.32 × 10^8	2.3 × 10^2 8.3 × 10^{10}	1.29	Y= 1.62 +0.21X

Fiducial limits are calculated by using equivalent deviate at P= 0.01 level with the help of SPSS.

Table 177. Time mortality response of black thripsto different entomopathogenic fungi

Sl. No.	Strains	LT_{50} at 1× 10^8 spores per ml (days)	Fiducial limit (Lower lim-it-upper limit) (days)	Heterogenity (χ^2)	Regression equation (Y)
1	*B. bassiana* (ICAR-NBAIR-Bb5a)	8.56	5.24 - 9.99	0.93	1.63 + 2.02x
2	*I. fumosorosea* (ICAR-NBAIR-Pfu 5)	8.10	1.28 - 10.60	2.31	1.11 + 2.35x
3	*M. anisopliae* (ICAR-NBAIR-Ma4)	8.76	2.09 - 10.46	0.72	1.23 + 0.76x
4	*L. lecanii* (ICAR-NBAIR-Vl8)	9.59	6.70 - 15.38	0.43	1.40 + 1.34x
5	*B. bassiana* (ICAR-NBAIR-Bb5a) × *I. fumosorosea* (ICAR-NBAIR-Bb5a)	5.81	5.33 - 8.89	1.02	1.31 + 2.74x

6	*B. bassiana* (ICAR-NBAIR-Bb5a) × *M. anisopliae* (ICAR-NBAIR-Ma4)	9.18	9.15 - 12.09	1.07	1.84 + 0.19x
7	*B. bassiana* (ICAR-NBAIR-Bb5a) × *L. lecanii* (ICAR-NBAIR-Vl8)	6.27	3.24 -8.21	0.32	3.02 + 3.93x

Fiducial limits are calculated by using equivalent deviate at P= 0.01 level with the help of SPSS.

IV. 22. Biological control of Okra Pests

IV. 22.1. Evaluation of entomopathogens against sucking pests (hoppers, aphids andWhitefly) of Okra (ICAR-IIHR Bengaluru; AAU, Anand)

AAU Anand

The lowest population of jassid was documented in treatment T_2-POP Recommendation, Imidacloprid 17.8 SL (6.79/ 3 leaves) as compared to treatment T_1-Oil based formulation of *Metarhizium anisopliae* IIHR Strain (8.50/ 3 leaves) and in case of whitefly treatment T_2-POP Recommendation Imidacloprid 17.8 SL significantly registered lowest whitefly population (6.16/3 leaves) as compared to treatment T_1-Oil based formulation of *M. anisopliae* IIHR Strain (8.03/3 leaves). The lowest population of aphid was documented in treatment T_2-POP Recommendation Imidacloprid 17.8 SL (9.36/ 3 leaves) as compared to treatment T_1-Oil based formulation of *M. anisopliae* IIHR Strain(11.40/ 3 leaves). The treatment T_2-POP Recommendation Imidacloprid 17.8 SL recorded the significantly higher yield (129.57 q/ha) as compared to treatment T_1-Oil based formulation of *M. anisopliae* IIHR Strain(107.71 q/ha) (Table 178).The highest (120.13%) increase in yield over untreated control was obtained in the treatment T_2-POP Recommendation Imidacloprid 17.8 SLas compared to treatment T_1-Oil based formulation of *M. anisopliae* IIHR Strain (82.99%).

Table 178. **Evaluation of entomopathogens against sucking pests of okra 2022-23**

Treatments	No of aphids/3 leaves		No of whitefly/3 leaves		No of jassid/3 leaves		YVMV disease incidence (%)	Yield (q/ha)	Yield increase over control (%)	B:C Ratio
	BS	Pooled over spray	BS	Pooled over spray	BS	Pooled over spray				
T1 - Oil based formulation of *M.anisopliae* IIHR Strain @ 5ml /L	4.63* (20.94)	3.45[b] (11.40)	3.90* (14.71)	2.92[b] (8.03)	4.35* (18.42)	3.00[b] (8.50)	16.02**[b] (7.62)	107.71[b]	82.99	2.5
T2 -Imidacloprid 17.8 SL @0.3ml/l)	4.49 (19.66)	3.14[a] (9.36)	3.87 (14.48)	2.58a (6.16)	4.63 (20.94)	2.70[a] (6.79)	12.66[a] (4.80)	129.57[a]	120.13	3.2
T3 - Untreated control	4.52 (19.93)	4.48[c] (19.57)	3.79 (13.86)	3.92[c] (14.87)	4.62 (20.84)	4.68[c] (21.40)	23.11[c] (15.41)	58.86[c]	-	1.5
S. Em ±(T)	0.23	0.05	0.17	0.04	0.21	0.05	0.88	3.77	-	-
C.D. at 5 %	NS	0.15	NS	0.14	NS	0.15	2.71	11.62	-	-
C. V. (%)	13.09	12.57	11.75	13.17	12.29	13.03	13.49	10.10	-	-

Note: *Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values
**Figures outside the parentheses are arcsine transformed values, those inside are retransformed values
BS: Before spray, NS: Non-significant

ICAR-IIHR, Bengaluru

Among the different entomopathogens evaluated *M. anisopliae* NBAIR Ma4 (1x10^8 spores/g) @ 5 g/L gave significantly effective control of leafhopper with 2.59 mean leafhoppers per plant. Followed by *B. bassiana* NBAIR Bb5a (1x10^8

spores/g) @5 g/L (2.70 mean leaf hopper per plant) and *M. anisopliae* IIHR Strain @ 5ml /L (2.89 mean leaf hoppers per plant)(Table 179).

Table 179. Evaluation of different entomopathogens against leaf hopper in Okra

	Treatment details	Mean number of leaf hoppers/plant									
		Pre count	First Spray		Second spray		Third spray		Fourth spray		Pooled
			3DAS	7DAS	3DAS	7DAS	3DAS	7DAS	3DAS	7DAS	
T1	*M. anisopliae* IIHR Strain @5ml /L	3.6 (2.01)	2.97 (1.86)	2.75 (1.79)	3.34 (1.95)	3.13 (1.87)	2.85 (1.83)	2.34 (1.51)	2.87 (1.82)	2.71 (1.79)	2.89 (1.83)
T2	*M. anisopliae* NBAIR Ma4 (1x10[8] spores/g)@5 g/L	4.1 (2.14)	3.15 (1.9)	2.73 (1.79)	2.65 (1.77)	2.52 (1.73)	2.5 (1.73)	2.07 (1.43)	2.72 (1.79)	2.4 (1.68)	2.59 (1.76)
T3	*B. bassiana* NBAIR Bb5a (1x10[8]spores/g) @5 g/ L	4.55 (2.21)	2.9 (1.84)	2.6 (1.75)	2.4 (1.69)	3.55 (1.98)	2.7 (1.77)	2.68 (1.61)	2.74 (1.77)	2.05 (1.58)	2.70 (1.79)
T4	*L.lecanii* NBAIR Vl8 @ (1x10[8]spores/g) @5g/L	4.25 (2.17)	3.01 (1.86)	3.51 (1.99)	3.01 (1.85)	2.42 (1.70)	3.23 (1.91)	3.22 (1.78)	2.81 (1.81)	2.62 (1.74)	2.98 (1.86)
T5	*P. fluorescens* NBAIR-PFDWD 10g/L	4.9 (2.31)	3.89 (2.07)	5.08 (2.35)	4.76 (2.28)	5.37 (2.41)	5.42 (2.43)	4.27 (2.05)	5.83 (2.51)	5.13 (2.37)	4.96 (2.34)
T6	Imidacloprid 17.8 SC @0.3mL/L	4.9 (2.31)	1.17 (1.27)	2.65 (1.76)	2.98 (1.86)	2.5 (1.71)	1.76 (1.50)	2.14 (1.45)	1.44 (3.91)	1.83 (1.52)	2.05 (1.59)
T7	Control	4.66 (2.32)	5.83 (2.51)	5.97 (2.54)	6.00 (2.54)	6.78 (2.69)	5.88 (2.52)	5.36 (2.30)	5.52 (2.45)	6.09 (2.54)	5.85 (2.52)
	CD @0.05%	NS	0.42	0.32	0.31	0.46	0.38	0.39	0.32	0.49	0.21
	CV	0.04	0.19	0.16	0.15	0.19	0.19	0.19	0.20	0.21	0.17

IV. 22.2. Evaluation of bio intensive IPM module against major pests of okra (AAU Anand; CAU, Pasighat & IGKVV, Raipur)

AAU, Anand

The treatment details of the experiment are detailed below,

T1 BIPM module

1. Installation of pheromone traps for *Helicoverpa armigera* & *Earias vittella* @ 60 traps/ha at 30 DAS.
2. Six releases of *Trichogramma chilonis* @ 50000/ ha at weekly interval with the initiation egg laying of the pest.
3. 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
4. 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.

Significant lower larval population of *E. vittella* was recorded in BIPM module (4.25/ plant) whereas, the chemical module recorded larval population of 5.90/plant. With regard to *H. armigera* population, larval population in BIPM module (2.36/ plant) and chemical module (2.53/plant) found non-significant. The lowest population of jassid was documented in chemical module (2.46/ leaf) as compared to BIPM module (3.87/ leaf) and in case of whitefly chemical module witnessed non significantly lowest whitefly population (3.70/leaf) as compared to BIPM module (4.04/leaf). The BIPM module has witnessed significantly the highest population of coccinellids (2.42/ plant) (Table 180).

The effect of various components of BIPM module in reducing the pest population was observed in reduced fruit damage and highest fruit yield. The fruit damage was significantly lower in BIPM module (4.92 % -

number basis, 4.63 %– weight basis) as compared to chemical module (6.08 % - number basis, 6.13 %– weight basis). The BIPM module recorded the significantly higher yield (123.44 q/ha) which was statistically at par with chemical module (112.52 q/ha) (Table 181). This result demonstrates the successful bio-intensive module, which helps in reducing the pest incidence in okra crop with higher yield.

Table 180. Effect of different modules on insect pests and natural enemies in okra 2022-23

Modules	*E. vittella* larvae/ plant	*H. armigera* larvae/plant	No. of jassids/ leaf	No. of whitefly/ plant	No. of coccinellids /plant
BIPM Module	2.18*[a] (4.25)	1.69 (2.36)	2.09[b] (3.87)	2.13 (4.04)	1.71[a] (2.42)
Chemical Module	2.53[b] (5.90)	1.74 (2.53)	1.72[a] (2.46)	2.05 (3.70)	0.95[b] (0.40)
S. Em ±(T)	0.04	0.03	0.03	0.03	0.03
C.D. at 5 %T	0.12	NS	0.09	NS	0.07
C. V. (%)	13.02	13.25	12.98	11.96	14.01

Note: * Figures are √x + 0.5 transformed values whereas those in parentheses are retransformed values NS: non-significant

Table 181. Effect of different modules on fruit damage and yield of okra 2022-23

Modules	Fruit Damage (%)		Yield (q/ha)
	No. basis	Weight basis	
BIPM Module	12.82[a] (4.92)	12.42[a] (4.63)	123.44[a]
Chemical Module	14.27[b] (6.08)	14.34[b] (6.13)	112.52[b]
S. Em ±(T)	0.45	0.60	3.67
C.D. at 5 % T	1.34	1.79	10.89
C. V. (%)	10.54	14.23	9.82

Note: *Figures are arcsine transformed values whereas those in parentheses are retransformed values

CAU, Pasighat

The trial was laid out during *rabi* 2022-23 in the farmer fields at Jampani and Jorkong villages, East Siang district with Arka Anamika variety in 2 ha area. Result revealed no significant differences were recorded between BIPM and POP (Chemical control) modules except for the coccinellid beetles which are found highest in BIPM module. However, the BIPM module recorded comparatively lower incidence of shoot & fruit borers (0.70 larvae/plant), fruit damage (5.80 %) and sucking pests (1.79/plant). Whereas, yield recorded in BIPM (64.60 q/ha) was statistically on par with the POP module (62.40 q/ha). However, C:B ratio was higher in BIPM module 2.06 as compare to 1.75 in POP module.

GKVV, Raipur

Results infer maximum percentage of okra shoot and fruit borer infestation was recorded in control (25.35) and minimum percentage of okra shoot and fruit borer infestation was recorded in Farmer's practice (20.76).

IV. 23. Biological control of Onion Pests

IV. 23.1. Evaluation of bio-efficacy of entomopathogens against onion thrips (*Thrips tabaci* L.)(TNAU Coimbatore)

Results revealed thrips population was 2.87 and 3.04 Nos. in *Beauveria bassiana* NBAIR Bb5a (1 x 10^8 spores/g) @ 5g/L and *Metarhizium anisopliae* NBAIR Ma4 (1x 10^8 spores/g) @ 5g/L respectively on 7 days after spraying and these two treatments were on par with insecticide treatment (2.75 Nos.). Among the entomopathogens treatments, the yield was maximum in *Beauveria bassiana* NBAIR Bb5a (1 x 10^8 spores/g) @ 5g/L (16661 Kg/ha) followed by *Metarhizium anisopliae* NBAIR Ma4(1x 10^8 spores/g) @ 5g/L (16225 Kg/ha). CB ratio was 2.62 and 2.61 in insecticide and *Beauveria bassiana* NBAIR Bb5a (1 x 10^8 spores/g) @ 5g/L treated plots respectively(Table 182).

Table 182. Effect of different entomopathogens on onion thrips, *Thrips tabaci* L.

Treatment	No. of thrips/leaf				Yield (Kg/ha)	% Yield increase over Control	CB ratio
	Pre treatment	3 DAS	7 DAS	10 DAS			
T1: *B. bassiana* NBAIR Bb5a (1 x 10^8 spores/g) @ 5gm/L	5.33 (2.323)	1.71 (1.309)[b]	2.87 (1.695)[a]	3.14 (1.772)[b]	16225.56 (127.37)[ab]	15.83	2.49
T2: *M. anisopilae* NBAIR Ma4 (1 x 10^8 spores/g) @ 5gm/L	4.67 (2.099)	3.04 (1.744)[f]	3.04 (1.743)[a]	3.18 (1.782)[b]	16661.11 (129.08)[a]	18.94	2.61
T3: *L. lecanii* NBAIR V18 (1 x 10^8 spores/g) @ 5gm/L	6.33 (2.125)	2.59 (1.611)[d]	3.85 (1.961)[b]	3.27 (1.808)[b]	16108.67 (126.91)[b]	14.99	2.48
T4: *P. fluorescens* NBAIR Pf-DwD – 2% WP 20gm/L	3.33 (2.231)	2.93 (1.712)[e]	3.99 (1.997)[b]	3.13 (1.767)[b]	16110.01 (126.92)[b]	15.01	2.47
T5: Azadirachtin 1500ppm @2ml/lit	5.72 (2.111)	2.36 (1.536)[c]	3.81 (1.951)[b]	4.06 (2.015)[c]	15922.22 (126.18)[b]	13.67	2.43
T6: POP recommendation (Dimethoate 30 EC)	4.33 (2.170)	1.62 (1.273)[a]	2.75 (1.657)[a]	2.62 (1.615)[a]	16627.11 (128.95)[a]	18.69	2.62
T7: Control	3.68 (2.143)	3.03 (1.741)[f]	5.06 (2.248)[c]	4.26 (2.063)[c]	14007.78 (118.35)[c]	15.83	2.21
SED	NS	0.011	0.051	0.060	0.813		
CD (P=0.05)		0.024	0.107	0.126	1.708		

*Figures in parentheses are Square root transformed values; DAS – Days After Spraying
In a column means followed by same letter(s) are not significantly different (P=0.05) by LSD

IV. 24. Biological control of Cucumber Pests

IV. 24.1. Efficacy of reduviid predator, *Sycanus collaris* against tobacco caterpillar, *Spodoptera litura* on cucumber in polyhouse (KAU, Thrissur)

The experiment was laid out during December 2023 with the variety KPCH 1. Results revealed cumulative mean fruit damage (12.49 %) was lowest in plots with release of *S. collaris* @ 20 no./10m^2 and was followed by plots treated with chlorantraniliprole @ 30 g.a.i/ha. The highest extent of damage was observed in untreated plots, averaging 29.10 per cent damaged fruits. Plots treated with predator and the insecticide recorded 57.08 and 51.65 per cent reduction in damage over control respectively. Insecticide treated plots recorded the highest mean yield of 2.19 kg per plant and was significantly superior to the other treatments(Table 183).

Table 183. Field efficacy of *Sycanus collaris* against *Spodoptera litura* on cucumber

Treatments	Mean fruit damage (%)				Cumulative mean fruit damage (%)	Per cent damage reduction over control	Marketable yield (kg/ plant)	Per cent yield increase over control
	1 DAT	3 DAT	5 DAT	7 DAT				
T_1: Release of *S. collaris* @ 20 nymphs/10 m^2	22.83 (26.85)	3.57 $(5.21)^b$	12.53 $(15.95)^b$	1.79 $(3.89)^b$	12.49 $(19.01)^b$	57.08	1.75^b	30.00
T_2: Chlorantraniliprole 18.5 SC	18.19 (21.70)	13.92 $(18.81)^{ab}$	17.31 $(22.69)^b$	6.64 $(11.64)^{ab}$	14.07 $(21.21)^b$	51.65	2.19^a	68.95
T_3: Control	29.50 (30.68)	38.74 $(38.01)^a$	40.35 $(41.29)^a$	12.73 $(19.42)^a$	29.10 $(32.42)^a$	-	1.30^c	-
CD @ (0.05)	NS	22.21	16.75	11.02	9.68		0.393	

(Values in parenthesis are ac sin transformed values)

IV. 24.2. Demonstration of *N. longispinosus* for the management of phytophagous mites, *T. urticae* on cucumber under polyhouse (HRS, Ambajipeta)

Results of the experiment revealed mite population before treatment varied from 4.20 and 4.4 mite/ cm^2 with no significant differences. The mite population decreased gradually and was 2.8,2.2, 2.0 and 1.2 mites/ cm^2in plants treated with *N. longispinosus* (50 nymphs/m row) on 7,14, 21 and 28 days, respectively. Similarly, after spray of Spiromesifen, the mite population decreased gradually and was 1.2, 0.8, 0.6 and 0.6 mites/ cm^2 in plants on 7, 14, 21 and 28 days, respectively. The mite population recorded with *N. longispinosus* and spiromesifen differed non significantly with each other on different sampling intervals. The highest yield (182 q/plant) was recorded in plants treated with spiromesifen (100g a.i./ha) followed by *N. longispinosus* (177 q/ plant).

IV. 25. Biological control of CabbagePests

IV. 25.1. Evaluation of Biointensive management practices for the cabbage pests (aphid, *Brevicoryne brassicae* L. and diamondback moth, *Plutella xylostella* L.). (MPKV, Pune; AAU, Anand & CAU, Pasighat)

The experiments were conducted with three treatments as detailed below,

T1 BIPM

- Growing Indian bold seed mustard as trap crop @ 25:2
- Installation of pheromone trap for *Plutella xylostella* @ 12 traps/ha at 30 DAT
- Eight releases of *Trichogramma chilonis* @ 100000/ ha at weekly interval with the initiation of pest
- Two sprays of *Bacillus thuringiensis* NBAIR BTG4 (2×10^8cfu/g) 1% WP (5g/ L). First spray with the initiation of lepidopteran pest and subsequent spray at ten days interval
- One spray of azadirachtin 1500 ppm (1%EC) (2ml/L) with the initiation of sucking pest/aphid and subsequent two sprays with *Lecanicillium lecanii* NBAIR Vl-8 (1×10^8cfu/g) 1% WP (5g/L) at ten days interval

T2 POP Recommendation (Spraying 5% NSKE)

T3 Untreated Control

MPKV, Pune

Results revealed that the treatment with BIPM components was significantly superior over rest of the treatments and recorded least aphids (24.32 aphids/plant) with 77.65 per cent reduction over control and least larval population of diamondback moth (0.28 larva/plant) with 88.97 per cent reduction over control. Moreover, this treatment recorded highest marketable yield (141.67 q/ha) of cabbage and significantly superior over rest of the treatments, The next effective treatment was POP recommendation (Spraying 5% NSKE) which recorded 32.58 aphids/plant and 0.66 larva per plant with 121.19 q/ha.

AAU, Anand

The lowest population of diamondback moth larvae was recorded in BIPM module (3.30/plant) as compared to chemical module (4.43/plant). With regard to aphid population chemical module recorded significantly lowest population (16.06/plant) as compared to BIPM module (18.86/plant). With respect to the population of natural enemies, BIPM module witnessed highest coccinellids population (2.12/plant) which was significantly higher than the population observed in chemical module (0.64/plant). Further, chemical module recorded significantly the lowest fruit damage (4.55 %) as compared to BIPM module (6.00 %). Due to significant low fruit damage in chemical module, it recorded the highest yield (26.32 t/ha) as compared to yield documented in BIPM module (22.52 t/ha)(Table 184).

Table 184. Impact of different modules on insect pests and natural enemies in cabbage during 2022-23

Modules	No. of larvae of DBM/plant	No. of aphids/ plant	No. of natural enemies/ plant	Yield (t/ha)
BIPM Module	1.95[a] (3.30)	4.40[b] (18.86)	1.62[a] (2.12)	22.52[b]
Chemical Module	2.22[b] (4.43)	4.07[a] (16.06)	1.07[b] (0.64)	26.32[a]
S. Em ± (T)	0.04	0.08	0.03	1.27
C.D. at 5 % T	0.12	0.21	0.09	3.77
C. V. (%)	12.52	12.63	16.26	16.44

Note: Figures are $\sqrt{x + 0.5}$ transformed values whereas those in parentheses are retransformed values

CAU, Pasighat

The BIPM module was recorded with significantly lower pest incidence (1.50 DBM larvae/plant, 3.26 aphids/plant and 8.50 % head damage) in comparison to POP module (2.36 DBM larvae/plant, 12.30 aphids/plant and 9.80 % head damage). Whereas, the predators population was significantly higher (1.20 coccinellids/plant) in BIPM; exhibits its eco-friendly nature towards natural enemies. Due to lower pest incidence, the BIPM module documented the highest cabbage head yield *i.e.,*24.50 t/ha and lowest in 13.61 t/ha due to highest head damage (18.30 %) (Table 185).

Table 185. Efficacy of BIPM module on pest incidence, head damage and yield of Cabbage

Modules	No. Lepidoptera larva/plant		No. of aphids /plant		Cabbage head damage (%) Post-T	No. of Predators/plant		Yield (t/ha)
	Pre-T	Post-T	Pre-T	Post-T		Pre-T	Post-T	
BIPM Module	5.90 (2.50)	1.50 (1.40)	11.41 (3.43)	3.26 (1.91)	8.50 (16.71)	1.14 (5.85)	1.20 (6.03)	24.50
POP recommendation	6.20 (2.57)	2.36 (1.67)	12.30 (3.55)	4.10 (2.10)	9.80 (18.01)	1.35 (6.44)	0.50 (3.99)	22.30
Untreated Control	6.35 (2.59)	7.50 (2.82)	11.64 (3.46)	8.38 (2.95)	18.30 (25.25)	1.23 (6.09)	1.46 (6.77)	13.61
S. Em ±	0.15	0.10	0.16	0.18	1.07	0.53	0.61	1.71
C.D. at 5 %	NS	0.29	NS	0.56	3.29	NS	1.88	5.26

*Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values
**Figures in the parenthesis are Arc Sine transformed values

IV. 26. Biological control of Cauliflower Pests

IV. 26.1. Large scale field evaluation of Biointensive management practices for the pests of cauliflower (YSPUHF, Solan; CAU, Pasighat)

The experiments were conducted with three treatments as detailed below,

T_1: BIPM

- Mustard as trap crop
- One spray of Azadirachtin 1500 ppm (1%EC) (2ml/L)
- Release of *Chrysoperla zastrowi sillemi* (4 larvae/infested plant) will be released 7 days after the application of Azadirachtin
- Mechanical destruction of egg masses and early gregarious larval instars of *Pieris brassicae*
- Two sprays of *Bacillus thuringiensis* NBAIR BTG4 10ml/L). First spray with the initiation of lepidopteran pest and subsequent spray at ten days interval

T_2: POP recommendation (Spinosad 45 SC @ 0.4 ml/lit water against DBM alternative with Imidacloprid 17.8 SL @ 0.5 ml/lit water against sucking pests at 15 days interval)

T_3: Untreated Control

YSPUHF, Solan

Minimum number of cabbage aphids, *B. brassicae* (1.57 aphids/plant) were recorded with T_2 (Spinosad 2.50 % SC) which differed statistically with T_1 (BIPM) and T_3 (Untreated) on Standard Meteorological Week -3. Whereas on SWM-4, the aphids recorded with BIPM and Chemical control were statistically at par with each other and both differed statistically untreated control. On SWM-5, the cabbage aphids recorded under chemical treatment (T_2) were minimum as compared with BIPM and untreated control. Thereafter, the population of cabbage aphid recorded with BIPM (T_1) and Spinosad 2.50 % SC was statistically at par on SWM-6,7 and SWM-8, both treatments differed statistically with untreated control (T3). The per cent reduction of aphids over control in BIPM and Spinosad 2.50 % SC were 74.04 and 78.93, respectively (Table 186).The cabbage yield recorded with BIPM (188.95 q/ha) was statistically at par with chemical treatment (193.66 q/ha) and both the treatments differed significantly with untreated control (165.71 q/ha).

Table 186. Evaluation of Biointensive management practices for pests of cauliflower

Treatments	Number of aphids/three leaves								Per cent Reduction over Control	Yield (q/ha)
	SMW 2	SMW 3	SMW 4	SMW 5	SMW 6	SMW 7	SMW 8	Mean		
T_1 (BIPM)	11.68 (3.56)	4.07 (2.24)	12.29 (3.64)	6.46 (2.73)	9.55 (3.24)	15.29 (4.03)	19.18 (4.48)	11.22	74.04	188.95
T_2(Spinosad 2.50 % SC)	12.86 (3.70)	1.57 (1.54)	10.14 (3.30)	2.71 (1.83)	7.29 (2.86)	13.86 (3.86)	15.29 (4.00)	9.10	78.93	193.66
T3 (Control)	12.29 (3.63)	20.86 (4.63)	28.29 (5.35)	36.71 (6.08)	52.86 (7.32)	65.71 (8.15)	85.71 (9.28)	43.20	-	165.71
$CD_{0.05}$	NS	0.52	0.75	0.76	0.51	0.58	0.62			16.04
SEm	0.11	0.17	0.24	0.25	0.16	0.19	0.20			5.15

SMW: Standard Meteorological Week

CAU, Pasighat

The trial was conducted during *rabi* 2022-23 in farmers field at Jarkong village, East Siang district with Pusa early snow ball variety.The BIPM module recorded significantly lower incidence of aphids (3.30 v/s 4.50 caterpillars/plant), Cabbage butterfly caterpillars (0.90 v/s 2.80/plant) and curd damage (4.40 % v/s 5.60 %)

in comparison to POP chemical module and untreated control. Due to higher pest incidence the POP module recorded with significantly lower curd yield of 31.11 t/ha as against BIPM (32.50 t/ha). However, the untreated control documented with highest pest incidence and lowest crop yields. The cost benefit ratio was higher in BIPM (2.50) in comparison to POP chemical module (2.10).

IV. 27. Biological control of Bitter gourd Pests

IV. 27.1. Evaluation of BIPM practices against sucking pests and fruit flies *Zeugodacus cucurbitae* in bitter gourd (ICAR-IIVR Varanasi)

Effect of different pest management modules on bitter gourd (cv. Kashi Mayuri) were tested during the *kharif* season 2022 at the experimental farm of ICAR- IIVR, Varanasi with the following treatments,

T1: BIPM practices

- Installation of cue lure @ 15/ha for mass trapping for cucurbit fruit flies
- Spray of *Lecanicillium lecanii* NBAIR Vl-8 (2.5 g /L) + Neem oil (2.5 ml/L) for sucking pests
- *Bacillus thuringiemsis* NBAIR Bt G4 @2 ml/L for leaf Webber (*Diaphania indica*)

T2: POP Recommendation (Jaggary 1% + Malathion 50 EC@2ml/L)

T3: Untreated control practice

From the Table 187 it is evident that lowest fruit fly damage (8.45%) on bitter gourd fruits were observed in the BIPM. The BIPM treated plots were also had lowest whitefly (0.57/leaf), jassid (0.33/leaf) and cucumber moth (3.23/plant) populations among all the three treatments followed by the POP Recommendation (Jaggary 1% + Malathion 50 EC@2ml/L). The untreated control plots suffered maximum fruit fly damage (26.08%) along with highest sucking pest population i.e., white fly (2.13/leaf) and jassid (1.68/leaf). However, two important predators in bitter gourd ecosystem *i.e.,* ladybird beetles (4.13/plant) and spider (4.21/plant) population were highest in the untreated control plots.

Table 187. Effect of different pest management modules on major insect pests and natural enemies of bitter gourd

Treatment/ Module	Fruit fly damage (%)	Whitefly /leaf	Jassids /leaf	Cucumber moth / plant	Lady bird beetle / plant	Spider / plant
M1	8.45	0.57	0.33	3.23	2.47	2.49
M2	15.64	1.69	1.21	6.49	3.89	3.87
M3	26.08	2.43	1.68	8.16	4.13	4.21
SEm (±)	1.17	0.36	0.32	0.67	0.38	0.29
LSD (5%)	2.56	0.87	0.79	1.56	0.92	0.67

IV. 28. Biological control of Cassava Pests

IV. 28.1. Field evaluation of parasitoids and predators for the management of cassava mealybug (TNAU, Coimbatore; ICAR- NBAIR, Bengaluru)

TNAU, Coimbatore

A field trial was conducted in Nagaranai village of Erode district.The cassava mealybug population was low in T2 (1.72 colonies / plant) followed by T1 (1.85 colonies / plant) and T3 (7.2 colonies / plant) on 60 days after imposing treatments. Rosette damage was also low in T2 (4.10%) followed by T1 (4.52%) and T3 (20.50%)

on 60 days after imposing treatments. *Anagyrus lopezi* population was maximum in T2 (2.9 Nos.) followed by 0.60 Nos. in T1. CB ratio was maximum in T3 (1:2.66) followed by T1 (1:2.58) while in insecticide treatment it was 1:2.45 (Table 188).

Table 188. Effect of entomophages on population and damage of cassava mealybug

Treatments	Colonies/plant (Nos.)*				Rosette damage (%) **				Yield (t/ha)	CB Ratio
	Pre treat-ment	15 DAT	30 DAT	60 DAT	Pre treat-ment	15 DAT	30 DAT	60 DAT		
T1: *A.astur*	6.83 (2.53)	5.30 (2.30)^{b}	4.16 (2.04)^{a}	1.85 (1.36)^{b}	23.72 (27.93)	23.04 (28.69)^{b}	21.64 (27.72)^{b}	4.52 (12.27)^{b}	31.03 (5.57)^{b}	2.58
T2:*A. lopezi*	7.20 (2.55)	5.26 (2.29)^{b}	5.08 (2.25)^{c}	1.72 (1.31)^{a}	24.3 (29.33)	25.45 (30.29)^{c}	22.34 (28.21)^{c}	4.1 (11.68)^{a}	31.67 (5.63)^{ab}	2.66
T3:Insecticide	7.45 (2.61)	3.82 (1.95)^{a}	4.43 (2.11)^{b}	7.20 (2.68)^{c}	22.86 (28.35)	21.53 (27.64)^{a}	17.8 (24.95)^{a}	20.5 (26.92)^{c}	32.45 (5.69)^{a}	2.45
T4:Control	7.10 (2.53)	8.14 (2.85)^{c}	9.33 (3.05)^{d}	8.46 (2.91)^{d}	23.4 (28.71)	26.37 (30.89)^{d}	28.9 (32.52)^{d}	31.5 (34.14)^{d}	26.53 (5.15)^{c}	2.14
SEd	NS	0.018	0.013	0.001	NS	0.160	0.08	0.088	0.45	-
CD(P = 0.05)	NS	0.037	0.027	0.020	NS	0.335	0.167	0.184	0.095	-

ICAR-NBAIR, Bengaluru

ICAR-NBAIR has undertaken a field efficacy study of *Anagyrus lopezi* in the farmers' fields (cv. White Thailand) at Alagampatti, Kattampatti, villages under Palacode block of Dharmapuri district, Tamil Nadu during 2022-23. In both the villages,cassava mealybug, *Phenecoccus manihoti* was the predominant mealybug observed.Before parasitoids were released, pre-treatment observations like the level of mealybug incidence (70. 0%), per cent level of crop damage (25%), cassava mealybug abundance (50 no./ tip) was recorded. Post release of parasitoids, after 20 days, parasitoid recovery studies indicated,*A. lopezi* had established very well in the released sites. Field parasitism rate was worked at fortnightly basis, one month post release of parasitoids till crop cut stage. Increase in per cent parasitism was witnessed during each observation and achieved maximum of 20.12 per cent at six months post release of *A.lopezi* with tuber yield of 25 tonnes/ha.

V. 29. Tribal Sub Plan

Table 189. TSP activities.

State	State. District, Sub district and Taluk	Name of the tribal villages	Description of the activities/ Achievements	Number of beneficiaries	Amount spent (in Lakhs)
ANGRAU	Andhra Pradesh Alluriseetharamaraju district (Earlier Visakhapatnam Dt) Araku division	44	Promoted biointensive pest mangement in rice, ragi, rajmah, niger, ginger, turmeric and vegetables in 150 acres through Demonstrations, trainings, awareness programmes and farmers interaction meetings	174	4.0
GBPUAT	Uttarakhand - District Udham Singh Nagar, Bajpur block	Vijayrmpura and Sheetpuri	1. 52q Biocontrol agent PBAT-3 (*Trichoderma harzianum* Th14 + *Pseudomonas fluorescens* Pf 173) was distributed to the farmers for soil, seed, root dip treatment and foliar spray through biocontrol agents to counter soil borne diseases. 2. Distributed quality seed of paddy (2q), a vegetable seed kit, 200nos. containing 50g seeds in each packet of, coriander, fenugreek, spinach, carrot, raddish and mustard. 3. Distributed polysheet (2x10m), 600nos. for nursery beds of paddy to demonstrate soil solarization technology to farmers. 4. Placed pheromone trap (nos.4500) with lure to control rice stem borer. 5. Placed yellow sticky trap (nos.3000) for control of sucking pest. 6. 16 field days conducted. 7. 06 trainings conducted.	200	10
IGKV	Chhattisgarh - Kondagaon Kanker Rajnandgaon Surguja (Ambikapur) Jagdalpur	Kokadi, Farsagaon, GadhpichavadiIchhapur, Bwarti, Tumbdikasa, Nichekohda, Surguja (Ambikapur), Kacchar (Lundra - block), Chhapra, Bhanpuri	To participate awareness programme and deliver lecture about **"Role of Biocontrol agents in organic farming"** and to distribute biocontrol agents and agricultural inputs to tribal farmer. To participate awareness programme and deliver lecture about **"Role of Biocontrol agents in organic farming"** and to distribute biocontrol agents and agricultural inputs to tribal farmer. To conduct awareness programme on Biocontrol and distribution of live bio-agents and Agriculture - inputs to tribal farmers. To conduct awareness programme on Biocontrol distribution of live bio-agents and Agriculture - inputs to tribal farmers. One day training programme on Biocontrol agents	1012	12.3 lakhs
Dr YSPUHF	Himachal Pradesh - Kaza , dist. Lauhal & Spiti	Mane (Spiti Valley), Bhar (Sagnam) (Pin Valley)	Trainings and input distribution	60	0.50

UBKV	West Bengal - Coochbehar-II Alipurduar II Coochbehar II	Singimari Baniagaon	Training imparted on biological control in rice **i)** Training programme on management of rice pests and diseases in panicle initiation stage through biological approaches **ii)** Distribution of microbial consortium for Rice, Trichocards and Neem based pesticide. Biointensive management of insect pests in rice. Training programme on Bee keeping for tribal farmers (programme was conducted in seminar hall of Entomology department, UBKV and was attended by tribal farmers of the mentioned villages) i) Training programme on biological control of insect-pests and diseases in vegetables ii) Distribution of pheromone traps for fruit fly and Neem based pesticide i) Training-cum-input distribution programme related to biological control of insect-pests and diseases	121	0.70
SKUAST, Srinagar	J&K - Baramullaha	Brandub,	Collection of base line data for fruit damage, awareness, trap catch and good agricultural practices	70 Nos.	2.25
AAU, Anand	Gujarat - Dahod, Limkheda, Chhota, Udepur, Sankheda and Devgadhbaria	Paniya Ruvabari, Toyani, Nani Mangoi, Aankal, Baina, Agaara, Rai Sundarpura, Bhuriyakuva, Panej, Khodiya, Kalachhala, Unchapaan, Segava Simali, Bhagavanpura, Kathamandava, Pitha, Rajpari, Amalpura, Vadgagha, Raipur, Aambapura, Bhuriyakuva and, Toraniya	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 1. *Bacillus thuringiensis* (ICAR-NBAIR *Bt*G4) 2. *Metarhizium anisopliae* (NBAIR strain) 3. *Trichoderma harzianum* (ICAR-NBAIR Th-3) 4. Bio NPK 5. Vegetable Seeds (Okra, Cluster bean, Brinjal and Pigeon Pea (100g each/farmer) 6. Knapsack sprayer & PPE kit 7. *Pseudomonas fluorescens* (ICAR-NBAIR PFDWD) 8. *Bacillus thuringiensis* (ICAR-NBAIR *Bt*G4) 9. Knapsack sprayer & PPE kit 10. Biological Control Book (Gujarati Language) 11. Mycorrhiza 12. *Pseudomonas fluorescens* (ICAR- NBAIR strain PFDWD) 13. *Bacillus thuringiensis* (ICAR-NBAIR strain *Bt*G4) 14. *Metarhizium anisopliae* (NBAIR strain) 15. Pheromone trap (funnel type)		

		Pitha, Thebarpura, Kadvaliya, Kath Mandava, Rajpariand, Bhuriyakuva, Moti handi, Kadvaal, Rabdal, Galaliyaval, Hajariya, Vansiya, Gadvel, Andarpura, Tokarva, Gunamali, Dungarpur, Chunhadi, Paniya, Degavala and Puvala	16. Lure (*Helicoverpa armigera*) 17. Yellow Sticky Trap 18. Biological Control Book (Gujarati Language) 19. Mycorrhiza *20. Pseudomonas fluorescens* (ICAR- NBAIR strain PFDWD) *21. Metarhizium anisopliae* (NBAIR strain) *22. Trichoderma harzianum* (ICAR-NBAIR Th-3) 23. Knapsack sprayer & PPE kit *24. Bacillus thuringiensis* (ICAR-NBAIR BtG4) *25. Pseudomonas fluorescens* (ICAR-NBAIR PFDWD) *26. Metarhizium anisopliae* (NBAIR strain) 27. Bio NPK 28. Knapsack sprayer & PPE kit *29. Bacillus thuringiensis* (ICAR-NBAIR BtG4) *30. Pseudomonas fluorescens* (ICAR-NBAIR PFDWD) *31. Metarhizium anisopliae* (NBAIR strain) 32. Bio NPK	175	4.74
AAU, Jorhat	Assam **-** Baganpara Block, Baksa, Dhemaji, Jorhat, Dhekorgora block, Karbianglong, Diphu, Majuli and Sibsagar	Baganpara, Uttarpara, Bongaon, Bahphala, Borising, hanse Gaon, Diphu, Maharichuck, Dhemaji, Cholapathar, Syam Gaon, Dipok, Dipjyoti, Bahumukhi, Krisak got, Mahari chuck, Bhobesh Doley(Leader) & Manam selfhelp group Bahphala missing Gaon	Training on application of biocontrol agents for pest management & Material distribution (small farm implements, neem oil, vermicompost, traps, lures Training on Mass production of biocontrol agents and their application for pest management & Material distribution (small farm implements, traps, lures, neem oil) Training application of biocontrol agents and their application for vegetable pest management & BIPM demonstration on tomato, chilli and brinjal Promotion of IFS	430	5.00

CAU, Pasighat	Arunachal Pradesh - East Siang, ShiYomi, Upper Siang, Lower Subansiri, Lower Dibang Valley	Mongku village, Ayeng village, Monigong, Nemasibo, Padu village, Ziro, Gelling, Tuting, Desali,	Talc based formulations of *Trichoderma viride* and *Pseudomonas fluorescence* (01 kg each) Talc based formulation of Vegetable seeds, *Lecanicillum lecanii* and Blue sticky traps Talc based formulation *Metarhizium anisopliae*, Vegetable seeds and 5 knapsack sprayers Talc based formulation *Metarhizium anisopliae* and Vegetable seeds Talc based formulation of Bio-BT and Neem oil 10000 ppm Yellow sticky trap and *Beauveria bassiana* (01 kg each) Talc based formulation of *Beauveria bassiana* and Neem oil 10000 ppm (01 each) Talc based formulation of *Beauveria bassiana* and Neem oil 10000 ppm (01 each) Talc based formulations of Neem oil 10000 ppm and Yellow sticky traps	319	1.50
UAS, Raichur	Karnataka - Raichur	Huda, Sirwar taluk	Distribution of inputs cum training programme on integrated crop management. The various inputs including seeds and bio-inputs were distributed to farmers and they were trained about integrated crop management in ground nut	48	3.75
MPUAT	Rajasthan - Udaipur	Rama (Badgaon), Parayo ki Bhagal (Badgaon), Piladar (Sarda), Oda (Sarda) Falichadakhedi (Mavli)	Three release of Tricho cards	180	-


Fig 50. ANGRAU: Awareness programmes on Biointensive pest management

Fig. 51. GBPUAT: Input distribution and demonstration of biocontrol technologies at the end of tribal farmers

Fig 52. DrYSPUHF: Photo graphs of Training Camps organised in Spiti Valley

Fig 53. : UBKV: Training & materials distribution

Fig 54. AAU, Jorhat: TSP Training cum material distribution at Diphu and sivsagar

Fig 55. CAU, Pasighat: Azadi Ka Amrit Mahotsav TSP Progarmme

Fig 56. UAS, Raichur : View of Inputs distribution cum Training Programme was organised

Fig 57. MPUAT: Various training conducted throughout the year

Fig 58. IGKV : Materials distribution under TSP

VI. 30. GENERAL INFORMATION

Functioning of the co – ordinate project

VI. 30.1. Scientific staff position

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VI. 30.2. Budget of AICRP on Biological Control for 2022 – 2023

Details of Expenditure	Sanctioned and allotted grants (Rs. In lakhs)	Grants released during 2022-23 from ICAR (Rs. In lakhs)	Total expenditure
Pay and allowances	248.67	248.67	248.67
Capital	0.00	0.00	0.00
Recurring contingency	327.60	327.60	327.60
TA	24.40	24.40	24.40
Total	600.67	600.67	600.67

VI. 30.3. PROBLEMS ENCOUNTERED DURING THE YEAR (2022 – 2023)

GBPUAT

- Constraint of funds.

IGKV

- Most of the farmers using insecticides for the management (knock down results) of insect pest.
- Slow effective of bio-agents.
- Lack of knowledge about using bio-agents among farmers.
- Lack of storage facilities for large scale production of bio-agents.

KAU, Thrissur

- Lack of adequate land and polyhouses for conduct of experiments.
- Non – availability of a serviceable vehicle

UBKV

- Fund under Contingency head was released on 22.07.2022. Therefore, extreme problem was faced for payment of the wages of daily wage workers from April, 22 to July, 22. These workers are involved with mass multiplication of bioagents and other related works.
- Different treatment materials for conducting BIPM trial in tomato was not provided timely. Therefore, the said trial is yet to be initiated.
- Under the studies on biodiversity of natural enemies, some parasitoids collected from rice ecosystem were sent to NBAIR for identification. But these were not identified till date.

KAU, Vellayani

- Delay in release of fund as the Uc was delayed

PAU, Ludhiana

- Recurring contingency was less during 2022-23
- Deficit funds under salary head

AAU, Jorhat

- From April to June, Covid-19 and flood

TNAU

- Bondars nesting whitefly population was more than Rugose spiraling whitefly population in coconut trees in various districts of Tamil Nadu
- Mealybug *(Phenacoccus manihoti)* damage in cassava was observed in Namakkal, Coimbatore, Erode Salem, Tiruppur and Dharmapuri Districts.
- Fall armyworm damage was observed in the maize growing areas in Tamil Nadu

VI. 30.4. VISITORS

ANGRAU

- Dr. L. Prasanthi, Director of Research, ANGRAU visited AICRP Biocontrol laboratory on 24.4.2022.
- AICRP on Sugarcane monitoring team visited AICRP Biocontrol laboratory on 29.07.2022.
- Dr. A.Vishnuvardhanareddygaru, Hon'ble Vice chancellor, ANGRAU visited AICRP Biocontrol laboratory on 06.8.2022.
- Dr. Hemanth Kumar, Principal Scientist (millets),ANGRAU visited AICRP Biocontrol laboratory on 29.9.2022
- Sri. Demudulugaru ANGRAU Board member visited on 12.10.22
- Sri. Nagireddygaru Andhra Pradesh State Agricultural mission Vice chairman, visited on 14.10.22
- Dr. Shyam raj Naik, Associate Dean , Agricultural college, Rajahmundry, ANGRAU visited AICRP Biocontrol laboratory on 4.11.22

Fig 59. ANGRAU Director of Research, Dr.L.Prasanthi visited AICRP Biocontrol on 24.4.2022

- Dr. S. N. Sushil, Director, ICAR-NBAIR & Project Coordinator, AICRP on Biological Control of Crop Pests, Bengaluru and QRT review committee chairman Dr. H. C. Sharma along with QRT members Dr. B. K. Agarwala; Dr. V.V. Belavadi; Dr. R. Swaminathan; Dr. H. S. Tripathi; Dr. G. Sivakumar,Nodal officer, AICRP PC Cell; Dr. M. Mohan, Member Secretary, QRT ; Dr.K.Sridevi, Principal Scientist, NBAIR &ICAR-National fellow visited AICRP Biocontrol lab on 11.4.2023.

Fig 60. AICRP BC lab visit by Dr. S. N. Sushil, Director, ICAR-NBAIR, QRT chairman Dr. H. C. Sharma and QRT members on 11.4.2023

CPCRI

- Sri P. Prasad, Hon'ble Minister of Agriculture, Government of Kerala on 12-08-2022 as part of India Post Special Cover release programme
- Sri C. Gopalakrishnan Nair, Chief General Manager, NABARD, Thirivananthapuram as part of inauguration of Mentoring Workshop of Farmers Producers Organization on 12-08-2022
- Dr. Michael Tharakan, Chairman, KCHR as part of inauguration of Science history workshop of India.

GBPUAT

- Lt. Gn. Gurmeet Singh, Governor of Uttarakhand.
- Dr. J. P. Mishra, Ex-AD (International Relations) & OSD (Policy, Planning & Partnership), ICAR.
- Dr. A.N. Mukhopadhyay, Ex- Vice Chancellor, Assam Agriculture University.
- Dr. U.S. Singh, Advisor, International Rice Research Institute, (IRRI).
- Dr. Serge Savery, Plant Pathologist & Editor, Phytopathology, USA.
- Dr. Letitia Willoquet, Professor, INRA, France.
- Dr. J. Kumar, Vice-Chancellor, Graphic Era University, Dehradun, UK.
- Dr. Manmohan Singh, Vice-Chancellor, GBPUA&T, Pantnagar.
- Dr. A.S. Nain, Director, Research, GBPUA&T, Pantnagar.
- Dr. S.K. Kashyap, Dean Agriculture, GBPUA&T, Pantnagar.
- Dr. S.C. Modgal, Ex-DG, UPCAR, Uttar Pradesh Council of Agriculture Research.

IGKV

- Hon'ble Vice Chancellor, IGKV, Raipur visited Biocontrol laboratory on 13/05/2022.
- The Pear Review Team (PRT) for accreditation from ICAR; Dr. S. R. Chaudhary, Chairman of PRT (Ex. VC/DRS), Dr. C. K. Narayan, Reg. Coordinator (South) from IIHR, Bangalore, Dr. Chaya Patil from Bhagalkot, Karnataka, visited the Biocontrol lab on 21/08/2022 and observed different activities and interacted with PG & Ph. D students working in the lab.
- 50 students with staff members from Gujarat visited Biocontrol laboratory on 17/08/2022 and saw various bio-agents.
- Hitavada News Reporter Visited Biocontrol laboratory on 12/09/2022.
- Chhattisgarh College students visited Biocontrol laboratory on 15/06/2022.
- Bhartiya College students visited Biocontrol laboratory on 13/06/2022.
- Dr.Chandis R. Ballal former Director of NBAIR visited Biocontrol laboratory on 07/06/2022.

- B.C. Shukla former HOD Dept. of Entomology visited Biocontrol laboratory on 05/04/2022.
- Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) Agronomy student visited Biocontrol lab on 08/02/2023.
- Bhartiya College, Durg (C.G.) IVth year student visited Biocontrol lab on 06/02/2023.
- CARS, Gariyaband, Fingeshwar students visited Biocontrol lab on 25/02/2023.
- Forest planting in-charge team visited Biocontrol lab on 15/03/2023 to 16/03/2023.

DrYSPUHF

- Conducted visit of farm women from Gujarat state on dated 23.9.2022
- Conducted visit of 6 International Students from Gujarat University, Gujarat on dated 11.12.2023.
- Conducted visit of Farm women from village -Lanacheta, District – Sirmaur, Himachal Pradesh
- Conducted visit of RAWE students of College of Horticulture, UHF, Nauni, Solan and created awareness about biological control agents.

UBKV

- Agriculture Officers of Sikkim visited the Biological control laboratory of UBKV, Pundibari on 18.10.2022 for hands-on-training as well as collection of Corcyra eggs and trichocards.

KAU, Vellayani

- Senior Scientists Dr. Gandhi Gracy and Dr. Ankita Gupta visited KAU Vellayani as a part of Montoring and Evaluation of ACICRP Biocontrol Project

MPKV, Pune

- Neelam Seolekar, Chairperson-FICCI-FLO Pune along with 23 women visited Biological Control Research Laboratory, Agriculture College Pune on 07.07.2022.
- Dr. Kolla Sreedevi, Principle Scientist, ICAR-NBAIR, Bengaluru Visited Biological Control Research Laboratory on 08.07. 2022.
- Dr. S. D. Masalkar, Associate Dean. College of Agriculture, Pune visited the research trials and took review on 20.08.2022.
- Dr. K. A. Vaidya, Fergusson College Pune along with 21 students (M.Sc Botany) visited Biological Control Research Laboratory on 26.08. 2022.
- Fifty trainees from State Agriculture Department visited the Biocontrol Lab on 7.10.2022.
- Seventy one students from College of Agriculture, Karad visited the Biocontrol Lab. On 11.10.2022.
- Dr. Priti Kamble, Sinhagad College of Science along with 37 undergraduate students visited Biological Control Research Laboratoryon 18.11. 2022.
- Dr. D. N. Yadav, Emeritus Scientist Visited Biological Control Research Laboratory, AAU, Anand on 06.01.2023.
- Mr. Pratap Medireddy, IPS, Director General, Andhra Pradesh visited Biological Control Research Laboratoryon 25.01. 2023.
- Dr. P. G. Patil, Hon'ble Vice Chancellor, MPKV, Rahuri visited and took review of Mass production of Biopesticides and research trials on 27.01.2023.
- Dr. C. S. Patil, Head, Dept of Entomology visited and took review of research work on 31.01.2023.

- Dr. D. S. Pokharkar, former Head, Department of Entomology MPKV, Rahuri, visited and took review of research work on 12, March 2023.

PAU, Ludhiana

- Dr R. K. Gupta, Professor & Head, Division of Entomology, SKUAST, Jammu visited Biocontrol laboratories on December 8, 2022

Dr. YSRHU, Ambajipeta

S. No.	Date	Name of the official
01	23.02.2022	Dr.Ravi Bhat, Scientist In charge, PC Cell, AICRP on Palms
02	25.02.2022	Dr. Ramesh Scientist (Principal scientist) of CSIR Bangalore
03	21.06.2022	Sri. M.V.S. Nagireddy, Vice Chairman, AP State Agriculture mission, Government of Andhra Pradesh
04	20.07.2022	Dr.Anitha Karun Director, ICAR-CPCRI
05	20.07.2022	Dr.Niral, Principal Scientist, CPCRI
06	04.11.2022	Sri Koyye Moshen Raju, Chairman, AP, Legislative council

AAU, Anand

- Dr. G. Sivakumar, and Dr. T. Venkatesan, Scientist, ICAR- NBAIR, Bengaluru Visited Biological Control Research Laboratory, AAU, Anand during 9-13 January 2023
- Dr. D. N. Yadav, Emeritus Scientist Visited Biological Control Research Laboratory, AAU, Anand on 06 January 2023

AAU, Jorhat

- Dr. Prabhat Kumar, Horticulture Commissioner, Govt. of India
- Dr. C.R. Chattapati, Retired Professor, Odisha University of Agriculture and Technology
- Sri. Gulab Chand Kataria, Governor of Assam
- Sri. Pulak Mahanta, DC, Jorhat
- Dr. B.C. Deka, VC, AAU, Assam
- Prof. Ajanta Borgohain Rajkonwar, VC, Assam Women University

Fig 61. Visited by Dr. Prabhat Kumar, Horticulture Commissioner, Govt. of India

Fig 62. Visited by Sri. Gulab Chand Kataria, Governor of Assam

Fig 63. Visited by Dr. C.R. Chattapati, Retired Professor, Odisha University of Agriculture and Technology

Fig 64. Visited by Sri. Pulak Mahanta, DC, Jorhat

PJTSAU, Hyderabad

- Mrs.Rani Kumidini, Principal Chief Secretary, Govt. Of Telangana on 11 November, 2022
- 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, 2023
- Dr. C S Patil, Head, Dept. Of Entomology, UAS Raichur on 8 December, 2022
- Dr.Chandish Ballal, Member, QRT Team for AICRP on Maize on 7 January, 2023
- Dr.M.Srinivas, Professor, Organic Agriculture, A & M University, Alabama, USA on 25 May 2022
- Dr.R C Agarwal, National Director, NAHEP ICAR visited the scheme on I July, 2022
- Dr.V.Anitha, Dean – P.G.Studies, PJTSAU, for discussions on Black Soldier Fly project for submission to NAHEP 12 February, 2021

Fig 65. Mrs.Ranikumidini, IAS, Spl. Principal Chief Secretary, Govt. of Telanagana
Dr. Chandish R. Ballal, Former Director, ICAR - NBAIR

Fig 66. Dean- PG studeis, Dr.V.Anitha and Dr.R C Agarwal, National Director, PIU, ICAR - NAHEP

TNAU

S.No.	DATE	VISITORS	PURPOSE
1.	02.12.23	Dr.G.Sivakumar, Principal Scientist, NBAIR, Begaluru	To review the activities of AICRP-BC
2.	13.03.23	Dr.G.Sivakumar, Principal Scientist, NBAIR, Begaluru	To review the activities of AICRP-BC

VI. 30.5. Awards/ Honours/ Recognition

CPCRI

- The poster entitled "First record of *Amitus* sp. (Hymenoptera: Platygastridae) parasitizing exotic Acacia whitefly, *Tetraleurodes acaciae* (Quaintance) [Hemiptera: Aleyrodidae] from India" presented by Logeshkumar P., Srinivasan G., Shanthi M., Chinnadurai S., **Josephrajkumar A.,**Poorani J., Venkatesh K. and Murugan M. during the *Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward* held at ICAR-NBAIR, Bengaluru during December 15-17, 2022 was adjudged as the best in the session VI on *Alien invasive pests & prospects of classical biological control*.

GBPUAT

- Awarded 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.
- Mr. ArunkumarDepartment of Plant Pathology, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India has beenawarded "Best Poster Presentation" for paper presentation on "Morphological andmolecular characterization of *Fusarium oxysporum* infecting scented geranium *Pelargonium graveolens* (L.) Herit] in southern Karnataka" in IPSCONF2022 held at SKNAU, Jobner-Jaipur, Rajasthan, India.

IGKV

- Dr.Chandish R Ballal Team Award for "Outstanding Extension Work in Biological Control", during the Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward held at ICAR-NBAIR, Bengaluru during December 15-17, 2022.
- "Fellow of Society Award" Organized by SOCIETY FOR BIOCONTROL ADVANCEMENT, ICAR-NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES, Bangalore, during the Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward held at ICAR-NBAIR, Bengaluru during December 15-17, 2022.
- Prof. P. Kameswara Rao Award for best poster presentation at "AZRA International Conference" on 10th -12th November 2022, at Bhubaneswar, Odisha.

NCIPM

- Young Scientist Award to Anoop Kumar by the Society of Plant Protection Sciences during National e-Conference on "Biotic stress management strategies for achieving sustainable crop production and climate resilience" during 19-21 May 2022, New Delhi.

DrYSPUHF

- Member of Course curriculum Commmittee for Natural Farming for Gujarat state for UG and PG programme on Agriculture.
- Member of Course curriculum Commmittee of ICAR -New Delhi for development of course on Natural Farming for UG and PG programme
- Member of Course curriculum Commmittee of NCERT, New Delhi formulation of syllabus on Agriculture specially on Natural Farming for incorporation in NCERT Syllabus starting from Vatika-I to 12^{th}Class.

UHAS

- Best poster presentation Award for the paper on Comparative Evaluation of Gonandajala and Liquid Organic Manures on Growth and Yield of Rice in 3^{rd} International Web-Conference on Natural Resource Management for Global Food Security and Sustainable Development Goals, 83

UBKV

- Best oral presentation award in Seminar on Horticulture for sustainable development, nutritional and livelihood security (26-27^{th} May, 2022) held at UBKV, Pundibari, Cooch Behar, West Bengal.
- Out standing paper presentation in 5^{th} regional Science and technology congress 2022-23 organized by Cooch Behar Panchanan Barma University and DST, Government of West Bengal held on 17^{th}-18^{th} January, 2023 at Cooch Behar Panchanan Barma University on "Identification, characterization and evaluation of antagonistic potential of different *fluorescent Pseudomonads*"

SKUAST, Srinagar

- Selected as Overseas fellowship under NAHEP to conduct high end research in Germany
- Awarded BIG, Big Innovation Grant by BIRAC, Department of Biotechnology, GOI, New Delhi
- Established company M/S Pherobank Technology Private Ltd. under NEP as startup
- University awarded for the promotion of pheromone technology
- First German patent for the *Cydia Granulosis* virus from India as bio pesticide.
- Selected as SCIAC Fellow to pursue high end research at the JKU of Wurzburg, Germany

Dr. Barkat Hussain

- Apex committee member for devising organic agriculture for J&K headed by Agriculture Production commissioner.
- Acting as major guide of Ph.D. student Mr. Waseem Ahmad, Division of Entomology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as major guide of Ph.D. student Mr.Owais Ahmad Mir, Division of Entomology, Shalimar campus, Srinagar, SKUAST-K (J&K).
- Acting as major guide of M. Sc. student Ms. Gayathri Kishore, Division of Entomology.
- Acting as major guide of M. Sc. student Ms. Sabiha Hafeez, Division of Entomology.
- Acting as major guide of M. Sc. student Ms. Iqra, Division of Entomology.
- Acting as Co-guide to three students of PG and Doctoral level
- Acting as Dean, PG Nominee to three students of PG level
- Member of various university level committees

Dr. Zewar Hussain

- 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 Entomology, Faculty of Horticulture SKUAST Kashmir Shalimar
- Acting as major guide of M. Sc. student Ms. Iqra, Division of Entomology.

KAU, Vellayani

- Dr. Reji Rani OP received the "**Best Teacher in Biological Control**" award in the 7th NCBC by ICAR-NBAIR, held at Bengaluru during 14-15 December 2022
- Dr. Reji Rani OP received the "**Best Oral Presentation Award**" for the paper entitled "*Lecanicillium saksenae*, a versatile mycoflora from Kerala" in the 7th NCBC by ICAR-NBAIR, held at Bengaluru during 14-15 December 2022
- Dr. Reji Rani OP received the "**Bet Poster presentation award**" for the paper entitled "Tolerance of entomopathogenic fungi *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and *Lecanicillium lecanii* (Zimm.) Zare and gams to UVA irradiance" in the 7th NCBC by ICAR-NBAIR, held at Bengaluru during 14-15 December 2022

PAU, Ludhiana

- Dr P.S. Shera elected as Fellow, Society for Biocontrol Advancement, ICAR-NBAIR, Bengaluru

Dr. YSRHU, Ambajipeta

- Dr. NBV Chalapathi Rao, Principal Scientist (Ento.) from Dr. YSRHU- HRS, Ambajipeta received the outstanding research scientist and distinguished scientist award for the year 2021 at 5th global meet on science and technology for minimizing innovation cost and time held during 8th-9th, October, 2022 at Swami Vivekanand Subharti University, Meerut.
- Dr. YSRHU- HRS, Ambajipeta working under AICRP on Biological control received the best performing AICRP centre on biological control in the 31st Annual group meeting held at GKVK, Bangalore from 20.10.2022 to 21.10.2022 organized by ICAR- NBAIR, Bangalore
- Dr. NBV Chalapathi Rao, Principal Scientist (Ento.) participated in 50th International cocotech conference and Exhibition organized by ICC, Indonesia from 7-11th November, 2022 held at Kuala lumpur, Malaysia and presented the paper on Rugose spiralling whitefly in coconut and later awarded with third winner of the world coconut day, 2022 under the best coconut scientist category from India.

AAU, Anand

- All India Coordinated Research Project on Biological Control, Anand Agricultural University, Anand, Gujarat has been adjudged the Best Performing Centre for the Period 2021-22 by AICRP-BC & Director, ICAR- NBAIR, Bengaluru.
- Ghelani Agricon Private Limited Award – 2021 for Outstanding Research Work done in the field of bio-pesticides has been conferred to Dr. Raghunandan B. L., AICRP on Biological Control of Crop Pests, AAU, Anand During the state level seminar on 'Prakrutik Krushima Pak Sanrakshan organized by Plant Protection Association of Gujarat (PPAG) held at AAU, Anand on 5th April, 2022.
- Dr. N. M. Patel, Research Associate, Anand Agricultural University, Anand has been awarded by Insect Environmentalist Award for Best Insect Photography (Senior Category) for the year 2022 by Insect Environment (Quarterly Journal).

- Mr. Pavan J. S., the post graduate student of Dr. Nainesh B. Patel has been awarded by Chancellors' Gold Medal in 2023 at AAU, Anand.
- Certificate of appreciation has been awarded to Dr. Nainesh B. Patel as organizing secretary of 'Capacity building on Mass Production of Biocontrol Agents' hosted by AICRP on Biological Control of Crop Pests, AAU, Anand in collaboration with Centre for Agriculture and Bioscience International (CABI), South Asia and Better Cotton Initiation (BCI), India during October 2022 at AAU, Anand.
- Certificate of appreciation has been awarded to Dr. Raghunandan B. L. as Co-organizing secretary of 'Capacity building on Mass Production of Biocontrol Agent's hosted by AICRP on Biological Control of Crop Pests, AAU, Anand in collaboration with Centre for Agriculture and Bioscience International (CABI), South Asia and Better Cotton Initiation (BCI), India during October 2022 at AAU, Anand.
- Certificate of fellowship in appreciation and recognition of his outstanding achievements and contributions in the field of Biological Control of Crop Pests and Diseases has been awarded to Dr. Nainesh B. Patel AAU, Anand and he admitted to the Fellow of the Society for Biocontrol Advancement Bengaluru, India on 15th December 2022.
- Certificate of fellowship in appreciation and recognition of his outstanding achievements and contributions in the field of Biological Control of Crop Pests and Diseases has been awarded to Dr. Raghunandan B. L. AAU, Anand and he admitted to the Fellow of the Society for Biocontrol Advancement Bengaluru, India on 15th December 2022.

AAU, Jorhat

	Topic	Received by	Date	Provided by	Location
1.	2nd position in oral presentation: Studies on efficacy of certain biopesticides against honey beees (*Apis cerana* F) under laboratory and field condition	Dr. Anjumoni Devee	24-25. Nov, 2022	Indian Phytopathological Society- North Eastern Zonal Symposium and National conference	Department of Plant Pathology, AAU, Jorhat
2	External Question paper setter for the courses ENT505 (Biological Control Of Insect Pests And Weeds) and ENT 602 (Insect Physiology and Nutrition)	Dr. Anjumoni Devee	15.2.23	Colleg of Post-graduate Studies In Agricultural Sciences (Central Agricultural University-Imphal) Umiam-793103, Meghalaya	
3	Received 2nd best exhibit award at Farmer's Fair at AAU-ARRI- Titabar	Combinely AICRP BC, Honey, AINP soil arthropod, VPM & acarology	09.11.2022	AAU-ARRI- Titabar	

Fig 67. Received 2nd best exhibit award at Farmer's Fair at AAU-ARRI- Titabar

UAS, Raichur

- Incentive Award for ad-hoc projects of 40 lakhs worth
- Best Hightech stall category award for Biocontrol at University level
- Best Hightech stall category award for Biocontrol at Internation Millet at Bengaluru

VI. 29.6. Extension Activities

ANGRAU

- Participation in Diagnostic field visit as team member Every month during the year 2022 in Bheemili division, Visakhapatnam district
- Participation in Training &Visit Meetings orgainsed at RARS,anakapalle Every month during the year 2022 at RARS, Anakapalle
- Participation in RBK level farmers interaction and rythusadassu meetings as a team member every month in Atchutapurammandal, Anakapalle district during the year 2022
- Participation in Field visits as a team member in Validation of Natural farming systems in farmers fields every month during the year 2022 in Anakapallemandal
- Participation in Polambadiprogramme in maize, demonstrated BIPM on Maize FAW organized by department of agriculture in Boni village on 15.2.23.
- Monitored NGO-Vikasa Biocontrol lab at Sagaram, Madugulamandal and gave suggestions on 23.2.23

ANGRAU

- Participated in ZREAC meeting for Kharif & rabi, 2023-24 at Srikakulam on 24-25 April, 2023 recorded the proceedings and discussions on research and extension gaps for future programmes under AICRP BC.

GBPUAT

Conducted 32 meetings/field days at farmer's field.

- *Trichoderma* for value addition of vermicompost used for soil treatment.
- Use of *Trichoderma* for seed treatment in chickpea to control wilt.
- Introduction of Bioagents to farmers for the management of diseases.
- Seed treatment of rice with PBAT 3.
- *Trichoderma* for value addition of vermicompost.
- *Trichoderma* for seed treatment in pea for the control of wilt.

- Value addition of vermicompost through addition of Biocontrol agent.
- Management of sheath blight of rice by the use PBAT 3.
- Biological control in organic Rice.
- Bioagents an ecofriendly method for disease control in crops.
- Common Minimum Programme for vegetable and field crops.
- Methods for use of Biocontrol agents in Rice crop.
- Biological control in Pea for the management of wilt.
- Introduction to vegetable cultivation in Kitchen garden.
- Bioagent for seed treatment.
- *Trichoderma* for the disease management in crops.
- Nursery management through Biological control.
- Method of seedling treatment of plantation crops through Bioagent.
- Mass production of *Trichoderma* in Compost.
- Use of PBAT 3 in rice.
- PBAT 3 for tomato cultivation.
- *Trichoderma* for tomato cultivation.
- Use of Biocontrol agents in different crops for disease management.
- Use of Bioagents in vegetables for the management of diseases
- Use of Trichoderma in rice cultivation for disease management.
- Application of Bio agents in standing crops for the management of diseases.
- Seed treatment of rice with PBAT 3.
- Methods of seed treatment through Bioagents in different crops.
- Seed treatment of Pea with Pant Biocontrol agent -3 .
- Soil solarisation: eco friendly method for Pest control in Nursery of Crops.
- Implementation of Pheromone traps in Rice for the control of Stem borer.
- Use of Pant Bio control agent -3 for soil treatment, seed treatment, seedling treatment in Tomato and other plantation crops.

Fig 68.

IGKV

- To deliver lecture on "Awarnecess Programme on Insect Control through Bio – agents" on 14/09/2022 at RMD College of Agriculture and Research Station Ambikapur.
- To deliver lecture on use of Biocontrol agents in organic farming "Jajvalvadev Lok Mahotshava Agritech Krishi Mela" on 01/02/2023.
- To deliver lecture on "Role of Biocontrol Agents on Insect Pest Management" NSS CAMP at Tulshi Baradera on January 2023.

NCIPM

- Organized farmer's field school and interaction with the farmers at Village: Ikla, Gautambudhnagar, UP on 28.09.2022 in which 50 farmers participated.
- Organized "Cotton field day" on 17th September 2022 at Bhainichanderpal village of Rohtak district of Haryana. More than 100 farmers participated in the programme.

DrYSPUHF

- Role of Natural Farming in Subhash Palekar Natural Farming to the farmers of Kinnaur and Lahaul Spiti on dated 21.6.2022 organised by department of Business Administration, UHF, Nauni, Solan HP in which 30 participants participated.
- Identification of important pests and their control through natural Farming in Skill Development Programme on protected cultivation on dated 16.7.2022 organised by department of Soil Science and Water Management, UHF, Nauni, Solan HP in this 30 participants participated
- Role of Natural enemies in Subhash Palekar Natural Farming to the UG students of College of Horticulture, VBUU of Horticulture Bharsar on dated 7.12.2022 organised by college of Horticulture VBUU, Horticulture Bharsar in this 110 students participated
- Role of Natural Enemies in Subhash Palekar Natural Farming for farmers of Solan and Arki Block on dated 10.12.2023 in which 30 farmers attended the trainings organised by DEE, UHF, Nauni, Solan HP
- Insect-pests management in Natural Farming in this 6 International Students from Gujarat University participated on dated 11.12.2023 organised by DEE, UHF, Nauni, Solan HP
- Role of Subhash Palekar Natural Farming in Recent Technological Advancement in Horticulture and Forest Crops in this 30 scientists participated on dated 23rd December,20230th December,2022 organised by Dept. of Biotechnology, UHF, Nauni, Solan HP
- Role of Natural enemies in Natural Farming for farmers from Lahaul and Spiti in this 25 farmers psrticipated on dated 6.1.2023 organised by UHF, Nauni, Solan HP
- Role of Natural enemies in Natural Farming for 30 farmers from Nalagarh on dated 16.1.2023 organised by DEE, UHF, Nauni, Solan HP
- Role of Natural Farming Practices in Medicinal, and aromatic Plants to 30 farmers on dated 12.1.2023 organised by Dept. of Forest Products, UHF, Nauni, Solan HP
- Role of Natural enemies in Subhash Palekar Natural Farming for farmers of Kinnaur for 30 farmers on dated 18.1.2023 organised by DEE, UHF, Nauni, Solan HP
- Role of Natural enemies in Subhash Palekar Natural Farming in Medicinal and aromatic plants cultivation for 30 farmers on dated 20.1.2023 organised by DEE, UHF, Nauni, Solan HP.
- Insect-Pests Management under Natural Farming to 30 farmers of Bilaspur on dated 23.1.2023 organised by DEE, UHF, Nauni, Solan HP.
- Role of Natural enemies in Subhash Palekar Natural Farming in Medicinal and aromatic plants cultivation for 30 farmers on dated 7.2.2023 organised by DEE, UHF, Nauni, Solan HP.
- Role of Natural enemies in Subhash Palekar Natural Farming to 30 farmers on dated 8.2.2023 organised by DEE, UHF, Nauni, Solan HP
- Role of Natural enemies in Subhash Palekar Natural Farming to 30 farmers from Anni and Nirmand block of Kullu district organised by DEE, UHF, Nauni, Solan HP
- Role of Natural enemies in Subhash Palekar Natural Farming to 30 farmers from Chamba district organised by DEE, UHF, Nauni, Solan HP
- Role of Natural enemies in Subhash Palekar Natural Farming in two days training programme for gram Panchayats Pradhans and ward members on dated 24.2.2023 organised by department of Entomology, UHF, Nauni, Solan HP
- Role of Natural enemies in Subhash Palekar Natural Farming to 25 farmers from Chaupal FPC, Shimla on dated 26.2.2023 organised by department of Entomology, UHF, Nauni, Solan HP

- Role of biocontrol agents in management of insect-pests of crops under Natural Farming in Skill Development Programme on protected cultivation on dated 6.3.2022 organised by department of Soil Science and Water Management, UHF, Nauni, Solan HP in this 30 participants participated.

SKUAST, Srinagar

- Delivered talk at the JKU of Wurzburg, Germany entitled, Pheromones and their role in India.
- Conducted Awareness camp at Brandeb village of Rafiabad for the management of apple fruit borer
- Conducted Impact assessment of inputs provided to farmers under Tribal sub plan on Integrated Management of apple fruit borer in Rafiabad
- Conducted field visit at Zainapura, Shopian to observe magnitude of damage by apple blotch leaf miner and other adjoining areas
- Acted as Expert member for the promotion of holistic agriculture in J&K
- Acted as resource person for various diagnostic visits for identification of new insect pests.
- Attending expert meetings in Civil Secretariat for the promotion of Holistic Agriculture.

KAU, Kumarakom

Sl. No	Date	Place	Field Problem Identified
1	04.4.2022	Pallichira	Bacterial blight in cucumber
2	18.04.2022	Maravanthuruthu	Visit to natural calamity rain affected areas
3	22.04.2023	Cherthala	Post entry quarantine (inspection of orchids)
4	04.06.2022	Melukavu (Dept. of Agriculture)	Giant African snail
5	26.07.2022	Pampakkuda block	Cassava tuber and root rot
6	27.08.2022	Erumeli	Rambutan disease
7	27.09.2022	Pala	Dragon fruit disease
8	01.10.2022	Kanjirapally	Pepper foot rot, slow wilt, nutmeg thread blight
9	13.12.2022	Karukachal and pathanad	Dragon fruit disease

KAU, Vellayani

- Dr. Reji Rani OP conducted one day seminar to the Agricultural Extension officers of Tamil Nadu on 19.11.22 organised by the Dept. of Agriculture and Farmers welfare and farmers welfare, Govt. of Kerala
- Dr. Reji Rani OP conducted one day training to the farmers on pest management in spices as a part of two day training organized by Farming Sysytems Research Centre, Kottrakara, KAU on 24-25 January 2023
- Dr. Reji Rani OP conducted one day training to the Pesticide Dealers as part of DAESI programme organized by Govt.of Inida at IFSRS, Karamana KAU on 5.11.22
- Attended farmers field for diagnosis of scorching in mango orchard in TVM district

- Attended one day programme on farmer filed visit organized at district level as a part of krishidarshan programmae of State Dept.of Agriculture and Farmers Welfare, Govt.of Kerala on 26th January 2023

MPKV, Pune

- Dr. N. D. Tamboli attended Virtual Meeting of CROPSAP organized by State Dept. of Agriculture on 23.09.2022 and 27.09.2022.
- Dr. N. D. Tamboli visited and delivered lecture on Management of Giant African Snail of Dahegoan, Tal. Khed on 27.09.2022.
- Dr. N. D. Tamboli attended Virtual Meeting of CROPSAP organized by State Dept. of Agriculture on 01.10.2022, 08.10.2022, 22.10.2022,05.11.2022, 27.11.2022 and 10.12.2022.
- Dr. N. D. Tamboli delivered lecture on IPM of *Kharif* crops at Regional Agriculture Extension Management Training Institute, Pune on 08.10.2022.
- Dr. B. A. Bade, Entomologist participated in Farmers ralley at Kadus, Tal. Khed Dist. Pune and delivered lecture on, 5 Importance of Biocontrol in Pest Management of Field Crops, on 13.11.22.
- Dr. B. A. Bade attended *Shivar feri* at village Nannaj, Dist. Solapur on 16.02.2023.

PAU, Ludhiana

Kisan mela	**Date**	**Name of Scientist(s)**
Virtual Regional *Kisan Mela*	14.3.2022, 18.3.2022 & 21.3.2022	Dr. Neelam Joshi, P S Shera, Rabinder Kaur & Sudhendu Sharma
Virtual PAU *Kisan Mela*	24.3.2022 & 25.3.2022	Dr. Neelam Joshi, P S Shera, Rabinder Kaur & Sudhendu Sharma
PAU *Kisan Mela*	23.9.2022 & 24.9.2022	Dr. K S Sangha, Neelam Joshi, P S Shera & Sudhendu Sharma
PAU *Kisan Mela*	24-25.3.2023	Dr. K S Sangha, Neelam Joshi, P S Shera Rabinder Kaur, Sudhendu Sharma

Exhibitions arranged

Event	**Date(s)**
Training programme for Extension officials of State Agriculture and Applied Departments organized by PAMETI, Ludhiana	20.4.2022
Training to field scouts of Sustainable Cotton Production program organized by Reviving Green revolution Cell (Tata Trust)	4.7.2022
Research and Extension Specialists Workshop for *Rabi* crops at PAU Ludhiana	23-24.8.2022
Regional *Kisan mela*, Amritsar	2.9.2022
Regional *Kisan mela*, Ballowal Saunkhri	6.9.2022
Regional *Kisan mela*, Gurdaspur	9.9.2022
Regional *Kisan mela*, Faridkot	13.9.2022

Regional *Kisan mela*, Patiala	16.9.2022
Kisan mela, PAU, Ludhiana	23-24.9.2022
Regional *Kisan mela*, Bathinda	29.9.2022
Regional *Kisan mela*, Amritsar	2.3.2023
Regional *Kisan mela*, Ballowal Saunkhri	7.3.2023
Regional *Kisan mela*, Gurdaspur	10.3.2023
Regional *Kisan mela*, Faridkot	14.3.2023
Regional *Kisan mela*, Bathinda	21.3.2023
Kisan mela, PAU, Ludhiana	24-25.3.2023

Dr. YSRHU, Ambajipeta

- On 11.04.2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) conducted field Demonstration on management of black headed caterpillar with bioagents "*Goniozus nephantidis*" in Makarampuram village, Kanchali Mandal, Srikakulam district.
- On 20.04.2022, **Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.)** conducted roving survey in coconut and cocoa gardens located in the Devarapalli, Yernagudem, Kamavarapukota and Dwaraka Tirumala mandals of West Godavari district and recorded the pest and disease incidence in cocoa and coconut cropping systems later conducted the CDB TMOC Project training programme to the FPO farmers of the above mandals on field mass production of biocontrol agents for the management of coconut diseases.
- on 26.04.2022, **Dr.N.B.V.Chalapathi Rao, Principal Scientist (Ento.)** at adopted village Mamidikuduru under Vice chancellor to Village program conducted at field meeting on adoption of new varieties, hybrids and improved package of practices in coconut, pest and disease management in coconut particularly integrated management practices for controlling Rugose Spiralling Whitefly in coconut
- On 28.04.2022, **Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) Smt. B. Neeraja, Scientist (Pl. Path.) &** Scientists of HRS Ambajipeta participated in the district level workshop on scientific coconut technologies/Value addition organized by CDB Vijayawada in association with HRS, Ambajipeta as a part of Azadika Amrit mahotsav, Annadata devobhava and explained about different insect pests/diseases of Coconut and their management. Around 50 farmers participated in the meeting.
- On 29.04.2022, **Dr.N.B.V. Chalapathi Rao, Principal Scientist (Ento.)** participated in the district level workshop on scientific coconut technologies/ Value addition organized by CDB Vijayawada in association with DRYSRHU V.R Gudem in West Godavari district,AP at KVK, VR Gudem as a part of Azadika Amrit mahotsav, Annadata devobhava and explained about Bio control based management in coconut. The meeting was chaired by Honble Vice Chancellor Dr T. Janakiram and Director of Research Dr RVSK Reddy, DSA Dr A.Sujatha and Zonal Research Head Dr. B.V.K. Bhagavan. Around 90 farmers participated in the meeting.
- On 09.06.2022, **Dr.N.B.V. Chalapathi Rao, Principal Scientist (Ento.)** carried out diagnostic field visit at Dwarapudi and Vemulapalli villages in East Godavari district and observed the incidence of Rugose spiralling whitefly and suggested the farmers about the biocontrol management of Rugose spiralling whitefly through clipping of *Apertochrysa astur* eggs.

- On 13.06.2022, **Dr.N.B.V. Chalapathi Rao, Principal Scientist (Ento.)** created awareness and field demonstration of Biocontrol management of Black headed caterpillar at Makarampuram village of Kanchili mandal, Srikakulam district.
- On 14.06.2022, **Dr.N.B.V. Chalapathi Rao, Principal Scientist (Ento.)** conducted meeting for explaining on importance of cultivation practices for improving yield in coconut and soil testing importance for fertilizer application and conducted demonstration on collection of soil samples for soil testing and collected soil samples from the farmer's field at adopted village Vakalagaruvu, Dr. BR Amdekar Konaseema district.
- On 05.07.2022, **Smt. B. Neeraja, Scientist (Pl.Path.)** participated in AICRP Biocontrol Technical Review meeting and presented the technical programme of work for the year 2022-2023.
- On 08.07.2022, **Dr.N.B.V. Chalapathi Rao, Principal Scientist (Ento.)** participated as resource person in a meeting organized in P.Gannavaram, Konaseema district, Andhra Pradesh on eve of Rytu dinosthavam along with department of Agriculture and explained in detail role of biological control in pest management. District collector also participated as chief guest of the programme at P.Gannavaram participated in Rythu Dinothsavam organized by Dept. of Agriculture.
- On 15.07.2022, **Dr.N.B.V. Chalapathi Rao, Principal Scientist (Ento.)** participated in District Level Agriculture Advisory Board Meeting organized by Dept. of Agriculture and explored about whitefly complex management in coconut at Mummidivaram village .
- On 25.07.2022, **Dr.N.B.V. Chalapathi Rao, Principal Scientist (Ento.)** Visited Agricultural College farm, Bapatla, ANGRAU, inspected the black headed caterpillar *Opisina arenosella* incidence and released the Bio agent's *Goniozius nephantidis* and *Bracon brevicornis* for its management. Later gave a lecture on Bio control based management of Rugose spiraling Whitefly to post graduate students in Department of Entomology
- On 26.08.2022, **Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) & Smt. B. Neeraja, Scientist (Pl. Path.)** explained in detail about the nutri/Kitchen garden establishment to the farmers and also demonstrated the layout of kitchen. As part of VC to village programme at adopted village, Vakalagaruvu, Ambajipeta mandal
- On 05.09.2022, **Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) & Smt. B. Neeraja, Scientist (Pl. Path.)** imparted training to DAESI Facilator, Marteru along with 40 farmers of West Godavari district on crop production, crop improvement, insect pests, diseases and their management and Mass multiplication of biocontrol agents to the farmers.
- On 13.09.2022, **Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) & Smt. B. Neeraja, Scientist (Pl. Path.)** imparted training to DAESI dealers (70 members) of two mandals Jaggampet and Kothapeta of East Godavari district and Dr BR Ambedkar konaseema district on cultivation practices of coconut and biocontrol based management of pest and diseases to the farmers.
- On 13.09.2022, **Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) & Smt. B. Neeraja, Scientist (Pl. Path.)** imparted training 40 Farmers from Nellore district on the crop production, crop improvement, insect pests, diseases and their management and Mass multiplication of biocontrol agents to the farmers.
- On 13.09.2022, Dr. B. Srinivasulu, Principal scientist and Head, **Smt. B. Neeraja, Scientist (Plant Pathology)** and Sri. A Kireeti, Scientist (Hort.) carried out to Thondavaram village as part of VC to village programme along with RHWEP students and created awareness on Horticulture, importance and growing of horticultural crops to the school children.
- On 30.09.2022, **Smt. B. Neeraja, Scientist (Plant Pathology),** Dr. YSRHU - Horticultural Research Station, Ambajipeta carried out and created awareness on Importance of kitchen gardens, layout and nutritional facts among the progressive farmers at Vakalagaruvu village as part of VC to village programme

- On 12.10.2022, **Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) & Smt. B. Neeraja, Scientist (Pl. Path.)** and Scientists of Dr.YSRHU - HRS, Ambajipeta conducted vigilance awareness week to the RHWEP students on the topic corruption free India for a developed nation.
- On 15.10.2022, **Smt. B. Neeraja, Scientist (Plant Pathology)** carried out and demonstrated the technologies on paste application of *T. reesei* against stem bleeding patches and crown application of *T. reesei* powder against bud rot disease in coconut at vakalagaruvu village as part of VC to village programme along with RHWEP students
- On 27.10.2022**,** Dr. YSRHU-Horticultural Research Station, Ambajipeta organized a one day Horticulture fair on cocoa with the financial support of the Directorate of Cashew and Cocoa Development Board, Kochi, Kerala at Dr.YSRHU-Horticulture Research Station, Ambajipeta of Dr. B.R. Ambedkar Konaseema District, A.P. On the occasion of horticulture fair on cocoa organized exhibition, training programme and field visit.
- On 17.10.2022, **Smt. B. Neeraja, Scientist (Pl.Path)** participated in the meeting organized by DAO, Dr. B.R. Ambedkar konaseema district on YSR Rythubharosa 4th release at Ambedkar Bhavan, B.R. Ambedkar konaseema district.
- On 15.11.2022, Smt. **B. Neeraja, Scientist (Plant Pathology)** carried out to vakalagaruvu village as part of VC to village programme along with RHWEP students and created awareness on planting of horticultural crops in the premises of schools, RBKs and village secretariats etc.
- On 25.11.2022, **Smt. B. Neeraja, Scientist (Plant Pathology)** created awareness to farmers on quality planting material, soil testing and latest technologies in banana crop (Dr. YSRHU –Year of banana (2023) to the farmers as part of VC to village programme in the adopted village, vakalagaruvu village.
- On 12.12.2022, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento.)** Attended the Farmer Scientist interaction programme conducted by the Department of Horticulture on "Pest and Disease Management in Chilli Crop" at Durgada Village, Gollaprolu Mandal.
- On 13.12.2022, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento.)** carried out to Mori village of Malkipuram mandal participated in Black level seminar organized by Coconut Development Board, State Centre, Vijayawada.
- On 28.12.2022, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento.)** visited coconut orchards for validation of farmers technology in coconut on fertilizer application to the palms and collected local accession tender nuts for evaluation purpose as the perception of the farmer good for tender nut purpose and having good amount of tender nut water in Allavaram village of Ambajipeta Mandal.
- On 02.01.2023, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento.)** carried out to Pallipalem, Mummidivaram, Muramalla, Serilanka villages carried out diagnostic field visit on yield pest and disease incidence in coconut and intercrops in coconut.
- On 03.01.2023, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento.)** visited the Coconut plantation of at Mummidivaram, Muramalla and observed nutrient deficiency symptoms, pest and disease incidence and suggested management practices.
- On 11.01.2023, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento)** carried out to VR Gudem, Chinnagollapalem, Kruthivenu Mandal, Krishna Dt., VR Gudem carried out diagnostic survey of newly planted coconut plantations and suggest measures regarding production and protection measures in Coconut.
- On 27.01.2023, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento.)** carried out diagnostic survey on coconut plantations infested with Rugose Spiralling Whitefly in Tallarevu village and later proceeded to Kakinada collected vacuum cleaner employed in biocontrol lab from Euraka Forbes authorized service centre

- On 01.02.2023, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento.)** delivered lectures on insects pests of coconut and explained about biocontrol of coconut insect pests and role of lab rearing parasitoids and predators in insect pest management of coconut to trainees during biocontrol lab visit. Shri. A. Kireeti Scientist (Hort.) explained about the ground pollination technique in coconut to trainess.
- On 14.02.2023, **Smt. B. Neeraja Scientist (Plant Pathology)** created awareness on Insect pests and disease management of Banana to the farmers at RHWEP Village, Gangalakurru Agraharam under the Year of Banana.
- On 17.02.2023, **Dr. NBV Chalapathi Rao, Principal Scientist (Ento.)** observed combined incidence of Black headed caterpillar and Rugose spiraling whitefly at coconut plantation in Poduru village of West Godavari district.

AAU, Anand

- Five days awareness programme on '*Jaivik niyantrako ange no Jagruti Saptah'* was organized by AICRP on Biological Control of crop pests, ICAR Unit-9, AAU, Anand at different villages of Tarapur, Anand and Umareth taluka during 22/08/2022 to 26/08/2022.
- Five days awareness programme on'*Jaivik niyantrako ange no Jagruti Saptah'* was organized by AICRP on Biological Control of crop pests, ICAR Unit-9, AAU, Anand at different villages of Tarapur and Umreth taluka during 26/09/2022 to 30/09/2022.
- Three days awareness programme on'*Jaivik niyantrako ange no Jagruti Saptah'* was organized by AICRP on Biological Control of Crop Pests, ICAR Unit-9, AAU, Anand at different villages of Petlad, Sojitra and Borsad taluka during 15/11/2022 to 17/11/2022.

AAU, Jorhat

Training	Scientist attended	Date	Organized by	Location
General training	Dr. Anjumoni Devee	15.08.2022	AICRP BC, AAU Jorhat	Dangdhora, Golaghat
General training	Dr. Anjumoni Devee	03.09.2022	AICRP BC, AAU Jorhat	Charing Baruati Gaon, Sivasagar
General training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	23.09.2022	AICRP BC, AAU Jorhat	Namdang gohain gaon, Sivasagar
General training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	24.09.2022	AICRP BC, AAU Jorhat	Hatimuria gaon, Amguri block, Sivasagar
General training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	28.09.2022	AICRP BC, AAU Jorhat	Bahphola, Jorhat
General training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	10.11.2022	AICRP BC, AAU Jorhat	Sivasagar
General training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	22.11.2022	AICRP BC, AAU Jorhat	Golaghat

General training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	30.11.2022	AICRP BC, AAU Jorhat	Nagaon
TSP training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	15.11.2022	AICRP BC, AAU Jorhat, under ICAR, TSP	Baganpara, Baksa,
TSP training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	15.11.2022	Do	Uttarpara Baksa
TSP training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	16.11.2022	Do	Bongaon, Baksa,
TSP training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	29.11.2022	Do	Bahphala Lality chapori missing Gaon,
TSP training	Dr. Anjumoni Devee	10.12.2022	Do	Diphu, Karbi Anglong
TSP training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	22.12.2022	Do	Mahari chuck, Majuli
TSP training	Dr. Anjumoni Devee and Dr. Nomi Sarmah	21.01.2023	Do	Dhemaji
TSP training	Dr. Nomi Sarmah	20.03.2023	Do	Cholapathar Shyam gaon Sivsagar
Farmer's Fair	Dr. Anjumoni Devee and Dr. Nomi Sarmah	09.11.2022	AAU-ARRI- Titabar	Titabar
Farmer's Fair	Dr. Anjumoni Devee and Dr. Nomi Sarmah	14.12.2022	AAU-SRS- Buralikson	Buralikson

PJTSAU, Hyderabad

- 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 2023
- 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, 2023 in the village
- Demonstrating the erection of pheromone traps to IPM farmers

UAS, Raichur

Sl. No	Activity	No.
1	Field visits	85
2	Diagnostic visits	25
3	All India Radio Programme	08
4	News paper coverage	05
5	Phone calls attended	3500
6	Farmers visit to Bio control lab for pest and disease diagnosis and management	21000

VI. 30.7. Radio/TV talk

UBKV

Radio Programme

- Recording on "Beekeeping for livelihood improvement of rural people" at AIR, Siliguri on 15.02.2023
- Live Phone in Programme on " Biological pests management" at Radio Centre, PBU, Coochbehar on 20.02.2023.

VI. 30.8. Post/Under graduate teaching

ANGRAU

- St.Joseph's college, Vizag students (80 No) with faculty (3 No) trained on Biocontrol agent, Trichogramma production on 14.11.22
- Agricultural college (SKYCA), Etcherla, Srikakulam district students (54 No) with faculty (3 No) trained on Biocontrol agent, *Trichogramma* production on 18.11.22
- Agricultural college, Naira B.Sc (Ag) third year students (56 no) and faculty (2 No.) trained on Biocontrol agent, *Trichogramma* production on 27.8.2022
- Agricultural college, Naira B.Sc (Ag) second year students (76 no) and faculty (2No.) trained on Biocontrol agent, *Trichogramma* production on 24.3.2023

Fig 69. Trainings to Students of Agricultural college Naira on Biocontrol agents production

CPCRI

- **Anes, K. M.**, Merin Babu, Jilu V. Sajan, **Josephrajkumar, A.** and Anithakumari, P. (2022). Training manual on 'Diagnosis and Management of Pests and Diseases in Coconut, ICAR-CPCRI, Regional Station, Kayamkulam, p.33.

GBPUAT

- Under Graduate students of Graphic Era University.
- Post Graduate students from Swami Tirthankar University, Moradabad.
- School Students from 20 different Government school of nearby area.
- Representative of different pesticide companies.
- Farmers from UP, Bihar, MP, Nepal and Uttarakhand.
- Officers of Agriculture Department, Government of Uttarakhand.
- Scientist of 11 different states of India under Centre of Advance Faculty Training Programme.

IGKV

M.Sc. (Ag.) Prev.

- ENT-502 - Insect Anatomy, Physiology and Nutrition- (II semester)

Ph.D.

- ENT- 607 – Advance Insecticide toxicology - (II semester)

KAU, Thrissur

- Thesis submitted during the period - PG (1), PhD (1)
- Scientists of the project have been handling classes on biocontrol and IPM for U.G, P.G. and Ph. D programmes as well as guiding M.Sc and Ph.D students on regular basis.

DrYSPUHF

- Total number of courses taught to UG/PG: 08
- Total Contact hours : 31
- Number of students guided(M.Sc/PG) : 05

UBKV

- The UG students under Student Ready programme as well as ELP programme have been educated and trained for mass multiplication of different bio-agents. Besides some progressive farmers and FPO were also imparted hands-on-training.

SKUAST, Srinagar

- 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.
- IPM on fruit flies
- IPM on apple leaf miner
- IPM on fruit borer

- Demonstration of pheromone technology on fruit borers
- Training to technical officers of Agriculture in district Budgam about use of non-chemicals
- UG and PG practicals related to mass production of bio-agents and their utilization.

KAU, Vellayani

- Dr. Reji Rani O P handled 3 UG courses of which one is Eperiential learning to final year B.Sc Ag students on Bioinocualnts and Bioagents
- Dr. RejiRani O P handled 2 PG and 1 PhD courses on Biological Control and Insect Pathology
- Guiding 3 PG and 3 PhD students on various aspect of Biological Control

MPKV, Pune

- Dr. N. D. Tamboli worked as ADR for Unit Attachment exam. of RAWE students at College of Agriculture, Vilad Ghat during 8-9, Sept., 2022.
- Dr. B. A. Bade worked as ADR for Unit Attachment exam. of RAWE students at College of Agriculture, Pune during 6-8, Sept., 2022.
- Dr. N. D. Tamboli worked as ADR for Village Attachment and Plant Clinic exam. of RAWE students at College of Agriculture, Vilad Ghat during 29-30, Sept., 2022.
- Dr. B. A. Bade worked as ADR for Village Attachment and Plant Clinic exam. of RAWE students at College of Agriculture, Pune during 29-30, Sept., 2022.
- Dr. B. A. Bade worked as ADR for Unit Attachment exam. of RAWE students at College of Agriculture, Pune during 31, Oct ., - 02, Nov., 2022.
- Dr. B. A. Bade worked as Deans Representative for SER EL ENTO-406 exam of Module students at College of Agriculture, Pune during 17-18, Oct ., 2022.
- Dr. N. D. Tamboli worked as ADR for Industrial Attachment exam. of RAWE students at College of Agriculture, Vilad Ghat during 31 Oct.,- 02 Nov., 2022.
- Dr. N. D. Tamboli worked as Moderator for ENTO-365 course during 12-13, Oct., 2022.
- Dr. N. D. Tamboli worked as Invigilator for Ph.. D. CET examination on 13, Nov., 2022.
- Dr. N. D. Tamboli worked as External Examiner for Semester end practical exam. of ENT-508 course at AC, Pune on 21, Nov., 2022.
- Dr. B. A. Bade worked as External Examiner for Semester end practical exam. of ENT-507 course at PGI, Rahuri , Pune on 29, Nov., 2022.
- Dr. N. D. Tamboli worked as Team Leader for Education Trip of IV semester students of EDNT-242 course at Hyderabad during 22-26, Nov., 2022.
- Dr. N. D. Tamboli worked as External examiner for Semester end practical exam. of ENT-591 course at AC, Pune on 09, Oct., 2022.
- Dr. N. D. Tamboli worked as ADR for Industrial Attachment exam. of RAWE students of Diploma batch at College of Agriculture, Vilad Ghat during 27-28, Dec., 2022.

PAU, Ludhiana

Teacher	No. of courses taught	
	PG	UG
Dr. K S Sangha	2	1
Dr. Neelam Joshi	3	1
Dr. Parminder Singh Shera	2	2
Dr. Rabinder Kaur	-	2
Dr. Sudhendu Sharma	1	2
	No. of PG students guiding/guided	
	Ph. D.	**M.Sc.**
Dr. K S Sangha	2	1
Dr. Neelam Joshi	2	3
Dr. Parminder Singh Shera	2	1
Dr. RabinderKaur	2	1
Dr. Sudhendu Sharma	1	1

Thesis evaluation / Viva-Voce / Examinership

- Dr. Neelam Joshi appointed as an external examiner to set question paper of B.Sc. Agriculture (Hons.) of SR University, Warangal, Telangana, India
- Dr. P. S. Shera evaluated M.Sc. thesis and conducted viva-voce as external examiner of M.Sc. student from CSKHPKV, Palampur
- Dr. K. S. Sangha evaluated PhD thesis and conducted viva voce as external examiner of PhD student from SKAUST Jammu
- Dr. K S Sangha evaluated M.Sc. thesis as external examiner of student from MPUAT, Udaipur
- Dr. P.S. Shera acted as Rapporteur of technical session in 31th Biocontrol Workers Group Meeting of All India Coordinated Research Project on Biological Control of Crop Pests held at Bengaluru on October 20-21, 2022
- Dr. P.S. Shera acted as reviewer of journal – International Journal of Tropical Insect Science
- Dr. P.S. Shera performed invigilation duty in End-Term Examination of Under-graduate Courses of College of Agriculture
- Dr. K S Sangha acted as reviewer of journals – International Journal of Tropical Insect Science, Egyptian Journal of Biological Pest Control & Journal of Environmental Biology
- Dr. K S Sangha conducted the End-Term Examination of Under-graduate Courses of College of Agriculture as Superintendent.
- Dr. Rabinder Kaur acted as external examiner to evaluate the progress of research work for the up-gradation of fellowship of JRFs and SRFs (CSIR-UGC), Department of Zoology, Guru Nanak Dev University, Amritsar (8.3.2022, 15.3.2023)

- Dr. Rabinder Kaur acted as an external examiner to conduct final practical examination of PG Course ZOP 573, Department of Zoology, Guru Nanak Dev University, Amritsar Entomology (19.5.2022)

Dr. YSRHU, Ambajipeta

- On 21-09-2022**,** Smt. B. Neeraja, Scientist (Plant Pathology) Dr. YSRHU - Horticultural Research Station, Ambajipeta explained in detail about the coconut diseases and integrated disease management practices to the RHWEP students and later showed the method demonstrations on 1% Bordeaux mixture, Bordeaux paste preparation and their application in coconut and cocoa, copper oxy chloride paste application on stem bleeding patches and crown spraying of coc (3g/litre) of water against bud rot disease
- On 27-10-2022, as part of educational tour, students (75 Numbers) from the college of Horticulture, Anantharajupeta, 2nd year B.Sc (Horticulture) visited Dr.YSRHU-Horticulture Research Station, Ambajipeta and scientists explained about the research station activities and technical information on coconut and cocoa.
- On 5-11-2022, RHWEP (college of Horticulture, Parvathipuram and VR Gudem) students of Dr. YSRHU - HRS, Ambajipeta conducted Ryhusadassu programme as per the RHWEP programme. In this programme the students organized exhibition and conducted role plays on roles of RBKS and village sachivalayam. The programme was inaugurated by the Honourable Vice chancellor, Dr. T. Janaki Ram, Dr. YSRHU.
- On 3-01-2023, Students of B.Sc (Hons.) Agriculture of Pandit Jawaharlal Nehru College, Karaikal, Puducherry visited Dr. YSRHU-HRS, Ambajipeta. The scientists of Dr. YSRHU - HRS, Ambajipeta explained in detail about the research station activities and biocontrol based management of pests and diseases in coconut.

AAU, Jorhat

- During 2022-23, three Ph. D and one M.Sc. students completed their degree under AICRP BC
- Two Ph. D and three M.Sc. students doing their research under AICRP BC in 2022-23
- Ph. D. Student Mr. G. Naveen able to receive UGC-NFPWD fellowship, for his research proposal ‘Development of plant based formulation for management of insect pests of stored pulses’.
- Ph. D. Student Miss Sunita Chetry received 10th position in DST INSPIRE-2021 fellowship for her research proposal ‘Para pheromone based product for monitoring and management of fruit fly complex in vegetable ecosystem’
- Research publications=6
- Collaboration with Deptt. Of plant pathology for biopesticides production, M.Sc and Ph.D. research
- Collaboration with Deptt. Of Agronomy, Soil Science and Horticulture for pest management of organic and natural farming
- Research collaboration with BARC
- Collaboration with IPFT, Delhi
- Student research collaboration with Tezpur University
- Student research collaboration with Agricultural University of Athens, Greece
- Farmer’s training=12, beneficiaries:334
- Training for Scientist, SMS, State Govt. officers=3 nos

- Area covered under large scale demonstration of technologies=65 ha
- Under TSP, village covered 8 from 6 district with 410 beneficiaries
- Technical/extension bulletin=4
- Monograph=1
- Income generation Rs. 50850.00

UAS, Raichur

- Experential learning programme to UG students

TNAU

Ph.D courses

- **ENT 605. Bio-Inputs for Pest Management ENT05** (2+1) - Dr.S.Jeyarajan Nelson

VI. 30. 9. LIST OF PUBLICATIONS

ANGRAU

Research articles

- Manisha L, Visalakshi M, Sairam Kumar DV, Kishore Varma P. 2022. Exploring the ethology of gravid trichogramatids towards heterospecific hosts. Journal of Exp. Zoology India. 225(1): 897-901.

Technical Bulletin

- Biological control- A sustainable tool for Eco friendly pest management.
- Empowering Tribal farmers of Visakhapatnam district under Tribal Sub Plan – Realizing the vision of Prime Minister of India.

Reports/Manuals

- Report on Technology- Efficacy of NBAIR *Bacillus thuringiensis* Bt 25 against maize fall armyworm submitted to NBAIR.
- Report on Technology- Efficacy of NBAIR *Metarhzium anisopliae* Ma35 against maize fall armyworm submitted to NBAIR.
- Report on Collaborative trail – Field evaluation of ICAR-NBAIR strains against thrips species in *Capsicum annum* submitted to NBAIR.
- Annual Report, 2021-22 of AICRP BC centre submitted to NBAIR.
- Annual Report, 2021-22 of RARS, Anakapalle compilation for submission to ANGRAU.
- Available Biocontrol facilities and mass production of natural enemies and other bioagents by AICRP on Biocontrol, RARS, Anakaplle – ANGRAU centre Uploading of data in google form given by NBAIR, Bengaluru.

Conference papers

- Visalakshi M, Jagadeesh Patil, Suresh M, Manisha BL. Seasonal incidence and ecofriendly management of white grub in sugarcane in coastal districts of Andhra Pradesh. 7th National Conference on Biological control held at ICAR-NBAIR, Bengaluru from 15-17 Dec, 2022.

Any other item

- Associated in Mobile app's developed by ICAR-NBAIR, Bengaluru
  - ✦ Maize fall armyworm mobile app
  - ✦ *Tuta absoluta* mobile app

CPCRI

Research articles

- Alagar M, Srinivasan T, Rajamanickam K, Josephrajkumar A, Yasmin A, Chinnadurai S, Sivakumar V, Praneetha S, Maheswarappa HP. 2022. Efficacy of botanical formulations against coconut rhinoceros beetle, *Oryctes rhinoceros*. Indian Journal of Entomology, 21213.
- Josephrajkumar A, Evans GA, Mohan C, Merin Babu, Anes KM, Alagar M, Hegde V. 2022. Morphological and Molecular identification of the woolly whitefly, *Aleurothrixus floccosus* (Maskell). Int. J. Trop. Insect Sci, 42: 2493-2500.
- Saneera EK, Raguraman S, Kannan M, Josephrajkumar A**,** Jeyarani S. 2023 Microscopy-based morphological characterization of rugosespiraling whitefly, (*Aleurodicus rugioperculatus* Martin)-an exotic pest on coconut in India. Microsc. Res. Tech.
- Thube SH, Pandian RTP, Josephrajkumar A, Bhavishya A, Nirmal Kumar BJ, Firake DM, Shah V, Madhu TN, Ruzzier E. 2022. *Xylosandrus crassiusculus* (Motschulsky) on Cocoa Pods (*Theobroma cacao* L.): Matter of Bugs and Fungi. Insects, 13(9): 809.
- Vinayaka Hegde, Merin Babu, Josephrajkumar A. 2022. Global scenario on Phytoplasmal diseases on palms. Indian Journal of Entomology, 22034.

Book

- Anes KM, Nihad K, Anithakumari P, Najeeb PH. 2022. Compendium of Lecture Notes, Diploma in Agricultural Extension Services for Input Dealers (DAESI) ICAR-CPCRI, RS, Kayamkulam. 128.
- Anithakumari P, Regi J, Thomas, Josephrajkumar A, Abdul Haris A, Anes KM, Merin Babu, Shareefa M, Nihad K, Jeena Mathew, Indhuja S. 2022. ICAR - CPCRI, Regional Station, Kayamkulam @ 75-Serving Coconut Farmers since 1947. ICAR - CPCRI Publication No. 302, 52.

Book chapters

- Chandrika Mohan A, Josephrajkumar PS, Prathibha M, Sujithra Jilu V, Sajan KM. 2022. Anes Pests and Their Management in Coconut. In: Mani M (eds). Trends in Horticultural Entomology. Springer Nature Singapore Pte Ltd, Book, 1411-1440.
- Chandrika Mohan A, Josephrajkumar, Shivaji H, Thube EK, Saneera, Mani M. 2022. Pests and their management in cocoa. In: Mani M (eds). Trends in Horticultural Entomology. Springer Nature Singapore Pvt Ltd, Book , 1441-1456.
- Chandrika Mohan A, Josephrajkumar, Shivaji H, Thube EK, Saneera, Rajkumar. 2022. Pests and their management in arecanut. In: Mani M (eds). Trends in Horticultural Entomology. Springer Nature Singapore Pvt Ltd, Book, 1529-1544.
- Josephrajkumar A, Mani M, Anes KM, Mohan C. 2022. Ecological Engineering in Pest Management in Horticultural and Agricultural CropsIn: Mani M (eds). Trends in Horticultural Entomology. Springer Nature Singapore Pte Ltd, Book, 123-155.
- Josephrajkumar A, Anes KM, Merin Babu, Vinayaka Hegde. 2022. New frontiers in pest Management

in coconut. In: *Compendium in Coconut* Eds. K Vanaja, P.C. Balakrishnan and K.N. Satheesan, KAU publications, Kerala Agricultural University, Thrissur. 229-237.

- Josephrajkumar A, Merin Babu, Anes KM. 2022. Incursion Management of Invasive Pests on Coconut. In: *E-manual: Kalpa Graduate Readiness Programme-II*. Eds. Jayasekhar S, Neema M. September, 17, 2021 to March 28, 2022 ICAR-CPCRI, Kasaragod. 181-187.
- Regi J, Thomas, Josephrajkumar A. 2022. Pollination Services in Coconut Plantations. *In*: *Ecosystem Services Analysis: Concepts and applications in diversified coconut and arecanut gardens* Eds. V. Arunachalam, V. Paramesha, A.R Uthappa and Parveen Kumar, ICAR-CCARI, Old Goa, Pp: 161-182.
- Subramanian P, Alka Gupta, Murali Gopal, Selvamani V, Josephrajkumar A, Surekha R, Krishnakumar V, Rav Bhat, Vinayaka Hegde, Thomas GV. 2022. Organic cultivation practices in coconut. In :*Compendium in Coconut* Eds. Vanaja K, Balakrishnan PC, Satheesan KN, KAU publications, Kerala Agricultural University, Thrissur. 140-155.

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- Anithakumari P, Regi J, Thomas, Josephrajkumar A, Abdul Haris A, Anes KM, Merin Babu. 2022. Central Plantation Crops Research Institute, Kayamkulam @75 (In Malayalam). Indian Naleekara Journal, 13(4): 6-10.
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- Anithakumari P, Regi J, Thomas, Josephrajkumar A, Abdul Haris A, Anitha Karun. 2022. History and research accomplishments of ICAR-CPCRI, Regional Station, Kayamkulam. Indian Horticulture, 67(6): 19-23.
- Josephrajkumar A, Merin Babu, Jilu V, Sajan, Anes KM, Prathibha PS, Regi J, Thomas, Vinayaka Hegde. 2022. Strengthening Quarantine and Incursion Management of Invasive Pests on Coconut. Indian Cocon. J, 65(2): 22-28.
- Josephrajkumar A**,** Nafeesa M, Nimisha Mathews, Remya JS, Murugan M. 2022. Spotted Grasshopper, a threat to high range plantations (*In Malayalam*). Kerala Karshakan, August Issue 67(11)**:** 57-59.
- Jilu V, Sajan, Prathibha PS, Diwakar Y, Josephrajkumar A. 2022. New distributional record of palm whitefly, *Aleurotrachelus atratus* Hempel in Kerala, India. Indian Cocon. J, 65(1): 10-12.
- Sunny Thomas, Abdul Haris A, Josephrajkumar A. 2022. Coreid bug damage and management in coconut (In Malayalam). Indian Nalikera Journal**,** 14(8): 14-15.
- Vinayaka Hegde, Josephrajkumar A. 2022. Integrated management of pests and diseases for the successful cultivation of Coconut, Arecanut and Cocoa. Indian Horticulture, 67(6): 59-65.
- Merin Babu, Josephrajkumar A, Anes KM, Thangeswari S, Surulirajan M, Vinayaka Hegde. 2022. Re-emergence of lethal wilt disease in east coast regions of Tamil Nadu. Indian Coconut Journal**.** 65(2): 16-18.

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- Jerard BA, Josephrajkumar A, Damodaran V, Zamir Ahmed, SK, Jaisankar I, Chakurkar EB. 2022. Management of Invasive Whiteflies on Coconut Palms. Extension Folder, ICAR-CIARI, Port Blair, Andaman and Nicobar Islands, India

- Josephrajkumar A, Regi J, Thomas, Merin Babu, Anes, KM, Jilu V, Sajan, Shareefa, M, Indhuja S, Anithakumari P, Anitha Karun. 2022. Good Management Practices for Pests and Diseases in Coconut. Extension Folder, ICAR-CPCRI, RS, Kayamkulam.
- Rajkumar, Sujithra M, Shivaji H, Thube, Josephrajkumar A, Ramchandran E. 2022. Mithra Neemavaragala Kau vingilaberuthinnipullikallaniyanthirikum. ICAR- Central Plantation Crops Research Institute, Kasaragod. Extension folder No. 265.

Presentations in workshops/Seminars/Conference

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- Josephrajkumar A, Anes KM, Merin Babu, Jilu V Sajan, Vinayaka Hegde. 2022. Advances in pest management in oil palm Keynote lecture 4.1.2. pp 52 In: Souvenir and Abstracts of Third National Conference on Oil Palm-Way Forward for increasing vegetable oil pool through AtmaNirbhar Bharat for doubling the income and social security to farmers, (Eds.) P. Rethinam, K. Suresh. and V. Krishnakumar, Society for Promotion of Oil Palm Research and Development, ICAR-IIOPR, November 23-25, 87.
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- Josephrajkumar A, Regi J, Thomas, Merin Babu, Jilu V Sajan, Anes KM, Hegde V. 2022. Insect-regulated ecosystem services in coconut. T2- LP- 02 pp25. In: Book of Abstracts, Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward (Eds.) U. Amala *et al*., Society for Biocontrol Advancement, ICAR-NBAIR, December 15-17, 2022 Bengaluru, viii+179p.
- Logeshkumar P, Srinivasan G, Shanthi M, Chinnadurai S, Josephrajkumar A, Poorani J, Venkatesh K, Murugan M. 2022. First record of *Amitus* sp. (Hymenoptera: Platygastridae) parasitizing exotic Acacia whitefly, *Tetraleurodes acaciae* (Quaintance) [Hemiptera: Aleyrodidae] from India. T6-PP-02 pp 123. In: Book of Abstracts, Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward (Eds.) U. Amala *et al*., Society for Biocontrol Advancement, ICAR-NBAIR, December 15-17, 2022 Bengaluru, viii+179p.
- Rajkumar, Sujithra M, Surekha, Josephrajkumar A, Vinayaka Hegde. 2022. Integrated eco-friendly management of white grub in coconut palms using entomopathogenic nematodes. Paper presented in First International IPM Symposium on Coconut-Implementing IPM to sustainability, Protect Coconut, Producers and Industry, held at ICC, Jakarta during August 23-26.
- Regi J, Thomas, Josephrajkumar A, Anes KM, Indhuja S, Shareefa M, Merin Babu, Jilu V Sajan, Anithakumari P. 2022. Commemorating Mendel and Comprehending Microscopy (CMMC)-Workshop proceedings, 16th July 2022, ICAR-CPCRI, Regional Station, Kayamkulam, p.34.
- Sujithra M, Rajkumar M, Monisha M, Josephrajkumar A, Vinayaka Hegde. 2022. Synergistic effect of *Metarhizium majus* and *Steinernem acarpocapsae* in the Management of Coconut rhinoceros Beetle, *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae)". Presented in 1st International Symposium on Coconut IPM 2022 held from 23-26 August 2022.

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Research articles

- Sapna, Sharma R, Dubey S. 2022. Evaluation of Consortium of Fungal and Bacterial Bio-control agents for Management of Rice Sheath Blight caused by *Rhizoctonia solani*.Biological Forum – An International Journal, 14(2a): 545-549.
- Kabdwal BC, Sharma R, Kumar S, Singh KP, Srivastava RM. 2022. Occurrence and status of sheath blight of rice in Kumaun region of Uttarakhand. Plant Disease Research, 36 (2): 209-214.
- Negi M, Sharma R, Negi A, Kabdwal BC. 2022. Effect of different varieties of *Raphanus sativus* as bio-fumigants and microbial biocontrol agents for the management of *Pythium aphanidermatum* causing damping off in tomato. Pantnagar Journal of Research, 20(2): 75-80.
- Kabdwal BC, Sharma R, Arunkumar, Kumar S, Singh, KP, Srivastava RM. 2023. Efficacy of different combinations of microbial biocontrol agents against sheath blight of rice caused by *Rhizoctonia solani*. Egyptian Journal of Biological Pest Control, 33:29.
- Chaudhary D, Maurya RP, Dobhal P, Suyal P, Sreedhar M, Koranga R. 2022. Preference of generalist predator, *Eocanthecona furcellata* (Wolff.) (Heteroptera: Pentatomidae) against live and larval extracts of three different insect pests. International Journal of Tropical Insect Science.
- Maurya RP, Koranga R, Samal I, Chaudhary D, Paschapur AU, Sreedhar M, Manimala RN. 2022. Biological control: a global perspective. International Journal of Tropical Insect Science.
- Sreedhar M, Pant SD, Maurya RP, Vasudha, A. 2022. A study of the attraction of natural enemies in the cabbage crop ecosystem using various flower extract sprays. Journal of Experimental Zoology, India. 25(2):1745-1750.

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- tSovfHkdrkZ ,ao mudkiz;ksx.
- Biocontrol Agents & their applications.

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- Sharma R, Arunkumar, Kabdwal BC. 2022. Integrated Management of Potato Crop. Indian Farmers Digest. September, 55, (09). 09-11pp.
- Sharma R, Arunkumar, Kabdwal BC. Risk Assessment of Secondary Metabolites of Microbial Bioagents. Indian Farmers’ Digest. Volume: 55, No. 03 March 2022.

Book Published

- Mall P, Pandey AK, Maurya RP. 2022. An Introduction to Fundamentals of Entomology. AGRO India Publications, Prayagraj. 21- 4.

Book Chapter

- Maurya RP, 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–1). Mahima Research Foundation and Social Welfare, Karaundi, BHU, Varanasi-221005, UP, India. 118-133.

Extension folder /Bulletins/Manuals

- Success story video
- Success stories of biological control
- Bio control agents & their applications
- Management of sheath blight of rice through biocontrol agents
- tSo fu;U=.k dh lQyrk dh dgkfu;k¡ fdlkuksa dh tqckuh
- tSo vfHkdRkkZ ,oa mudk iz;ksx
- —'kd - oSKkfud laokn iqlfrdk
- v.M ijthoh] Vªkbdksxzkek% fdlku Hkkb;ksa dk fe= dhV

Conference papers

- Kumar S, Arunkumar, Kumar S, Kabdwal BC, Sharma R. Biointensive management of *Meloidogyne enterolobii* in tomato under glasshouse conditions. 8th International Conference (Hybrid Mode) Plant Pathology: Retrospect and Prospects. March 23-26, 2022 SKNAU, Jobner-Jaipur, Rajasthan
- Kumar S, Kabdwal BC, Kumar S, Sharma S. Management of *Meloidogyne enterolobii* in guava (*Psidium guajava*) using biointensive approaches under glasshouse conditions. National Symposiumon Multidisciplinary Approaches for Plant Health Management 4th - 5th November, 2022.

IGKV

Research articles

- Rashmi Gauraha, Jayalaxmi Ganguli. 2022. First report of aphid mummy, *Diaeretiella rapae* (Mcintosh) recorded on Cabbage from Raipur, Chhattisgarh J. of Appl. Zool. Res, 33(2): 120-123.
- Beerendra, Priyanka Nagdev, Jayalaxmi Ganguli, Ashitosh Mohanan. 2022. Feeding potential of green lacewing, *Chrysoperla* sp. (Chrysopidae: Neuroptera) on eggs of chickpea pod borer, *Helicoverpa armigera* (Hubner) Paper Accepeted in Journal of Experimental zoology, India.
- Priyanka Nagdev, Beerendra HK, Chandrakar, Jayalaxmi Ganguli. 2022. Determination of insect faunal diversity through light trap catches at Raipur, Chhattisgarh during kharif (2018). The journal of Pharma Innovation, 11 (92): 373-375.
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- Priyanka Nagdev, Beerendra HK, Chandrakar, Jayalaxmi Ganguli. 2022. Seasonal incidence and management of rice leaf folder, *Cnaphalocrosis medinalis* through Bio Intensive Pest Management (BIPM) at Raipur, Chhattisgarh. J. of Exp. Zool. India, 25 (1): 1077-1081.
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- Anjali Manhar RN, Ganguli, Jayalaxmi Ganguli, Rohit Kumar. 2022. Color preference for egg laying and emergence of *Trichogramma japonicum* (Ashmead) using sentinel cards under laboratory condition. The Pharma Innovation Journal, 11(12): 2089-2093.

Technical Bulletin

- Jaivik Keet Niyantran- ek parichay.
- Gajar Ghass ka Jaivik Niyantran.

Popular articles

- "Jaivik Kheti aaj ki Aavshyakta"- Krishi World, March 2023, 24-27.

Extension folder /Bulletins

- Mexican Beetle- *Zygogramma bicolorata* dwara gajar ghas ka jaivik unmulan.
- Lady Bird Beetle- Mahu/Maini ka bahupayogi parbhakshi keet.
- Jaivik Keet Niyantran- ek parichay.
- And parjivi Trichogramma prajati ka keet prabandhan me upyog.
- Reduviid bug- ek bahupayogi parjivi keet.
- Bracon- ek prabhavshali parjivi keet.
- Reduviid bug – Ek Bahupayogi parbhashi keet.
- Trichocard keetoon ke undon awastha ke liye prabhavi jaivik niyantran.
- Braco card utpadan taknik.

II Millet R, Hyderabad

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- Shyam Prasad G, Stanley J, Aruna Sai S, Srinivasababu K, Gangaiah B. 2022. Management of fall armyworm, *Spodoptera frugiperda* in organic sorghum cultivation. In International Conference on Reimaging rainfed agroecosystems: Challenges and opportunities. 22-24 December, 2022, Indian Society of Dryland Agriculture, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad.
- Shyam Prasad G, Stanley J, Aruna Sai S, Srinivasa Babu K, Gangaiah B. 2022. Management of fall armyworm, *Spodoptera frugiperda* in sorghum through bioagents. In Proc. of 7th National Conference on Biological Control: 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and Way Forward (Amala U., Ankita Gupta, David, K.J et al. eds), 15-17 December 2022, ICAR-NBAIR, Bengaluru, 116.

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KAU, Thrissur

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- Pavithrakumar K, Smitha MS, Chellappan M, Subramanian M. 2022. Toxicity of some insecticides to life stages of *Cheilomenes sexmaculata* under laboratory conditions. Indian J. Entomol. 84(4): 878-880.

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Conference paper

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- Kumar A, Suroshe Sachin S, Sonam, Saini GK, Singh Jitendra. 2023. Efficacy of genetically transformed *Metarhizium anisopliae* against *Spodoptera litura* and *Aphis craccivora*. Saudi Journal of Biological Sciences, 30(1): 103493.
- Kumar A, Birah A, Tanwar RK, Khokhar MK, Singh SP. 2022. Population of whitefly, *Bemisia tabaci* (Gen) and its natural enemies in cotton field in Northwest India. Annals Plant Protection Sciences, 30(1): 61-64**.**
- Kumar A, Suroshe Sachin S, Sonam, Sagar D. 2022. Effect of rearing methods on *Spodoptera litura* (F.) under laboratory condition. Indian Journal of Entomology, 22237.
- Parvez R, Kumar A, Pankaj, Sehgal M, Khokhar MK, Singh SP, Chander S. 2022. Occurrence of Plant Nematodes in rice IPM fields of rice-wheat cropping system in district Rohtak (Haryana) and GautamBuddh Nagar (Uttar Pradesh). Indian Journal of Nematology, 52(2): 234-237.

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DrYSPUHF

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- Singh DP, Verma SC, Kaler NS, Kumar A. 2022. Impact of Organic inputs and transplanting dates on foraging mode of honey bees in radish (*Raphanus sativus* L.). Annals of Agriculture Research New Series, 43(2): 241-247.
- Sharma T, Verma SC, Sharma PL, Chandel RS, Banshtu T, Katoch S, Sharma N, Sharma P. 2022. Biology and demographic parameters of *Diaeretiella rapae* (McIntosh) against *Brevicoryne brassicae* (L.) Acta Scientific Agriculture, 6(1): 3-14.
- Sharma P, Verma SC, Sharma PL, Chandel RS. 2022. Host Stage Preference, Functional Response and Biological Parameters of A*phelinus asychis* Walker on *Myzus persicae* (Sulzer) in Bell Pepper. Indian Journal of Ecology, 49(5): 1764-1769.
- Katoch S, Sharma PL, Verma SC, Chandel RS, Sharma P, Sharma N. 2022. Demographics and host-kill parameters of *Diglyphus horticola* Khan against *Chromatomyia horticola* (Goureau). Bulletin of Entomoloigcal Research, 1-13.

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- Palial S, Verma S, Sharma PL, Chandel RS, Kumar R, Gupta M, Sharma N, Sharma P. 2022. Biology, predatory potential and growth parameters of the syrphid fly, *Scaeva pyrastri* (L.) (Diptera: Syrphidae) feeding on the cabbage aphid, *Brevicoryne brassicae* (L.) Egyptian Journal Biological Pest Control, 32: 134.
- Gaikwad MB, Verma SC, Sharma PL, Chandel RS, Challa N. 2022. Effect of meteorological parameters and natural enemies on population dynamics of rose aphid, *Macrosiphum rosae* L. under mid hills of Himachal Pradesh, India. Journal of Entomological Research, 464:731-737.
- Banshtu T, Verma SC, Dengta G, Sharma P, Sharma D. 2023. Influence of abiotic variables on seasonal occurrence of pea leaf miner, *Chromatomyia horticola* (Goureau) afflicting damage to pea. Journal of Agrometeorology, 25(1): 170-172.

Reports/Manuals

- Annual progress report of AICRP-BC for Solan centre
- Annual progress report of Department of Entomology, YSPUHF, Nauni, Solan
- Annual progress report of the project on Subhash Palekar Natural farming
- Certificate course on Natural Farming for under graduate, post graduate and practitioners

Paper presented in Symposium/Conference

- Sharma P, Sharma PL, Verma SC. 2022. Demographic parameters of *Hippodamia variegata* (Goeze) against *Macrosiphum euphorbiae* (Thomas) on tomato. Abstract No. 162. *In*: Third National Symposium of Entomology 2022: Innovation and Entrepreneurship w.e.f. December 8-10, 2022, Hyderabad, India.
- Sharma P, Sharma PL, Verma SC. 2022. Population growth parameters of *Aphelinus asychis* Walker on *Myzus persicae* (Sulzer) in bell pepper. Abstract No. IC-T7-091. *In:* International Conference on Advances in Agriculture and Food Systems towards Sustainable Development Goals w.e.f August 22-24, 2022. University of Agriculture Sciences, Bangalore. India.
- Verma SC, Sharma PL, Chandel VGS, Chandel RS, Sharma N, Sharma P. 2022. Management of phytophagous mites (*Tetranychus urticae* Koch) on cucumber using *Blaptostethus pallescens* Poppius and *Neoseiulus longispinosus* (Evans) under polyhouse conditions. Abstract no. T7-OP-03. Page 132. *In:* Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forwardw.e.f. 15–17 December 2022, Bengaluru.
- Chandel VGS, Verma SC, Sharma PL, Chandel RS, Sharma P, Chauhan N. 2022. Evaluation of some biocontrol agents against leopard moth, *Zeuzera multistrigata* Moore (Cossidae: Lepidoptera) in apple.Abstract no. T7-PP-10. Page.149. *In*: Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward w.e.f. 15–17 December 2022 Bengaluru.
- Sharma P, Sharma PL and Verma SC. 2023. Predatory potential and biology of *Coccinella septempunctata* L. against *Macrosiphum euphorbiae* (Thomas) on tomato. Abstract No.114. *In:* National Conference on Agro-Ecology Based Agri-Food Transformation Systems w.e.f. January 27-28, 2023. ICAR- IIFSR, Modipuram, Meerut, India.

DrYSPUHF

Seminar/Conference

- Attended International Conference on Trans Himalayan Conference on localised Solutions and Implementation Strategy w.e.f 19-22 December, 2022, Organised by Sewa International in Collaboration with UHF, Nauni, Solan.
- Delivered lead lecture in International Conference: International Conference on Trans Himalayan Conference on localised Solutions and Implementation Strategy w.e.f 19-22 Dec, 2022, Organised by Sewa International in Collaboration with UHF Nauni, Solan.
- Put up exhibition depicting Natural enemies of insect-pests of crops on the occasion of Shoolini Fair at Thodo ground Solan
- Conducted visit of 15 farmers from Guru gram, Haryana brought by HAU, Hissar on dated 25/02/2023.
- Conducted visits of RAWE students (Final Year B.SC Horticulture) in Bio Control Laboratory of the department.
- Demonstrated bioagents to B.Sc. Horticulture -IInd year students during practical of course PPE-221

Participation in meetings/Workshops

- Attended workshop on National Workshop on Innovation on Natural Farming on dated 25.4.2022 organised by NITI Aayog, New Delhi.
- Attended meeting for Course Curriculum on Natural Farming for UG and PG programme on dated 5-6/5/2022 at CAU, Rani Pool Sikkim.
- Attended meeting for Course Curriculum on Natural Farming for UG and PG programme on dated 21-22/5/2022 at KVK, Kaneri Math, Kohlapur, Maharashtra.
- Attended meeting for Course Curriculum on Natural Farming for Gujarat State UG programme on dated 22/7/2022 in Gujarat.
- Attended meeting for formulation of syllabus on Agriculture specially on Natural Farming for incorporation in NCERT Syllabus starting from Vatika-I to 12 Class.
- Attended meeting of GITZ members from Germany in Director of Research Office on dated 14.12.2022.
- Attended 3st AICRP meet on Biological Control of Crop pests w.e.f 20.10.2022 to 21.10.2022 at NBAIR, Bengaluru.
- Delivered lecture on History concept and farming practices of Natural Farming on dated 21.12.2022 under International Conference on Trans Himalayas Conference on localised solutions and Implementation Strategy 19-22 December, 2022 at UHF, Nauni, Solan, HP.

UHAS

- Pradeep S, Divya M, Sunil C, Srikanth CD, Shilpashree YP. 2022. Comparative Evaluation of Gonandajala and Liquid Organic Manures on Growth and Yield of Rice. 3rd International Web-Conference on Natural Resource Management for Global Food Security and Sustainable Development Goals, December 02-03, 2022

UBKV

Research Articles

- Maji A, Pal S, Gurung B, Chatterjee M, Sahoo SK. 2022. Diversity of aphids and their predatory coccinellids from West Bengal. Indian Journal of Entomology, 22276.

- Patra B, Mandal S, Sahoo K, Hath TK. 2022. Higher active of Glutathione S-transferase enzyme is associated with field evolved resistance in *Empoasca flavescens* Fabricius. 2022. Inter. Journal of Tropical Insect Science.
- Sarkar S, Pal S**,** Sahoo SK, Laskar N, Ghosh J. 2022. Field efficacy study of different biorationals and insecticides against brinjal fruit and shoot borer under terai region of West Bengal. Uttar Pradesh Journal of Zoology, 43(16): 57-66.
- Polu P, Sahoo SK, Bhowmick N. 2022. Susceptibility of different rejuvenated mango cultivars to leaf cutting weevil (*Deporaus marginatus*). Agricultural Mechanization in Asia, 53(05): 7589-7594.
- Mounika T, Sahoo SK, Chakraborty D. 2022. Diversity and distribution of *Callosobruchus* spp. attacking stored chickpea in northern tracts of West Bengal. International Journal of Environment and Climate Change, 12(10): 488-493.
- Patra B, Mandal S, Sahoo SK, Hath TK. 2022. Higher activity of Glutathione S-transferase enzyme is associated with field evolved resistance in *Empoasca flavescens* Fabricius. Int.J.Trop.Insect.Sci, 42: 2887–2895.
- Patra B, Hath TK. 2023. Resistance status and activity of detoxifying enzymes in *Oligonychus coffeae* (Nietner) (Acari: Tetranychidae) on tea. Crop Protection, 167:106-201.

Book Chapters

- Sahoo, SK, Nayak US, Maji A. 2022. Pests of Mango ecosystem and their integrated management. In: Pests of Fruit Crops, Publisher: Nipa Genx Electronic Resources & Solutions Pvt. Ltd., New Delhi, 1-38p.

Extension Folder/ Bulletins/ Manuals:

- Trichocard- Jaibik Upaye Fasaler Poka Niyantraner akti Notun Upay (Written and edited by Moulita Chatterjee, Shyamal Kumar Sahoo, Anamika Debnath, B. Patra, Debanjan Chakraborty). Published by AICRP-Biocontrol (UBKV Unit) during 2022-23.
- Management of insect pests of large cardamom.
- Modern package of practice for turmeric cultivation by Anamika Debnath, Ramkrishna Sarkar & Suchand Datta

Seminars/Symposiums attended

- 6th International conference on Current issues in Agricultural, biological and applied sciences for sustainable development, June 11-13, 2022, held at Kalimpong.
- 4th International conference –Global efforts on agriculture, Forestry, Environment and food security, September 17-19, 2022, held at Pokhara, Nepal.
- Seminar on Horticulture for sustainable development, nutritional and livelihood security, 26-27th May, 2022, held at UBKV, Pundibari, Cooch Behar, West Bengal.
- National Seminar on Climate Resilient and Input Efficient Agriculture for Food and Nutritional Security, January 19-20, 2023, UBKV, Pundibari, Coochbehar.
- National Seminar on Horticulture for Sustainable Development, Nutritional & Livelihood Security, 26th-27th May, 2022 at UBKV, Pundibari campus, organised by NAHEP, Uttar Banga Krishi Viswavidyalaya, Pundibari.

- 6th International Symposium on Minor Fruits, Medicinal & Aromatic Plants: Health, Wealth & Sustainability from 24.11.2022 to 26.11.2022 at UBKV, organized by Uttar Banga Krishi Viswavidyalaya and Society of minor fruits, medicinal and aromatic plants & COBACAS, UBKV, Pundibari
- 5th regional Science and technology congress 2022-23 organized by Cooch Behar Panchanan Barma University and DST, Government of West Bengal, 17th- 18th January,2023 at Cooch Behar Panchanan Barma University.

SKUAST, Srinagar

Research articles

- Angmo T, Rehman MU, Mir MM, Bhat BH, Bhat SA, Kosser S, Ahad S, Sharma A. 2022. Abscisic acid application regulates vascular integrity and calcium allocation within apple fruits. Canadian Journal of Plant Science, 102(5): 964-72.
- Ahmad R, Ahmad TA, Hussain B. 2022. Report of Guava Fruit Fly *Bactrocera correcta* Bezzi from Temperate Kashmir. Indian Journal of Entomology, 31:1-3.
- Hassan S, Ahmad T, Hussain B. 2022. Food preferences and consumption parameters of Cabbage butterfly, *Pieris brassicae* (Lepidoptera: Pieridae) on different kale genotypes. Journal of Plant Diseases and Protection, 21:1-1.
- Kour R, Gupta RK, Hussain B, Kour S. 2022. Synergistic effect of naturally occurring Granulosis virus isolates (PbGV) with phagostimulants against the cabbage butterfly, *Pieris brassicae* (L.) for its eco-friendly management. Egyptian Journal of Biological Pest Control, 32(1):1-9.
- Khan MR, Vijay A, Hussain B. 2023. Efficacy of gamma radiation on the greater wax moth *Galleria mellonella* L. Indian Journal of Entomology.

Books/Book Chapters

- War AR, War MY, Hussain B, Sharma HC. 2022. Evolution of Constitutive Constitutive and Induced Resistance Induced resistance in Plants Plants Against Insect Herbivory Insect Herbivory. In Molecular Advances in Insect Resistance of Field Crops: Modern and Applied Approaches. Cham: Springer International Publishing, 163-179.

KAU, Kumarakom

Research articles

- Dhanya MK, Murugan M , Ashokkumar K, Sajeena A, Neenu TT, Bisnamol KJ, Doncy SP, Amitha P, Surya R. 2022. First report of tiller rot of small cardamom (*Elettaria cardamomum* (l) Maton) caused by *Marasmiellus* sp. in India, J. Plant Pathol**.**
- Murugan M, Ashokkumar K**,** Alagupalamuthirsolai A, Anandhi, Ravi R, Dhanya MK, Sathyan T. 2022. Understanding the effects of cardamom cultivation on its local environment using novel systems thinking approach the case of Indian cardamom hills. Front. Sustain. food syst.
- Ashokkumar K, Gandara JS, Murugan M, Dhanya MK, Pandian A. 2022. Nutmeg (*Myristica fragrans* Houtt.) essential oil: A review on its composition, biological and pharmacological activities, Phytotherapy Research, 36(7): 2839-2851.
- Sajeena A, Deepu M, Jacob J, Dhanya MK, Sushitha K, Ruby NP. 2022. First report of jack fruit caused by *Athelia rolfsii* in India, J.Plant Pathol. Springer.
- Aishwarya M, Dhanya MK, Joy Michal Johnson, Murugan M, Beena R, Ambily P. 2022. Individual and combined effects of beneficial fungal root endophytes *Piriformospora indica* and *Glomus*

fasciculatum on growth, nutrient uptake and IAA production in small cardamom, J. plant .crops, 50(1): 35-41.

- Preethy TT, Dhanya MK**,** Aswathy TS, Sathyan T, Backiyarani S, Murugan M. 2022. Assessment of Genetic Diversity of Small Cardamom (Elettaria cardamomum M.) in India, Indian J. Plant Genet. Resour. 35(2): 169–177.
- Murugan M, Alagupalamuthirsolai M, Ashokkumar K, Anandi A, Ravi R, Rajangam R, Dhanya MK, Krishnamurthy KS. 2022. Climate change scenarios, Their impacts and implications on Indian cardamom-coffee hot spots, One of the Two in the world. Front. sustain food Syst.

Conference paper

- Ashokkumar K, Dhanya MK, Murugan, M. 2022. Assessment of genetic diversity in cardamom accessions using ISSR Markers. VIIth International Conference in Hybrid Mode on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2022), during 21-23 November 2022. Organized by: Astha Foundation, Meerut in Collaboration with CSAUAT Kanpur; BAU Ranchi; ICAR-CIFE Mumbai; SKRAU Bikaner; RLBCAU Jhansi; AFU Chitwan Nepal; NPU Palamu; RG (PG) College Shamli & SSDAT, Meerut. pp. 92-93.

KAU, Vellayani

Research articles

- Tejaswi G, Gowda, Reji Rani OP. 2022. Compatibility of entomopathogenic fungus *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno with insecticides. Journal of experimental zoology India, 25(2): 1785-1791.

Conference papers

- Rani ROP, Sreeja P, Tejaswi GG, Shree Naveena P, Jasmy Y, Hari Shankar SS, Divyasree S, Keerthana K. *Lecanicillium saksenae* - A versatile mycoflora from Kerala. In: Abstracts, Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward. p.88.
- Tejaswi GG, Rani ROP. 2022. Tolerance of entomopathogenic fungi *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and *Lecanicillium lecanii* (Zimm.) Zare and gams to UVA irradiance. In: Abstracts, Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward. p.53.
- Shree Naveena P, Rani ROP. 2022. Plant growth promoting traits of entomopathogenic fungi *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and *Lecanicillium lecanii* (Zimm.) Zare and Gams. In: Abstracts, Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward. p.98.
- Karthik RS, Rani ROP. Field efficacy of bioformulations of *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno on cowpea pod bug, *Riptortus pedestris Fabricius*. In: Abstracts, Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward. p.99.
- Neema D, Rani ROP. *Metarhizium* tablets for mosquito control. In: Abstracts, Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward. p.101.

MPKV, Pune

Research Papers

- Salunkhe AS, Bade BA, Tamboli ND. 2023. Management of fall armyworm infesting maize by sequential application of insecticides and biopesticides. The pharma Innovation Journal, 12(1): 2310-2316.
- Sushma Tamgond SA, More, Tamboli ND. 2023. Role of insect pollinators on mustard yield. The pharma Innovation Journal, 11(12): 4789-4791.
- Mutalikdesai VB, Lolage GR, Tamboli ND. 2023. Biology of pulse beetle, *Callosobruchus maculatus* (Fab.) infesting cowpea. The pharma Innovation Journal, 12(1): 674-676.
- Bhalchim NR, Tamboli ND, More SA, Lolage GR, Jadhav AC. 2023. Compatibility of *Metarhizium anisopliae* with botanicals under laboratory condition. The Pharma Innovation Journal 12(3): 5747-5751.

Technical publications

- More SA, Bade BA, Tamboli ND, Lolage GR. A Success story on Biological Suppression of Sugarcane Woolly Aphid in Maharashtra.
- Bade BA, Tamboli ND, Lolage GR, Patil CS. A Success story on Biological Suppression of Papaya Mealy Bug in Maharashtra.

Popular publication

- Bade BA, Tamboli ND, Lolage GR, Patil CS. Mitra kitak sukshmajiv aadharit kitaknashkancha wapar. Agrowon 12/8/2022. Page 9
- Bade BA, More SA, Lolage GR, Patil CS. Jaivik Kid Niyantran. Shetakari. September, 2022 Pages 47-48.
- Tamboli ND. Trichocard's effective for biological control of pests, Dainik Chalu Varta, Indapur, 13. 12. 2022.
- Tamboli ND. Trichocard's effective for biological control of pests, Janprawas, Babhulgaon, 13. 12. 2022.
- Tamboli ND. Entomopathogenic Fungi useful for biological control of pests, Shirdi Express, Indapur, 03.04. 2023.
- Tamboli ND. Environmental friendly control of White grub is possible due to Phule *Metarhizium*, Maharashtrachi Bhumi, Saptahik, 21. 12. 2022- 27. 12. 2022.
- Tamboli ND. Environmental friendly control of White grub is possible due to Phule Metarhizium, Jagatara Times, Pune, 22. 12. 2022
- Tamboli ND. Environmental friendly control of White grub is possible due to Phule Metarhizium, Balkadu, 22. 12. 2022.
- Tamboli ND. '*Metarhizium'* effective weapon for control of white grub, Prabhat, Satara, 03.04.2023.
- Tamboli ND. '*Metarhizium'* useful for biological control of pests, Awaz, Akluj, 31.03.2023
- Tamboli ND. Fungi useful for biological control of pests, Shivsrushti, Indapur.
- Tamboli ND. Biological Pest Control: The need of the hour in face of increasing use of toxic pesticides, Laxmi Vaibhav News, Indapur, 13.12.2023.

- Tamboli ND. ‘Trichocards’ effective for biological control of pests, Shiv Kalyan, 13.12.2022.
- Tamboli ND. Biological Pest Control: The need of the hour in face of increasing use of toxic pesticides, Apla Maharashtra, 14.12 2022.

Conference

- Bade BA, attended National conference on Biological Control at NBAIR, Bangalore during 15-17, Dec., 2022 and presented poster.
- Bade BA, attended one day online Webinar on “Don’t Dream Your Life Live Your Dream” organised by MPUAT, Udaipur, Rajasthan on 07.08.2022.
- Bade BA, Tamboli ND attended National Webinar on “Quit India Movement to Food Secured India” on 08th August, 2022 organized by Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan.

Reports/Manuals

- Prepared manual For PG course no. ENT 505 Biological control of crop pests and weeds
- Prepared Research Report (2022-23 Research Riview Committee of Agril. Entomology.
- Report of Quinquennial review team on AICRP on Biological Control of Crop Pests (2017-2022)

Conference papers

- Management of powdery mildew of grape by using Bio-Control Agents
- Biological suppression of Fall armyworm, *Spodoptera frugiperda* (G. E. Smith in Maize)
- Management of White grub *Holotrichia serrata* (F.) using entomopathogenic nematodes in sugarcane ecosystem in Maharashtra.

PAU, Ludhiana

Research papers

- Gill JK, Sangha KS, Shera, PS, Sharma S. 2022. Insecticidal toxicity to *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) and subsequent effects on parasitic efficiency and adult emergence rate of descendant generation. Int J Trop Insect Sci, 42(5): 3489-3498.
- Ghongade DS, Sangha KS, Dhall RK, Bhullar MB. 2022. Field evaluation of *Blaptostethus pallescens* Poppius (Hemiptera: Anthocoridae) in controlling *Tetranychus urticae* Koch on parthenocarpic cucumber under protected environments. Int J Acarology, 48 (2): 139-144.
- Kaur M, Joshi N, Sharma S, Kalia A. 2022. Pathogenicity of nucleopolyhedrovirus (NPV) against *Spodoptera litura* (Fabricius). J Biol Control, 35 (4): 218-226.
- Bharti K, Joshi N, Khosla S, Kaur R. 2022. Compatibility of entomopathogenic fungus *Metarhizium rileyi* with biorationals. Indian J Ent.
- Sharma T, Shera PS. 2023. Biological characteristics of ectoparasitoid, *Fulgoraecia melanoleuca* (Fletcher) on various stages of its host, *Pyrilla perpusilla* (Walker). Int J Trop Insect Sci.

Paper presented in conferences, symposia, trainings, workshops etc

- Sharma T, Shera PS. 2022. Disruptive influence of insecticides and biopesticides on various stages of ectoparasitoid, *Fulgoraecia melanoleuca* (Fletcher). Amala U, Ankita Gupta, David, KJ, Gandhi Gracy R, Jagadeesh Patil, Kandan A, Mahendiran G, Manjunatha C, Mohan M, Omprakash Navik, Rachana

RR, Ramya RS, Richa Varshney, Sampath Kumar M, Selvaraj K, Sivakumar G, Sreedevi K, Sreerama Kumar P, Subaharan K, Sushil SN. (Eds). 2022. Book of Abstracts, *Seventh National Conference on Biological Control – 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and Way Forward*, Society for Biocontrol Advancement, Bengaluru, p 155.

- Sangha KS, Shera PS, Sharma S, Kaur R. 2022. Augmentative biological control against sugarcane borers: large scale dissemination and impact. Amala U, Ankita Gupta, David, KJ, Gandhi Gracy R, Jagadeesh Patil, Kandan A, Mahendiran G, Manjunatha C, Mohan M, Omprakash Navik, Rachana RR, Ramya RS, Richa Varshney, Sampath Kumar M, Selvaraj K, Sivakumar G, Sreedevi K, Sreerama Kumar P, Subaharan K, Sushil SN. (Eds). 2022. Book of Abstracts, *Seventh National Conference on Biological Control – 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and Way Forward*, Society for Biocontrol Advancement, Bengaluru, p 92.
- Shera PS, Sharma S, Kaur R, Randhawa HS, Sangha KS. 2022. Dissemination and impact of biointensive pest management technology in organic basmati rice. Amala U, Ankita Gupta, David, KJ, Gandhi Gracy R, Jagadeesh Patil, Kandan A, Mahendiran G, Manjunatha C, Mohan M, Omprakash Navik, Rachana RR, Ramya RS, Richa Varshney, Sampath Kumar M, Selvaraj K, Sivakumar G, Sreedevi K, Sreerama Kumar P, Subaharan K, Sushil SN. (Eds). 2022. Book of Abstracts, *Seventh National Conference on Biological Control – 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and Way Forward*, Society for Biocontrol Advancement, Bengaluru, p 135.
- Shera PS, Sharma S, Sangha KS, Joshi N. 2022. Integration of botanical/microbial and insecticide spray schedule for the management of *Helicoverpa armigera* (Hübner) on chickpea. Amala U, Ankita Gupta, David, KJ, Gandhi Gracy R, Jagadeesh Patil, Kandan A, Mahendiran G, Manjunatha C, Mohan M, Omprakash Navik, Rachana RR, Ramya RS, Richa Varshney, Sampath Kumar M, Selvaraj K, Sivakumar G, Sreedevi K, Sreerama Kumar P, Subaharan K, Sushil SN. (Eds). 2022. Book of Abstracts, *Seventh National Conference on Biological Control – 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and Way Forward*, Society for Biocontrol Advancement, Bengaluru, p 171.
- Navdisha, Joshi N. 2023. Compatibility of *Splt*NPV virus and chemical insecticide with *Trichogramma chilonis* (Abstract). Proceedings of *26th Punjab Science Congress on Environment, Food Security and Health with Reference to Climate Change* held at Sri Guru Granth Sahib World University, Fatehgarh Sahib (February 7-9, 2023), p 189.

Extension Articles

- Shera PS, Sharma S, Kaur R. 2022. Biocontrol of lepidopteran insect-pests in sugarcane and organic rice. Progressive Farming, July, 2022. 11.
- Sharma S, Shera PS, Kaur R. 2022. *Mittar kiriyan rahin kamad ate jhoney de hanikarak kiriyan di jevik roktham. Changi Kheti*, July, 2022. 12.
- Randhawa HS, Shera PS, Sharma S, Damanpreet. 2022. *Sauni diyan mukh faslan de keeriyan dee jaivik dhanga naal roktham Kheti Duniyan* April 16, 2022: 02.

Extension Booklet

- Shera PS, Kaur R, Sharma S, Joshi N. 2022. *Punjab vich faslan de mittar keere*. Department of Entomology, Punjab Agricultural University, Ludhiana, pp 36.

Extension Folder

- Shera PS, Sharma S, Kaur R, Joshi N, Sangha KS. 2022. *Biointensive integrated pest management in organic rice*. Department of Entomology, PAU Ludhiana & All India Coordinated Research Project on Biocontrol of Crop pests and diseases, ICAR-NBAIR, Bengaluru.

- Shera PS, Kaur R, Sharma S, Joshi N, Sangha KS. 2022. *Biological control of borers in sugarcane*. Department of Entomology, PAU Ludhiana & All India Coordinated Research Project on Biocontrol of Crop pests and diseases, ICAR-NBAIR, Bengaluru.
- Joshi N, Shera PS, Kaur R, Sharma S, Sangha KS. 2022. *Biocontrol technologies in PAU package of practices*. Department of Entomology, PAU Ludhiana & All India Coordinated Research Project on Biocontrol of Crop pests and diseases, ICAR-NBAIR, Bengaluru.

Dr. YSRHU, Ambajipeta

Research articles

- Raghuteja PV, Chalapathirao NBV, Padma E, Emmanuel N, Kireeti A, Umakrishna K. 2022. "Influence of biochemical composition of coconut hybrid Godavari Ganga on Rugose spiraling whitefly, *Aleurodicus rugioperculatus"* M. infestation. Journal of Experimental Zoology. India 25, 1909-1913.
- Chalapathirao NBV, Kireeti A, Anoosha V, Neeraja B, Govardhan V, Srinivasulu B. 2022. "Climate change: Sustainable Coconut Production in Andhra Pradesh" District level workshop on climate resilient agri allied sectors organized by Nabard, AP Regional office.
- Neeraja B, Anoosha V, Govardhan V, Chalapathirao NBV, Kireeti A, Koteswra Rao G, Srinivasulu B. 2022. "Impact of climate change on occurrence of insect pests and diseases of coconut", District level workshop on climate resilient agri allied sectors organized by Nabard, AP Regional office.
- Chalapathi Rao NBV, Kireeti A, Anoosha V, Neeraja B, Govardhan V, Srinivasulu B. 2022. "Agro-management Practices for Sustainable Coconut Production in Andhra Pradesh" 13th National Symposium of ISCAR – Fostering Resilient Coastal Agro-Ecosystem 22nd - 25th February, 2023, organized by ANGRAU, Regional Agricultural Research Station, Tirupati.
- Chalapathi Rao NBV, Neeraja B, Bhagavan BVK, Reddy RVSK. 2022. Integrated management strategies adopted for suppressing invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin in Andhra Pradesh, India - ICC proceedings and Scopus index journal –Accepted for publication
- Neeraja B, Snehalaltha Rani A, Chalapathi Rao NBV, Bhagavan BVK. 2022. Early detection and integrated disease management against coconut basal stem rot disease– ICC proceedings and Scopus index journal –Accepted for publication

Technical Bulletin

- Bhagavan BVK, Govardhan Rao V, Chalapathi Rao NBV, Reddy RVSK, Srinivasulu B, Kireeti A, Koteswara Rao G, Devika Rani D. 2022. Kobbari parisodhanalo aaru dasaabdhala Ghana charitra - Rythula vijaya gaadhalu.
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- 1st international coconut symposium on "Implementing IPM to Sustainably Protect Coconut, Producers & Industry" organized by international coconut community and department of agriculture, Philippines and made oral presentation on "Early detection and integrated disease management in coconut against Basal stem rot disease"- August 23-26th (2022) - B Neeraja, A Snehalatha Rani , NBV Chalapathi Rao and BVK Bhagavan
- 1st international coconut symposium on "Implementing IPM to Sustainably Protect Coconut, Producers & Industry" organized by international coconut community and department of agriculture, Philippines

and made oral presentation on Integrated management strategies adopted for suppressing invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin in Andhra Pradesh, India August 23-26th (2022) - Chalapathi Rao, NBV, Neeraja B, Bhagavan BVK and Reddy RVSK.

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- Third position in Best Oral Presentation Award in Indian Phytopathological Society North Eastern Zonal Symposium & National Conference on 'Reframing Futuristic Plant Health Safeguards' during 24-25th November, 2022 at AAU-Jorhat.
- Best Oral Presentation Award in 7th National Conference on Biological Control: '75 Years of Biological Control of Crop Pests and Diseases in Agriculture: Challenges and the way forward' during 15 to 17th December, 2022 at ICAR-NBAIR-Bengaluru.

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VI. 30. 10. Participation in national seminars/ symposia/ conferences/ workshops

ANGRAU

- Attended webinar on Plant Biosecurity system needed for managing Biological Threat Incursions on 18.01.2022 online organized by Plant protection association of India Golden Jubilee lecture series
- Attended webinar talk on application of genome editing in insect pest management

  20.01.2022 Online organized by ICAR- NBAIR, Bangalore
- Attended webinar on Success master class personality development with soft skill learning on 05.02.2022 organised by College of Horticulture and forestry, Central Agricultural University (Imphal), Passighat

- Undergone Faculty development programme on Statistical data analysis using R –Studio through online from 5-6, Feb, 2022 organised by Faculty of Agriculture, Sri Sri university, Cuttack, Odisha
- Undergone Use of Reference Manager Tools and software in research Article writing online programme from 25-27, march, 2022 organised by UAS,Raichur
- Attended Webinar talk on The Progress and future of Green Pesticides in India 29.04.2022 organised by ICAR- NBAIR, Bangalore
- State level technical programme for, 2022-23 at RARS,Tirupati from 19.5.2022 and 21.5.2022, presented workdone report of 2021-22 and proposed programme for the year, 2022-23.
- IDP (NAHEP) Workshop on Increasing research visibility use of reference manager tools and software for publishing in scopus indexed journals for 2 days organized by ANGRAU, Guntur at national level on 8.9.22 and 9.9.2022 at RARS, Anakapalle
- Annual Group Meet on AICRP on Biological control of crop pests and diseases from 17.10.23 to 19.10.2022 organized by ICAR- NBAIR, Bangalore. As a Speaker Presentation of workdone by AICRP centres on Biological suppression of pests of Pulses
- 31st annual group meeting of AICRP on biological control of crops pests organized by NBAIR, Bangalore on 20-21 Oct, 2022 at GKVK, UAS, Bangalore and presented experimental results of pulse crops of AICRP Centres as a speaker for the technical seesion on Biosuppression of pests of pulses.
- 7th National Conference on Biological control at ICAR-NBAIR, Bangalore from 15-17 December,2022 for 3 days organized by Society for Biocontrol Advancement and ICAR-NBAIR, Bangalore and presented oral paper on Seasonal incidence and ecofriendly management of white grub in sugarcane in coastal districts of Andhra Pradesh.
- National conference on Enhancing farmers income through natural farming Challenges and opportunities held on 16-17, February, 2023 organised by The ICFAI University, Jharkhand and presented oral paper on Empowering tribal farmers of Visakhapatnam district, Andhra Pradesh under ICAR- Tribal Sub Plan
- Attended National Webinar on Synergising drone applications in agriculture organised by NIPHM, Hyderabad on 25.03.2023
- Participation in review meeting on APCNF Validation organized by Director of research, ANGRAU every month in the year 2022

Quinquennial review meeting of AICRP on Biological control of crop pests:

- Orgainsed Quinquennial review meeting of AICRP on Biological control of crop pests under ICAR-NBAIR, Bengaluru on 11.4.2023 at RARS, Anakapalle along with ADR, RARS, Anakapalle with the participation of Dr. S. N. Sushil, Director, ICAR-NBAIR & Project Coordinator, AICRP on Biological Control of Crop Pests, Bengaluru and QRT review committee chairman Dr. H. C. Sharma, Former Vice Chancellor, Dr.Y S Parmar University of Horticulture & forestry. Nauni, Solan, Himachal Pradesh along with QRT members Dr. B. K. Agarwala, Professor & Emeritus Scientist (Rtd.), Tripura University, Tripura Agartala; Dr. V.V. Belavadi, Professor & Emeritus Scientist (Rtd.), GKVK, Bengaluru; Dr. R. Swaminathan, Dean & Emeritus Scientist (Rtd.), MPUAT, Udaipur; Dr. H. S. Tripathi, Professor (Rtd.), GBPUAT, Pantnagar, Uttarakhand; Dr. G. Sivakumar, Nodal officer, AICRP PC Cell; Dr. M. Mohan, Member Secretary, QRT ; Dr. K.Sridevi, Principal Scientist, NBAIR & ICAR-National fellow and Principal Investigators of AICRP Biocontrol centres of PJTSAU, DR.YSRHU, OUAT, CPCRI. Presented the report on AICRP Biological control ANGRAU centre activities during review period (2017-2022)



Fig 70. QRT Review by Dr. S. N. Sushil, Director, ICAR-NBAIR, Bengaluru, QRT chairman Dr. H. C. Sharma and QRT members on 11.4.2023

CPCRI

Sl.No	Conference/Workshop	Place and Date
1.	24th RAC Meeting	ICAR-CPCRI, Kasaragod during July 4-5, 2022
2.	Advanced Microscopic workshop and delivered a talk on “Microscopy and Coconut Research	ICAR-CPCRI, RS, Kayamkulam16-07-2022
3.	KDISC meeting on YIP programme	Secretariat Annex, Thiruvananthapuram on 20-07-2022
4.	First International IPM conference	ICC Jakarta during August 23-25, 2022
5.	International Webinar on Growing Coconut for Prosperity	Coconut Research Station, TNAU, Aliyarnagar on 02-09-2022
6.	AICRP on Palms Annual Group Meeting	ICAR-CPCRI, Kasaragod during September 16-18, 2022
7.	Brainstorming session on Exploring the Researchable Issues in Agricultural Entomology	TNAU, Coimbatore on 14-09-2022
8.	Brainstorming session on mosaic disease management in bitter gourd	KVK-Alappuzha on 29-09-2022
9.	Entomology Society of India Annual Meeting and Award distribution	ICAR-IARI, New Delhi on 14-10-2022
10.	Third National Conference on Oil Palm-Way Forward for increasing vegetable oil pool through AtmaNirbhar Bharat for doubling the income and social security to farmers	Society for Promotion of Oil palm Research and Development, ICAR-IIOPR at Vijayawada during November 23-25, 2022
11.	National Conference-Bioinvasions: Trends, Threats and Management	Kerala State Biodiversity Board at Kerala Arts and Crafts village, Vellar, Thiruvananthapuram during December 3-4, 2022

12.	Seventh National Conference on Biological Control on 75 Years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward	Society of Biocontrol Advancement, ICAR-NBAIR, Bengaluru during December 15-17, 2022
13.	Regional conference of Cluster Based Business Organizations (CBBOs) & Farmer Producer Organizations (FPOs)	GKVK Campus, UAS Bengaluru on 27-05-2022
14.	Advanced Microscopic workshop	ICAR-CPCRI, RS, Kayamkulam16-07-2022
15.	International Workshop on Good Agricultural Practices in Coconut and World Coconut Day Celebration	Hotel Le Meridian, Kochi on 2-09-2022
16.	International workshop on Complementing Current Techniques with Next Generation Technology for Crop Health Improvement in online mode	Dept. of Plant Protection, AMU during 14-19, November, 2022

IGKV

- 7th National Conference on Biological Control; 75 years of Biological Control of Pests and Diseases in Agriculture: Challenges and the Way Forward. On 15th to 17th December 2022 at Ramada by Wyndham, Yelahanka, ICAR – NBAIR, Bengaluru.
- Quinquennial Review Meeting of AICRP-BC CENTRES; 2017-2022 attended at MPUAT, Udaipur (RJ) from 16-17 March, 2023.

KAU, Thrissur

- Attended the AICRP workshop by Dr. Smitha Revi at NBAIR, Bengaluru from 20th to 21st October 2022.
- Attended the QRT meeting by Dr. Madhu Subramanian and Dr. Smitha Revi at NBAIR Bengaluru on 17th February 2023.

SKUAST, Srinagar

- Recommendations and expert remarks from the DDG-PP of the Annual Review Meeting of AICRP –Bio control workshop
- Participated in the meeting regarding the eradication and management of fruit borer and leaf miner from Kashmir
- Participated in the meeting regarding finalization of plant protection schedule for Apple
- Participated in the meeting regarding the development of management capsule for apple blotch leaf miner and fruit borer.

KAU, Kumarakom

- Attended the AICRP annual workshop and QRT workshop(Dr Dhanya MK(Co PI)
- Attended the online meeting organized by ICAR-NBAIR for finalizing the technical programme (2022-2023) of AICRP on BCCP of RARS, Kumarakom on 02.07.2022 (Ms. Pallavi Nair K (PI)

KAU, Vellayani

- Dr. Reji Rani OP attended and presented the performance of KAU Vellayani Centre during the period 2018-22 in the QRT meeting held at ICAR-NBAIR during 16-18 Febraury 2023

- Dr. Reji Rani OP attended the Annual review meeting of AICRP on bIological control at ICAR-NBAIR during 21-22 October 2022

MPKV, Pune

- Dr. B. A. Bade and Dr. N. D. Tamboli participated in World Honeybee Day organized by the Head, Department of Agril. Entomology, MPKV on 20/05/22.

- Actively participated with Bioagent and Biopesticides demonstrtions in the "*GoDhan*-2022 Exhibition" during 27-29 May, 2022 at AHDS Farm, COA, Pune.

- Dr. B. A. Bade and Dr. N. D. Tamboli, attended online Meeting of Project Coordinator, NBAIR, Bangalore for review of research work on 26.09.2022.

- Dr. B. A. Bade and Dr. N. D. Tamboli attended XXXI Annual AICRP Biocontrol Workers Group Meeting at NBAIR, Bengaluru and presented the annual report of Center.

- Dr. B. A. Bade and Dr. N. D. Tamboli attended QRT Meeting of AICRP on Biocontrol at MPAUT, Udaipur during 16-18 March, 2023 and presented the five years (2017-18 to 2021-22) report of the Biocontrol Center, Pune.

- Dr. B. A. Bade attended the 83rd Board of Studies meeting of Entomology at MPKV, Rahuri on 12, January 2023.

- Dr. B. A. Bade attended Revolving Fund Meeting at MPKV, Rahuri on 28 February2023 and presented report of the Entomology Section, COA, Pune.

- Dr. B. A. Bade and Dr. N. D. Tamboli attended RRC Meeting of Entomology at MPKV, Rahuri on 02, March 2023 and presented report of the Biocontrol Center, Pune.

- Dr. B. A. Bade attended Research Planning Meeting of Entomology at MPKV, Rahuri during 04, March 2023 and presented planning of the Biocontrol Center, Pune

PAU, Ludhiana

- Drs Rabinder Kaur and Sudhendu Sharma attended the PMRC meeting of NABARD sponsored project "Validation and Dissemination of Biocontrol based IPM Technology in Sugarcane in Hoshiarpur" to present the progress report of the project on May 15, 2022 at Kheti Bhawan, Garhshankar

- Drs Neelam Joshi, Rabinder Kaur and Sudhendu Sharma participated Research and Extension Specialists' Workshop for *Rabi* crops at PAU Ludhiana on August 23-24, 2022.

- Dr Neelam Joshi attended online lecture on" Rhizospheric engineering for plant and soil health" by Dr R D Balachander, Professor Department of Agriculture Microbiology, Tamil Nadu Agricultural University, Coimbatore

- Dr Neelam Joshi participated in IPAC committee meeting for the evaluation of patent at University level on October 17, 2022

- Drs K.S. Sangha, Neelam Joshi, P.S. Shera participated in 31st Biocontrol Workers' Group Meeting of All India Coordinated Research Project on Biological Control of Crop Pests on October 20-21, 2022

- Dr Neelam Joshi participated in 26th Punjab Science Congress on Environment, Food Security and Health with Reference to Climate Change held at Sri Guru Granth Sahib World University, Fatehgarh Sahib on February 7-9, 2023

Dr. YSRHU, Ambajipeta

Participation in online Global Connect series organized by the Dr.YSRHU

Date	Name of the Topic
22.01.2022	Gene Technology Regulation in Australia
28.02.2022	Contribution of sustainable post harvest management practices to reduce losses in food crops
23.03.2022	Recent Developments in Protected Culture in Sri Lanka
21.04.2022	Cucumber breeding-Genetics and genomic resources, development of infrastructure for cucumber molecular breeding, cucumber domestication/evolution, use of crop wild relatives
07.06.2022	New Green Revolution Strategies in Pest Management of Horticultural Crops.
05.07. 2022	Searching for Heat Stress Tolerance in Blueberry
26.08. 2022	Biotechnology Research on Improving Disease Resistance and Nutraceutical Properties in Grape
26.09.2022	Cranberry Molecular Physiologist USDA-ARS and Dept. of Horticulture
31.10.2022	Global efforts on Agriculture, Forestry, Environment and Food Security"
27.11.2022	Plant Genomics & Biotechnology, West Virginia State University, USA
16.12.2022	Integrated agriculture-aquaculture farming system

Meeting

- On 01.04.2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) participated in online meeting on the topic "Discussion on Research Works to be allotted to PG & Ph.D students under the chairmanship of PG Dean, Dr. YSRHU.
- On 06.04.2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) participated in online meeting on the topic "Discussion on Research Works to be allotted to PG & Ph.D students under the chairmanship of Honble Vice-chancellor Dr. T. Janakiram.
- On 13.04.2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) along with Horticulture department officials participated in review meeting of the committee constituted to investigate the unusual death of coconut palms in Billakuru village at College of Agriculture, Rajahmundry.
- On 29.04.2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) participated District Level training programme on the eve of "Ajadi kaa Amruth Mahotsav – Annadata Devo Bhava" organized by CDB, Vijayawada.
- On 04.05.2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.), Smt. B. Neeraja, Scientist (Pl. Path) & Scientists of Horticultural Research Station, Ambajipeta virtually participated in ZREAC Meeting of Coastal zone –I. The meeting was conducted under the chairmanship of Honble Vice-chancellor Dr. T. Janakiram.
- On 04.05.2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) Smt. B. Neeraja, Scientist (Pl.Path.) HRS, Ambajipeta virtually attended the AICRP Biocontrol meeting on "Development and release of crop protection technologies guidelines" developed by the DDG (CS), ICAR under the chairmanship of NBAIR director.
- On 10.05.2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.), Smt. B. Neeraja, Scientist (Pl. Path) & Scientists of Horticultural Research Station, Ambajipeta virtually participated in "National webinar on Prospects of sapota cultivation in India" as a part of Azadi ka Amrit mahotsav under the chairmanship of Honble Vice-chancellor Dr. T. Janakiram.

- Smt. B. Neeraja, Scientist (Pl.Path.) HRS, Ambajipeta virtually participated in "National Conference on Horti Phyto Path" from 11th to 12th May 2022 organized by Plant Protection Advisory Cell, YSRHU, V. R. Gudem, West Godavari, A.P. and delivered the oral presentations of their research topics and also acted as rapporteurs in respective sessions.
- On 02-09-2022, Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.), HRS, Ambajipeta participated the World Coconut Day celebrations at BCT – KVK, Anakapalle District organized by the Coconut Development Board, Kochi and given the lecture on "Recent advances in coconut production technology".
- On 12.12.2022. Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.)Participated in farmers awareness programme on insect pests and disease management of chillies organized by Department of Horticulture, Kakinada at Durgada village.
- On 13-12-2022, Dr. NBV Chalapathi Rao, Principal Scientist (Ento.) Participated in coconut farmers awareness programme organized by Coconut development board and Dept of Horticulture in Mori village of Dr. B. R. Ambedkar Konaseema district.
- On 24.01.2023, Dr. N. B. V. Chalapathi Rao, Principal Scientist (Ento.) Participated in JICA Review Mission Meeting organized by Krishivala Farmers Producer company Limited At Nedunuru, Ainavilli Mandal and appraised about the technical support rendered by Dr. YSRHU-HRS, Ambajipeta to Krishivala FPO pertaining to Coconut production & production technologies to all dignitaries attended this meeting.

Seminars

- Scientists of HRS, Ambajipeta participated in the Ist international coconut symposium on "Implementing IPM to Sustainably Protect Coconut, Producers & Industry" organized by international coconut community and department of agriculture, Philippines from August 23-26th, 2022, where in Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ento.) presented the oral presentation on the topic on "successful integrated management strategies adopted for suppressing invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin in Andhra Pradesh" and Smt. B. Neeraja, scientist (Pl. Path) made oral presentation on "Early detection and integrated disease management in coconut against Basal stem rot disease".
- Dr. NBV Chalapathi Rao, Principal Scientist (Ento.) participated in 50th International cocotech conference and Exhibition organized by ICC, Indonesia from 7-11th November, 2022 held at Kuala lumpur, Malaysia and presented the paper on Rugose spiralling whitefly in coconut and later awarded with third winner of the world coconut day, 2022 under the best coconut scientist category from India.
- Smt. B. Neeraja, scientist (Pl.Path) participated in the Emerging Technologies in Horticultural Engineering conference – organized by Dr. YSRHU-VRgudem, 20th July of 2022.
- Smt. B. Neeraja, scientist (Pl.Path) participated in the Climate Resilient Natural Farming for Sustainable Agriculture organized by ICAR-IISWC, Research Centre, Udhagamandalam, Tamil Nadu, 22nd and 23rd July, 2022.
- Dr. NBV Chalapathi Rao, Principal Scientist (Ento.), Neeraja, B, Scientist (Pl. Path.) have participated in "International Conference on Trade and Marketing of Coconut product with the theme: "Global coconut Industry –Cruising to the pinnacle" held from 27-28th February, 2023 in Le Meridian Hotel, Hyderabad.

AAU, Anand

- Dr. N. B. Patel and Dr. Raghunandan B. L. Participated in Research Report (2022-23)-19th Meeting of Agricultural Research Sub Committeeof Plant Protection on March 9-10/2023 at AAU, Anand

- Dr. N. B. Patel and Dr. Raghunandan B. L. Participated in Report of quinquennial review team on AICRP on Biological Control of Crop Pests (2017-2022) on March 16-17/2023 at Udaipur

AAU, Jorhat

- XXXI[st] Annual Review Meeting of All India Coordinated Research Project on Biological Control of Crop Pests attended by Dr. Anjumoni Devee and Dr. Nomi Sarmah on 20-21.10. 2022 organized by NBAIR at GKVK, UAS, Bengaluru
- Zonal Research Advisory Committee (ZREAC) attended by Dr. Anjumoni Devee and Dr. Nomi Sarmah on 23.09.2022 organized by AAU-ARRI- Titabar at AAU-ARRI- Titabar
- Zonal Research Advisory Committee (ZREAC) attended by Dr. Anjumoni Devee and Dr. Nomi Sarmah on 10.01.2023 organized by AAU-ARRI- Titabar at AAU-ARRI- Titabar.
- Technology Committee meeting, Rabi, 2022, attended by Dr. Anjumoni Devee and Dr. Nomi Sarmah on 17.10.2022 organized by AAU, Jorhat.
- Technology Committee meeting, Kharif, 2022, attended by Dr. Anjumoni Devee and Dr. Nomi Sarmah on 16.02.23 organized by AAU, Jorhat.

News paper clipping

GBPUAT


अपना शहर ऊधमसिंह नगर

नैनीताल | बृहस्पतिवार, 9 जून 2022

फसलों में एंटागोनिस्ट के प्रयोग से बेहतर होगी उपज

सेहत रहेगी दुरुस्त, प्रदूषण से भी मिलेगी निजात

अमर उजाला एक्सक्लूसिव

रोगजनक कीटों का विनाश करने वाले चार बायोएजेंट्स जैव नियंत्रण प्रयोगशाला में किए गए हैं विकसित

Fig 71. Dr. Roopali Sharma PI AICRP on Biological control in an interview gave the information of production of Microbial bio control agents at GBPUA&T, Pantnagar. The use and application of bio formulations for disease management and plant health in different crops.

8 June 2022 AMAR UJALA

अमर उजाला | रुद्रपुर-काशीपुर-खटीमा

आर्टिफिशियल इंटेलीजेंस मशीन लर्निंग से हल होंगी खेती की समस्याएं

पंत विवि और एग्रोकेमिकल क्षेत्र की दिग्गज कंपनी 'यूपीएल' के बीच हुआ करार

संवाद न्यूज एजेंसी

Fig 72. For the commercialization of bio control agents Dr.Roopali Sharma PI AICRP on Biological control have made a presentation to CEO of different bio pesticide companies regarding available services and products for sale to bio pesticide companies

Proceeding Articles

- Sharma S, Arunkumar. 2022. Mass Production of Biocontrol Agents. *In* Proceedings of the 41st Training on "Advances in Plant Disease Diagnostic and Forecasting Tools". 29 November- 19 December, 2022. 146-149.

31. ACRONYMS

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