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Division of Entomology
Annual Report 2023

Division of Entomology
ICAR - Indian Agricultural Research Institute
(Deemed University)
New Delhi - 110 012

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Preface

The Division of Entomology was established in 1905 as one of the five major Divisions of the then Agricultural Research Institute located at Pusa, Bihar. It was shifted to its present premises in 1936. Eminent entomologists like H.M. Lefroy, T.B. Fletcher, H.S. Pruthi, S. Pradhan and K.N. Mehrotra laid strong foundation for basic and applied research in insect science. Prior to getting the status of Deemed University, Division of Entomology at Indian Agricultural Research Institute used to conduct training programs and an IARI Associateship Course equivalent to M.Sc. degree. The Division of Entomology has a specialized teaching faculty, and offers specialization in Taxonomy, Physiology, Toxicology, Biological Control, Ecology, and Pest Management. It has attracted PG students from several countries like Thailand, Vietnam, Ethiopia, Sudan, Egypt, Iran, Trinidad, Tobago, Myanmar, Sri Lanka, Nepal, and Bangladesh. So far, this Division has awarded 123 IARI Associateship, over 350 M.Sc. and 600 Ph.D. degrees, and several of the Entomology Division Alumni have occupied/occupying prestigious and senior positions in India and abroad. The postgraduate education and research programmes in the Division are being continuously upgraded to develop trained human resources with the recent advancements in the science of entomology.

The Division has continued its work in advancing knowledge and practical solutions in the domains of Insect Biosystematics, Physiology, Toxicology, Biological Control, and Integrated Pest Management, addressing critical challenges in agriculture and pest management. Among the notable achievements in the year 2023-24 are the discovery of new insect species, enhancement of National Pusa Collection, and DNA barcoding and molecular diagnostics, including the development of world's first RPA-CRISPR diagnostic tool for detecting invasive insect species. These advancements have enriched the understanding of insect diversity and facilitated precise identification for national and international collaborators.

In insect physiology, comprehensive studies have been carried out on mechanisms, reproductive physiology, biochemical and hormonal regulation, and genetics of diapause in *Chilo partellus*. Our innovative transcriptomic and metabolomic approaches have unveiled adaptations in pests like *Chilo partellus*, *Spodoptera frugiperda* and *Bemisia tabaci* providing insights into their survival mechanisms, insecticide resistance and interaction with environmental stressors. Similarly, the Division has been working on exploring sources, mechanisms and biochemical basis of insect resistance, offering avenues for developing pest-resistant varieties in maize, mustard and rice.

The Division's research on biological control, insect toxicology and integrated pest management has led to optimizing mass production of biocontrol agent, *Metarhizium rileyi*, and identification of effective insecticides and bio-pesticides. The new innovative approaches/tools like management of *Spodoptera frugiperda* through endophytically established native *Bt* strains in maize plants, and the 'Pusa MeFly Kit' for fruit fly management have been commercialized for the benefit of farmers. Additionally, studies on pheromone traps, remote sensing technologies, and weather-based forecasting models for pest infestation exemplify our commitment to leveraging advanced technologies for proactive pest management. These endeavours, carried out in collaboration with stakeholders from academic institutions, private industries, and government bodies, are paving the way for innovative and ecologically sound pest management solutions.

(Dr. M. K. Dhillon)
Head-Division of Entomology

1. Executive Summary

Research work in the Division of Entomology is undertaken in the five major areas viz., Insect Biosystematics, Physiology, Toxicology, Biological Control and Integrated Pest Management. The research highlights during the reporting period are summarized below.

Biosystematics and identification services

The research is focused on insect orders Coleoptera, Lepidoptera, Hymenoptera and Hemiptera. Identification services were provided to researchers from agricultural universities, private companies and ICAR institutes.

- The insect identification service provided to the stakeholders for 422 specimens covering Coleoptera, Lepidoptera and Hymenoptera, and the National Pusa Collection was augmented by around 1500 specimens, including few Holotypes and Paratypes.
- Around 10 new species belonging to Coleoptera, Hemiptera, Hymenoptera and Lepidoptera were described. A new tortricid species *Pseudancylis* sp. nov was discovered, along with 8 new records for India and 25 for Kerala. *Lipotriches burmica* (Hymenoptera: Halictidae, Nomiinae), *Crematogaster travancorensis* (Hymenoptera: Formicidae) was recorded for the first time in India. Catalogue of Elateridae from Northeastern India revealed 250 species across seven subfamilies, and *Ganoxanthus* was recorded for the first time in India.
- Documented four hymenopterous parasitoids of Diamondback Moth, *Plutella xylostella* with *Diadegma insulare* recorded for the first time in India. The highest parasitism was recorded in organically cultivated fields, *Cotesia vestalis* being the most dominant. The parasitoid species, *Brachymeria excarinata* Gahan, 1925 (Hymenoptera: Chalcididae) recorded first time from rice growing areas of India as hyperparasitoid of *Charops bicolor* (Szepligeti, 1906), and a larval parasitoid of *Scirpophaga incertulas* (Walker).
- More than 40 DNA barcodes were generated, and world's first RPA-CRISPR based diagnosis was developed for detection of invasive insect species *Keiferia lycopersicella, Phthorimaea absoluta* and *Scrobipalpa atriplicella*.
- The ultrastructure morphological study on *Maruca vitrata* antennal sensilla discovered three new sensilla types, which could have implications for chemical communication and management of this pest.

Insect Physiology

- Biochemical and stress-related enzyme regulations during hibernation were elucidated across tissues and life stages and validated through transcriptomic approach, which provide insights into adaptation and survival during overwintering in *Chilo partellus*.
- Biochemical characterization of rapeseed-mustard genotypes against mustard aphid showed that DRMR 150-35, RLC 3, NRCHB 101, Pusa Mustard 27, RH 749, Pusa Mustard 28, Pusa Mustard 25 and RH 0406 have adverse effects on host preference, survival and reproduction of *Lipaphis erysimi*, have greater induced plant biochemicals and defense enzymes, thus could be used in Brassica improvement program.
- Wild crucifers like *Crambe abyssinica, Eruca sativa, Diplotaxis* species, *Camelina sativa, Brassica fruticulosa, Capsella bursapestoris* and *Lepidium sativum* were found with reduced preference, survival and fecundity of *Lipaphis erysimi*.
- The characterization of 30 maize genotypes for resistance to *Spodoptera frugiperda* and *Chilo partellus* under field and laboratory conditions, using biological attributes

and antibiosis indices revealed that genotypes AI 125, AI 546 and CML 442 exhibit both antibiosis and non-preference mechanisms of resistance against both pests, thus could be used in breeding programs to develop multiple-borer resistant maize hybrids.

- RNA-Seq analysis revealed post-mating transcriptional changes in female *Spodoptera frugiperda*, with 13,207 differentially expressed transcripts, with significant changes peaking at 24 h post-mating. Upregulated genes, such as cathepsin B and cytochrome P450 6B1 were found linked to reproduction, detoxification and hormone synthesis, while downregulated genes were associated with immune responses.
- Sub-lethal effects of heat stress on *Spodoptera frugiperda* revealed higher heat shock levels (LT50 and LT75) significantly reduced reproductive fitness, including mating frequency and egg hatching rates, while LT25 had minimal impact. Heat stress also altered the sex ratio, increasing the proportion of females, highlighting the potential consequences of thermal stress on pest populations.
- Gut bacteria in *Anomala dimidiata* larvae was characterized using cultivable methods and 16S amplicon, isolating eight cellulolytic strains and identifying key taxa such as *Bacillus, Acinetobacter,* and *Paenibacillus* involved in cellulose digestion. Functional analysis revealed upregulated carbohydrate metabolism in the midgut and nitrogen/phosphorus metabolism in the fermentation chamber, offering insights for biotechnological applications.
- Expression patterns of chemosensory proteins (CSPs) in *Bemisia tabaci* Asia II-1, revealing significant variation across developmental stages, with CSP4 showing consistently higher expression, especially in later nymphal stages. The findings provide insights into stage-specific roles of CSPs, contributing to understanding chemosensory mechanisms in whiteflies.
- Characterized the cellulolytic and pectinolytic activities of gut bacteria in *Apis mellifera*, identifying key genera like *Aneurinibacillus*, *Bacillus*, and *Clostridium* that excel in breaking down cellulose and hemicellulose. The findings provide insights into the honey bee microbiome and their probable role.

Biological Control

- Mass production of *Metarhizium rileyi* on barley was found most effective for conidial yield, carrot supported highest spore production, while SMYB liquid medium produced maximum sporulation. The diphasic system combining SMYB with barley promise potential for optimizing mass production techniques for biocontrol applications.
- The study on *Geocoris sp.* at different temperatures revealed that survival was highest at 27°C, the life cycle was shortened as the temperature increased, and egg viability and early nymphal survival was poor at 36°C.

Insect Toxicology

- Chlorantraniliprole 18.5% SC was found most effective among the test insecticides and bio-pesticides against *Spodoptera frugiperda*. Combination of chlorantraniliprole with entomopathogenic fungus, *Metarhizium anisopliae* showed synergistic effect, hold promise to reduce insecticide use. Additionally, sublethal doses of spinetoram negatively impacted the growth, reproduction and survival of *S. frugiperda*.
- Toxicity of five green and one yellow labelled insecticide/s against *Bemisia tabaci* on two host plants, brinjal and tomato, revealed that spinetoram, clothianidin and novaluron were more effective than imidacloprid. The results indicated that brinjal

supported higher whitefly population and detoxification enzyme activity, while the tested insecticides showed promising nymphicidal and adulticidal effects.

- Field evaluation of whitefly attractant traps and nano-formulations revealed that compound 1 significantly increased attraction to traps by 76-339% compared to conventional sticky traps across multiple locations. Additionally, two synthetic compounds, C1 and C2, demonstrated high repellency and ovipositional deterrence, reducing egg laying and egg hatching by up to 74.13%.
- Combined use of phosphine and carbon dioxide enhanced 6.25-fold toxicity against *Stegobium paniceum* at 24 h of exposure as compared to phosphine alone.
- The study on *Callosobruchus maculatus*, carvacrol demonstrated dose-dependent toxicity, inhibiting oviposition and exhibiting repellent behavior, with lower lethal concentrations than deltamethrin, highlighting its potential as a bioinsecticide.
- The study on brown planthopper populations in North India revealed lower susceptibility to insecticides in populations from Haryana, with triflumezopyrim and flupyrimin being the most effective insecticides for managing this pest.
- Field studies on insecticides triflumezopyrim 10 SC and flupyrimin 20 SC showed high efficacy against the brown planthopper in rice, with both compounds proving effective at half the recommended dose, while chlorantraniliprole 18.5 SC showed control failure against rice leaf folder and stem borer populations.

Insect Pest Management

- The study on mustard aphid in rapeseed-mustard demonstrated that need-based insecticide applications significantly reduced aphid population and increased seed yield, with Radhika, Brijraj, and PM 30 showing yield increases of 19.7%, 30.8%, and 27.3%, respectively, under protected conditions compared to unprotected ones.
- Evaluation of 193 Brassica genotypes for resistance to mustard aphid using the AICRP-RM aphid testing protocol revealed that IVT genotypes like SBG 23-71, SBG 23-94, and SBG 23-110, and AVT entries such as SAG 23-12, SAG 23-46, and SAG 23-40, exhibited lower aphid resistance indices.
- Pheromone traps for monitoring *Helicoverpa armigera* showed peak catches in the 38th SMW, and the trap catches were positively correlated with temperature and sunshine, while negatively correlated with humidity and wind speed.
- Methyl Eugenol based 'Pusa MeFly Kit' was developed for fruit fly management. It is a low cost, do-it-yourself, ecofriendly, kairomone based kit for fruit crops.
- Evaluation of eight rice germplasm against the Brown planthopper revealed RP 2068-18-3-5 and Salkathi as highly resistant genotypes, showing minimal damage comparable to the resistant check PTB 33. Biochemical analysis revealed increased superoxide dismutase activity in all genotypes after BPH feeding, with RP 2068-18-3-5, Salkathi, and PTB 33 exhibiting effective resistance.
- A weather-based forecasting model was developed to predict Brown planthopper (BPH) infestation in rice for early, normal, and late transplanting dates using field data from 2017 to 2021, with validation during 2022 and 2023. The model revealed negative correlation with minimum temperature and evening relative humidity, and positive correlation with sunshine hours, especially for normal transplanted rice.

2. Scientific Report:

I. Biosystematics and identification services

Biosystematics studies on agriculturally important insects

Catalogue for the Elateridae of the Northeastern region: A catalogue for the Elateridae of the Northeastern region was compiled based on the literature, and it was found that 250 species under seven subfamilies, 20 tribes, and 48 genera are known from the Northeastern region. Among those the most diverse subfamily is Elaterinae, followed by the subfamily Agrypninae. Among the Elaterinae tribes, Megapenthini is the most diverse, with eight genera. Genus *Ganoxanthus* was recorded for the first time in India. The tribe Tetralobini is the least specious, with two species.

Two new species of *Glyphonyx* (Elateridae: Elaterinae): Two new species of *Glyphonyx*, ie. *Glyphonyx umiamis,* and G. *kyrdemkulaiensis* were collected from Kyrdemkulai, CAU, Umiam, Meghalaya and Umaim, BSI, Eastern Regional Centre, Meghalaya. These two new species are distinguishing based on their size, colour of pronotum and body; distribution of punctures, smooth line in the disc and length of the antennomeres as well as from the bursa sclerites of female. These two specieses are close to *G. semipunctatus, G. cordieri*, and *G. ranauensis* however can be separated based on colouration, length of antennae punctuations etc.

Two new species of *Neopsephus:* Two new species of *Neopsephus* namely *Neopsephus niger* and *Neopsephus umiamis* were discovered, from Meghalaya. These two species are similar to *N. assamensis* earlier reported. But differs in antennal ratios, presence of setae on antennae, length width ratios of pronotum and elytra, male genitalia characters etc.

Heavy infestation of flea beetle, *Sinocrepis* sp. (Coleoptera: Chrysomelidae): On *Abutilon indica* (L.) Sweet from New Delhi, India observed around 80–85% of the leaf damage, this species of flea beetle can be a potential biocontrol agent of this weed (Fig. 1).

Fig. 1. *Sinocrepis sp.* (Coleoptera: Chrysomelidae) on *Abutilon indica* (L.)

The hymenopterous parasitoids of the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), on cruciferous vegetables in Delhi, India: The diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), is a serious and economically important pest of crucifers in Delhi, India. Larvae and pupae of the pest were collected from the cabbage, cauliflower and broccoli crops grown in vegetable fields at the farm of ICAR-Indian Agricultural Research Institute (ICAR-IARI), New Delhi-110012, from December 2021 to June 2022. Four parasitoid species were emerged, viz. *Apanteles mohandasi* Sumodan & Narendran 1990, *Cotesia vestalis* (Haliday, 1834), *Diadegma insulare* (Cresson, 1865) and *Diadromus collaris* (Gravenhorst, 1829). Among them, *A. mohandasi*, *C. vestalis* and *D. collaris* were reported for the first time in Delhi, whereas *D. insulare* (Hymenoptera: Ichneumonidae) is recorded here for the first time in India. Additionally, the first record of parasitism by *A. mohandasi* on *P. xylostella* from Delhi was established (Fig. 2). The highest parasitism percentage was that of *C. vestalis* and *D. collaris*. Moreover, higher parasitism rate was recorded during May 2022 in organically cultivated fields. The parasitism percentage by *A.*

mohandasi, *C. vestalis*, *D. insulare* and *D. collaris* was 7.5, 22.5, 12.5 and 15%, respectively. Conversely, in conventionally farmed fields, the parasitism rates were 3.57, 16.67, 10 and 13.33%, respectively.

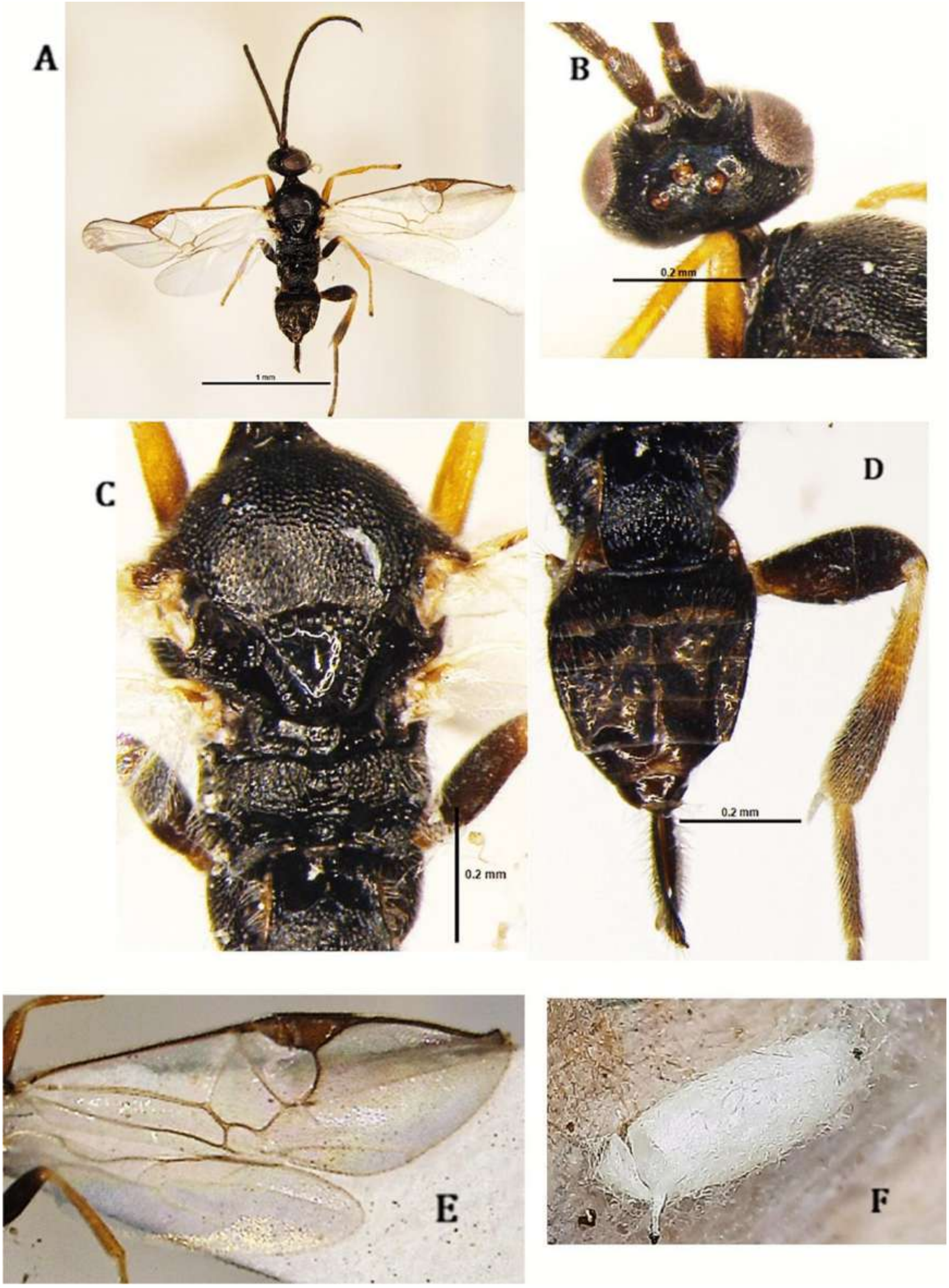

Fig. 2. *Apanteles mohandasi* Sumodan & Narendran, 1990 (female: A–E); A. dorsal habitus, B. dorsal view of head, C. dorsal view of mesosoma, D. dorsal view of metasoma, E. forewing and hind wing and F. pupa of parasite

First record of *Lipotriches (Rhopalomelissa) burmica* from India along with a checklist of species from India (Hymenoptera: Halictidae, Nomiinae): *L. burmica* is recorded for the first time from India. Both male and female of the species have been redescribed with color illustrations. An updated checklist of the genus *Lipotriches* from India is also prepared, including new regional records for other known species.

Two new species of the subgenus *Lasioglossum (Hemihalictus)* (Hymenoptera: Halictidae), with a checklist of the species from India: Two new species of bees of the family Halictidae, *Lasioglossum (Hemihalictus) rugulosum* sp. nov. and *L. (H.) longitudinale* sp. nov. from the state of Uttarakhand in northern India, are described and illustrated. An annotated list of Indian species of the subgenus *Hemihalictus* Cockerell, 1897 and map of their distribution are prepared.

New distributional records of ants of genus *Crematogaster* Lund (Hymenoptera: Formicidae) from India: Locality records and illustrations for five known species viz., *Crematogaster biroi* Mayr, 1897, *C. contemta* Mayr, 1879, *C. dohrni artifex* Mayr, 1879, *C. rothneyi* Mayr, 1879, and *C.subnuda* Mayr, 1879 are provided from India. These records expand the area of occurrence and distribution of these species in India. In addition, *Crematogaster travancorensis* Forel (1902) is redescribed based on the worker caste collected from Pachmarhi, Madhya Pradesh and Ri Bhoi, Meghalaya, India.

New record of hyperparasitoid: The parasitoid species, *Brachymeria excarinata* Gahan, 1925 (Hymenoptera: Chalcididae) is recorded for the first time from rice growing areas of India as hyperparasitoid of *Charops bicolor* (Szepligeti, 1906), a larval parasitoid of paddy yellow stem borer (YSB) *Scirpophaga incertulas* (Walker). Diagnostic characters supported with photographs have been included for identification of both parasitoid and hyperparasitoid of *S. incertulas*.

Morphological Characterization of the Antennal Sensilla of the Legume Pod Borer, *Maruca vitrata* (Fabricius) (Lepidoptera: Crambidae): Studied the ultrastructural organization of its antennal sense organs using scanning electron microscopy. The antennae of both sexes of *M. vitrata* were filiform with the number of flagellar segments varying from 72 to 84. Nine major morphological types of sensilla were observed on male and female antennae: sensilla trichodea (ST), sensilla basiconica (SB), sensilla auricillica (SA), sensilla chaetica (SCh), sensilla coeloconica (SCoe), sensilla cylindrica (SCy), sensilla squamiformia (SSq), sensilla styloconica (SSt), and Böhm sensilla (BS). Three of these sensilla types (SB, SSq, and BS) are newly reported for *M. vitrata*. Morphological observations revealed that four types are multiporous (ST, SB, SA, and SCoe), two types are uniporous (SCh and SCy), and three types are aporous (SSq, SSt, and BS) (Fig. 3). The average length of male ST was longer than that of the female. Sensilla cylindrica were observed only on male antennae, indicating sexual dimorphism. This study aims to provide some basic evidence for further studies on the mechanism of insect–plant chemical communication and future semiochemical-based management strategies of the major legume pest *M. vitrata*.

A new species and new record of the genus *Pexicopia* (Lepidoptera: Gelechiidae) feeding on *Abutilon indicum* from India: A new species, *Pexicopia tungabhadrai* sp. nov. (Lepidoptera: Gelechiidae), feeding on *Abutilon indicum* is described from Karnataka, India (Fig. 4). Also, this is the first report of the genus *Pexicopia* Common, 1958 from India. Images of adult moths, male and female genitalia and immature stages are provided.

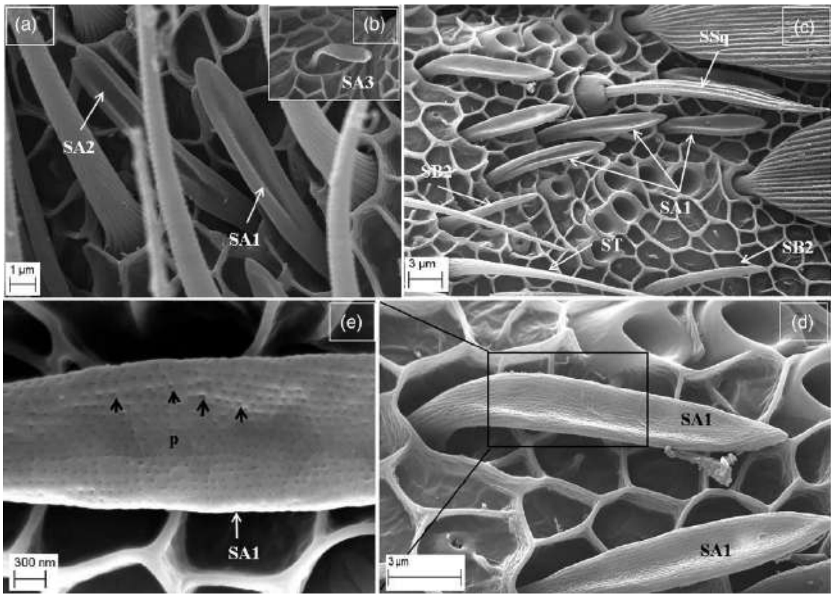

Fig. 3. SEM images showing three subtypes of sensilla auricillica on male and female antennae of *M. vitrata*. (a) Magnified view of male flagellomere displaying three subtypes of SA (SA1, pointed SA; SA2, bifurcated SA; and SA3, spoon-shaped SA). (b) SA3, spoon-shaped SA. (c) Female flagellomere displaying group of SA1. (d) Higher magnification of SA1. (e) Magnified view of SA1 showing numerous minute wall pores (p, small arrow heads). SA1, SA2, and SA3, sensilla auricillica subtype 1, subtype 2, and subtype 3, respectively; ST, sensilla trichodea; SB2, sensilla basiconica subtype 2; SSq, sensilla squamiformia; p, pores.

Fig. 4. Adults of *Pexicopia tungabhadrai* sp. nov. 1, Male (Holotype); 2, Female (Paratype).

Discovery of a new species and six new records of subfamily Olethreutinae (Lepidoptera: Tortricidae) from India: A new species of the genus *Theorica* Diakonoff, 1966 is described from Karnataka, India, namely, *T. malnadense* Reddy and Shashank, sp. nov. The genus *Theorica* Diakonoff, 1966 is reported for the first time from India, and an annotated checklist of all species of genus is provided. In addition, six species namely *Gatesclarkeana idia* Diakonoff, 1973; *Endothenia stibara* Razowski and Wojtusiak, 2012; *Olethreutes cerographa* (Meyrick, 1907b); *Tetramoera isogramma* (Meyrick, 1908); *Fulcrifera boavistae* Razowski, 2015; and *Pammene peristictis* Meyrick, 1912, are recorded for the first time from India.

Taxonomic studies of the family Tortricidae (Lepidoptera: Tortricoidea) of Northern Kerala: Over 400 specimens of microlepidoptera were collected from ten different sites in nine localities of Northern Kerala. Through meticulous examination, we identified 37 species belonging to 34 genera, categorized into two subfamilies and eight tribes. The majority of species, 29 in total, were found in the subfamily Olethreutinae, with the highest number belonging to the tribe Olethreutini. Additionally, nine species were identified in the subfamily Tortricinae. Notably, this study proposed a new species to science, *Pseudancylis* sp. nov, along with 8 new species records to India viz., and 25 new species record to the state of Kerala. A comprehensive checklist of previously reported tortricid species along with the studied species in this study is presented. To facilitate identification, presented illustrated diagnostic keys for the subfamilies, tribes, and species, offering a rapid and accurate method for species identification.

Molecular diagnosis:

DNA barcoding of *Pseudancylis* sp., *Cyclopelta siccifolia*, *Neocalyptis* sp., *Terthreutis chiangmaiana*, *Aproaerema* sp., *Endothenia stibara*, *Herpystis jejuna*, *Fulcrifera tricentra* and *Cryptophlebia ombrodelta.*

Insect identification service provided:

Total of 160, 162 and 100 specimens of Hymenoptera, Lepidoptera and Coleoptera, respectively belonging to 18 families were identified for >20 consignments received from different universities/research centres/ institutions/organisations across the country.

II. Insect Physiology

Identification of functional transcripts/genes involved in regulation of hibernation in *Chilo partellus* and molecular basis of differentiation in different *C. partellus* populations: The molecular characterization was carried out for 11 *Chilo partellus* populations from different agro-ecological regions viz., New Delhi (NCT Delhi), Solan (Himachal Pradesh), Umiam (Meghalaya), Udaipur (Rajasthan), Surat (Gujarat), Akola and Parbhani (Maharashtra), Hyderabad (Telangana), Raichur (Karnataka), and Kovilpatti and Coimbatore (Tamil Nadu), with five genes like Cyt B, NADH Dehydrogenase, COI, COII and 16s rRNA. The analysis for molecular differentiation in these 11 populations of *C. partellus* is in progress. Based on whole genome transcriptome sequencing of hibernation and non-hibernation *C. partellus,* a set of 23 distinguished primers have been designed and the gene expression analysis for these primers through RTPCR (RNA Validation) is in progress.

Deciphering different enzymes involved in regulation of hibernation in *C. partellus:*

This study aimed to elucidate the biochemical variations in digestive and stress-related enzymes across selected tissues (haemolymph, fat bodies, and integument) and life stages of hibernation and non-hibernation *Chilo partellus* larvae and pupae. Key enzymes and other parameters analyzed include ascorbic acid, amylase, protease, lipid peroxidation, peroxidase, total antioxidant capacity, esterase, catalase, and superoxide dismutase (SOD) and glutathione S-transferase (GST). The activity of test digestive and defense enzymes differed significantly in the haemolymph, fat bodies and integuments of non-hibernation, pre-hibernation and hibernation larvae of *C. partellus*, except in a few cases (Fig. 5). The amylase and lipid peroxidation significantly increased, while protease significantly decreased in haemolymph, fat bodies and integument tissues through non-diapause, pre-hibernation and hibernation larvae. Esterase also varied significantly in the haemolymph, fat bodies and integument of non-hibernation, pre-hibernation and hibernation larvae. The protease activity was almost two to five times higher in different tissues of non-hibernating larvae compared to their hibernating counterparts. Across the larval stages, highest amylase, esterase and protease activity was found in fat bodies, while across the larval tissue type these were highest in non-hibernation larvae. The lipid peroxidation, across the larval stages was highest in haemolymph, while across the larval tissues it was highest in hibernation larvae. Across the tissue types, catalase, peroxidase and SOD were greater in the hibernation larvae and post-hibernation pupae, while GST was greater in non-hibernation larvae and pupae (Fig. 4). Across the larval stages greater activity of SOD, GST and peroxidase were recorded in the cuticular tissue, while catalase activity was greater in the fat body tissues. Similarly, across the pupal stages, the catalase and GST were greater in fat body, peroxidase in cuticular tissue, while similar levels of SOD activity were found in the fat body and cuticular tissues (Fig. 5). In nutshell, the activities of antioxidant enzymes (peroxidase, total antioxidant capacity, catalase, and SOD) were enhanced in hibernation larvae, suggesting a robust antioxidant defense mechanism during overwintering. These antioxidant enzymes play a vital role in managing oxidative stress during hibernation. However, GST activity decreased in hibernation larvae, and there were also tissue-specific variabilities in selected enzymes. This study reveals the enzymatic adaptations during hibernation, advancing our understanding of the survival mechanisms of *C. partellus* during hibernation.

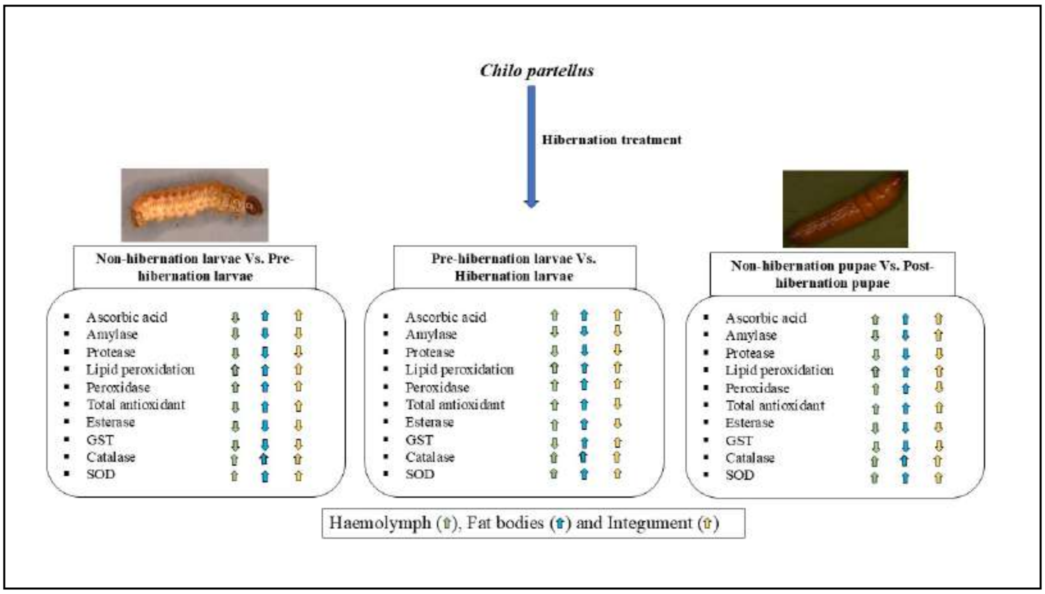

Fig. 5. Digestive and stress enzyme variations during hibernation in spotted stem borer, *Chilo partellus*

Biochemical characterization of diverse rapeseed-mustard genotypes for resistance against mustard aphid, *Lipaphis erysimi*: The characterization of diverse *B. juncea* cultivars revealed significant differences for host selection, population build-up, developmental and reproductive biology, and bionomics of *Lipaphis erysimi*, and constitutive and induced nutritional, antinutritional, photosynthetic pigments and the defense enzymes in buds and siliquae of the test *Brassica juncea* cultivars. The aphid preference and resistance index were significantly lower on RH 0406, RLC 3, DRMR 150-35, Pusa Mustard 25, NRCHB 101, Pusa Mustard 26, and Pusa Mustard 27, Pusa Mustard 30 and Pusa Tarak, except in a few cases (Fig. 6a). Further, the developmental periods, mean generation time and doubling time were significantly longer, while fecundity, survival, intrinsic and finite rates of increase, and net and gross reproductive rates were significantly lower on Pusa Mustard 27, NRCHB 101, RLC 3, RH 749, RH 725, DRMR 150-35, Pusa Mustard 26 and Pusa Mustard 25, except in a few cases (Fig. 6a).

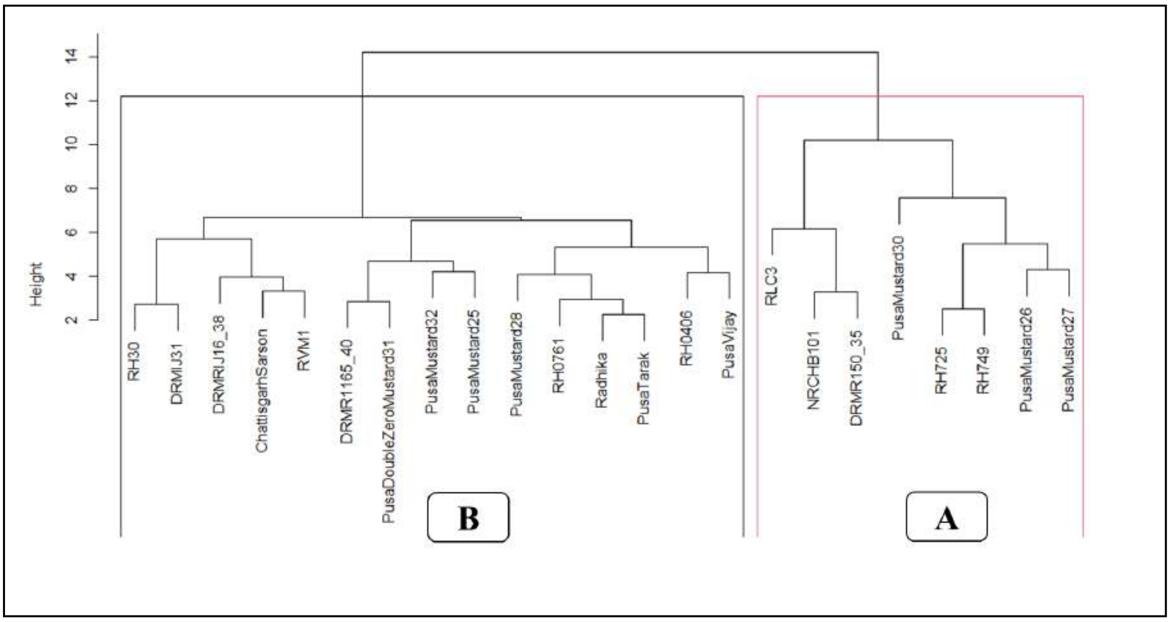

Fig. 6a. Categorization of diverse *Brassica juncea* cultivars based on host selection, population build-up, developmental and reproductive biology, and bionomics of *Lipaphis erysimi*

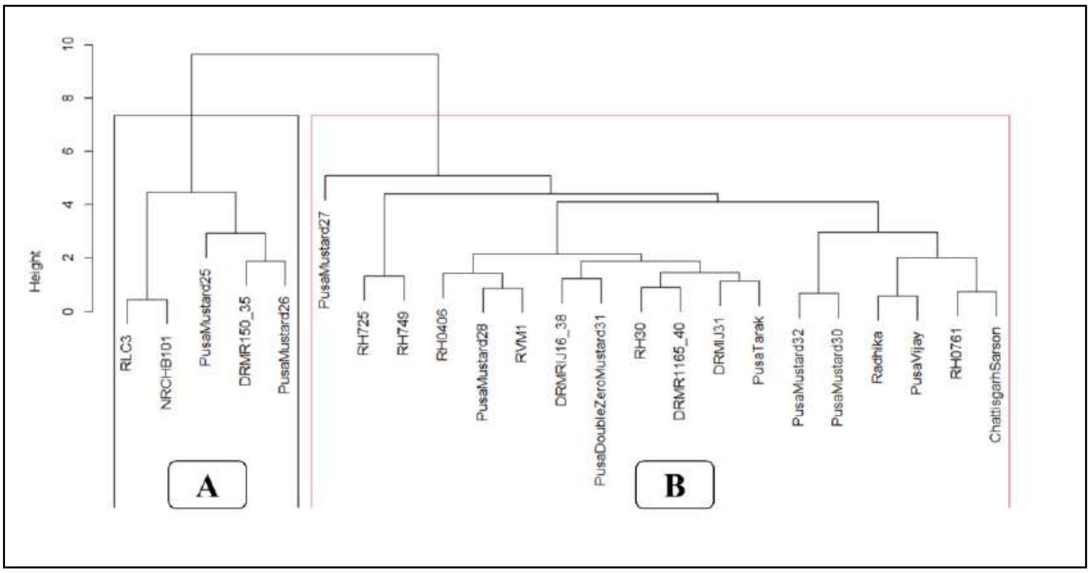

Fig. 6b. Categorization of diverse *Brassica juncea* cultivars based on constitutive and induced phytochemicals and defense enzymes in the buds and siliquae for biochemical defense against mustard aphid, *Lipaphis erysimi*.

Further, the constitutive and induced levels of different phytochemicals were significantly greater in NRCHB 101, RLC 3, RH 749, DRMR 150-35, Pusa Mustard 26, Pusa Mustard 27, DRMR 1165-40, Pusa Mustard 30 and RH 725 except in a few cases (Fig. 6b). The aphid-induced levels of total sugars, tannins, total chlorophyll, total glucosinolates, FRAP, AP, APX, PAL and TAL levels in *B. juncea* cultivars showed significant association with host preference, intrinsic and finite rates of increase, net and gross reproductive rates, and mean generation and doubling time of *L. erysimi* (Fig. 6b). However, the regression analysis revealed that the total sugars, phenols, antioxidants, FRAP, chlorophyll B, total chlorophyll, catalase, TAL and myrosinase content in buds and siliquae of test *B. juncea* cultivars contributed to 40.11 to 85.30% variability for host preference, multiplication rate and developmental biology, indicating their defensive role against *L. erysimi*, thus could be used as biochemical markers for identifying aphid-resistant mustard genotypes (Fig. 6). Overall, DRMR 150-35, RLC 3, NRCHB 101, Pusa Mustard 27, RH 749, Pusa Mustard 28, Pusa Mustard 25 and RH 0406 have shown adverse effects on host preference, population build-up, development, survival and reproductive potential of *L. erysimi*, have greater induced plant biochemicals and defense enzymes, thus could be used in *Brassica* improvement program.

Biochemical interactions in wild Brassicas for resistance against *Lipaphis erysimi:* Characterization of 29 wild *Brassica* genotypes along with three *B. juncea* cultivars revealed significant differences among the test genotypes for fecundity, survival, host preference and aphid resistance index by *Lipaphis erysimi*; and the aphid-induced biochemical constituents in the test wild species for resistance against mustard aphid. The principal component analysis biplot provides a comprehensive visualization of insect biological and plant biochemical relationships between 32 different genotypes, wherein Dim1/PC1 explains 23.3% variance, while Dim2/PC2 accounts for 19.5% variance, and placed the test wild *Brassica* species in four different groups. Genotypes like *Diplotaxis* species (*D. assurgens, D. erucoides, D. muralis, D. gomez-campoi, D. tenuisiliquae*), *Camelina sativa*, *Brassica fruticulosa* (Spain), *Brassica fruticulose, Capsella bursapestoris* and *Lepidium sativum* were found with reduced survival, fecundity, preference and aphid resistance index and associated with high ascorbic oxidase, total phenols, total antioxidants and other antioxidative measures, reinforcing their biochemical robustness (Fig. 7). Starch content was found significantly positively associated with fecundity, survival, host preference and aphid resistance index; total sugars with fecundity and survival; and myrosinase content showed significant and positive correlation with fecundity and survival of *L. erysimi* in the test wild Brassica species. Furthermore, the stepwise regression analysis of different biochemical traits of wild crucifers revealed that total sugars, starch, total chlorophyll, total antioxidants, carotenoids, myrosinase and catalase contributed to 75.4% variation in fecundity; total sugars, starch, carotenoids, myrosinase, phenylalanine ammonia-lyase and tyrosine ammonia-lyase contributed to 62.7% variation in survival; total proteins, sugars, starch, FRAP, carotenoids, catalase, ascorbate oxidase, ascorbate peroxidase and tyrosine ammonia-lyase contributed to 66.6% variation in aphid resistance index; and total sugars, starch, chlorophyll A, FRAP, tannins, myrosinase, ascorbate peroxidase, phenylalanine ammonia-lyase and tyrosine ammonia-lyase contributed to 86.3% variation in host preference by L. erysimi in the test wild crucifer genotypes (Fig. 7). In nutshell, genotypes like *Crambe abyssinica, Eruca sativa, Diplotaxis* species (*D. assurgens*, *D. erucoides*, *D. muralis, D. gomez-campoi, D. tenuisiliquae*), *Camelina sativa*, *Brassica fruticulosa* (Spain), *Brassica fruticulosa*, *Capsella bursapestoris* and *Lepidium sativum* were found with reduced survival, fecundity, preference and aphid resistance index and associated with high ascorbic oxidase, total phenols, total antioxidants and other antioxidative measures (Fig. 7).

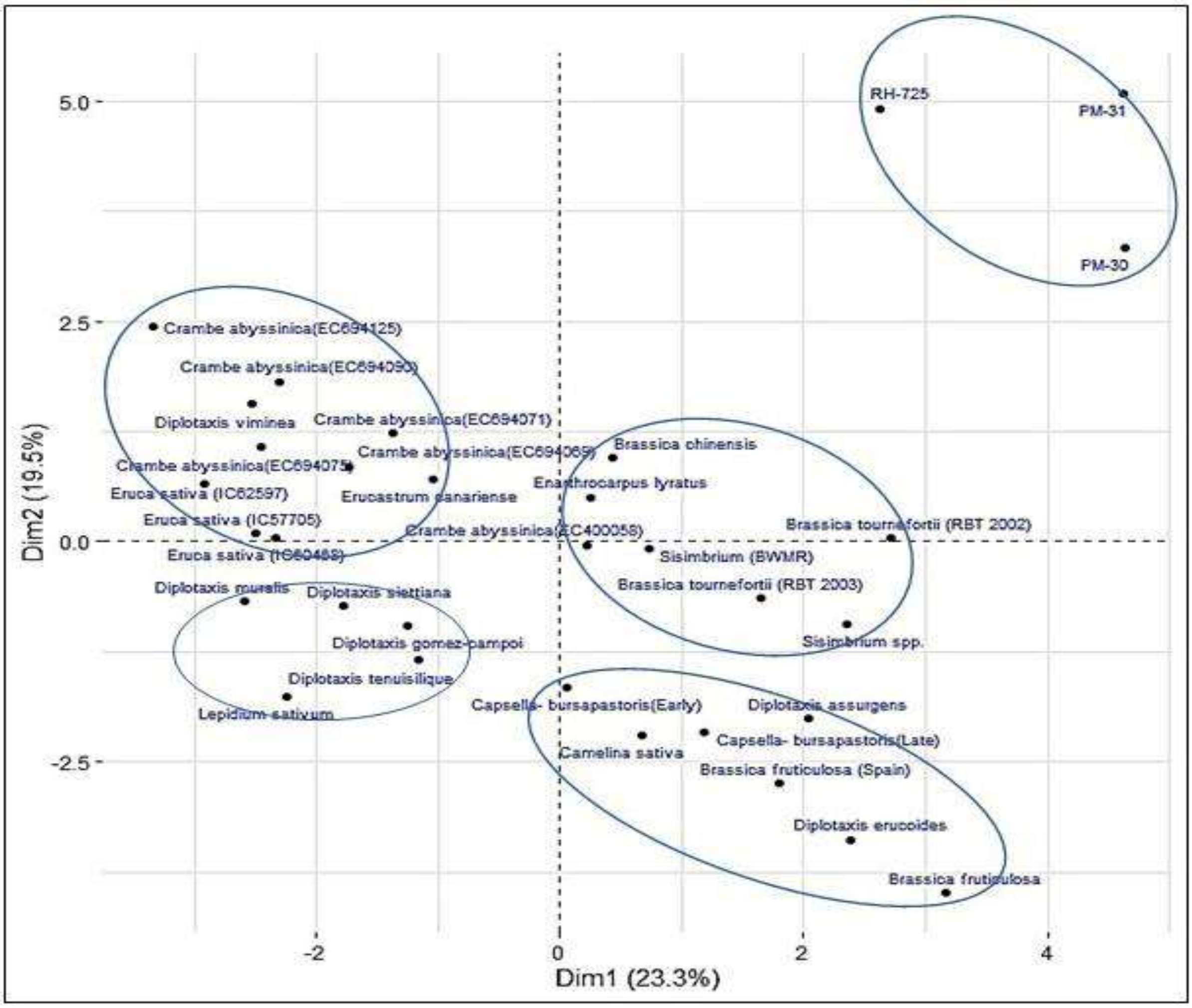

Figure 7. PCA biplot of wild crucifers based on biological traits of *Lipaphis erysimi* like fecundity, survival, aphid resistance index and host preference (Dim1), and 18 induced phytochemicals (Dim2).

Identify maize genotypes with diverse mechanisms of resistance to *Spodoptera frugiperda* and *Chilo partellus:* Thirty maize genotypes including resistant and susceptible checks were evaluated for leaf damage under field conditions, and larval preference and biological attributes of *S. frugiperda* and *C. partellus* under laboratory conditions. Biological attributes of *S. frugiperda* and *C. partellus* were used for calculating antibiosis index.

- ***Spodoptera frugiperda:*** The principal component analysis of maize genotypes (based on antibiosis index, per cent preference and LDR of *S. frugiperda*) placed them into six different groups. The resistant (CML 442) and susceptible (UMI 1210) checks were placed in separate groups. The test maize genotypes PDM 6555, PML 105, AI 518, C 70, AI 545, PDM 4061 and DDM 2309-O were found susceptible and grouped with susceptible check, while AI 196, DMS 4 B, AI 1100, AI 125, AI 178, AI 546 and AI 544 and PDIM 639 were placed with resistant check, hence found to be resistant to *S. frugiperda* (Fig. 8).

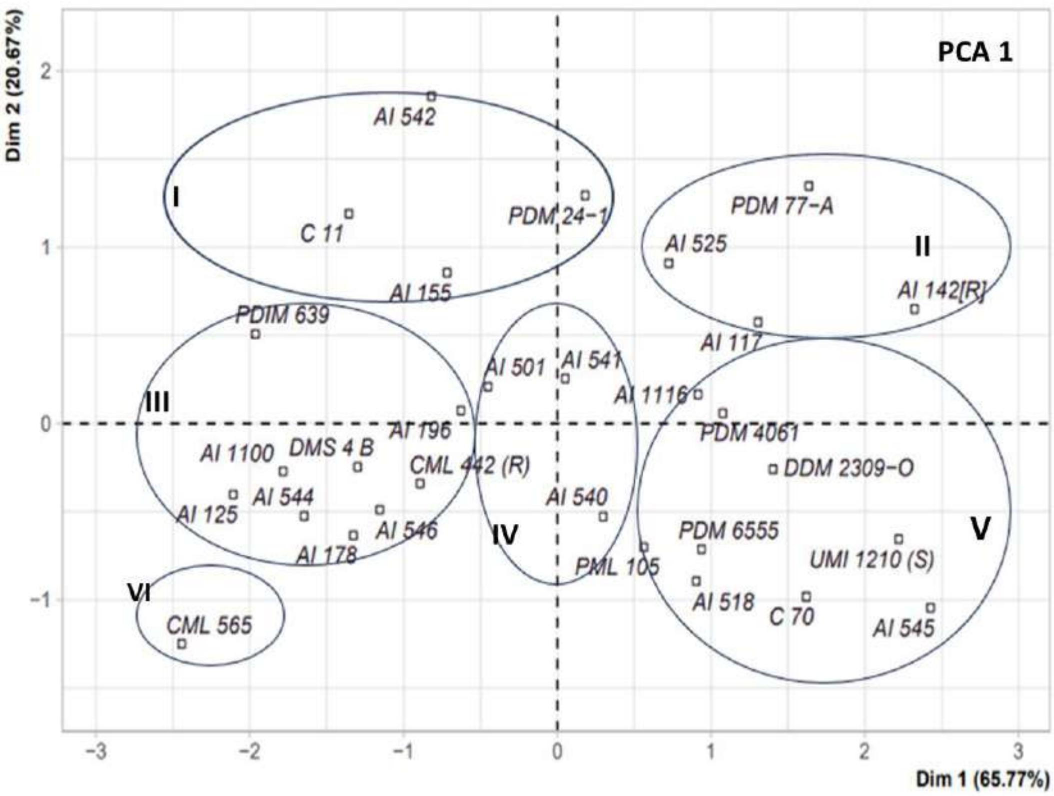

Fig. 8. PCA of maize genotypes based on antibiosis index and preference of *S. frugiperda* and leaf damage rating of maize genotypes

- ***Chilo partellus***: The principal component analysis (PCA) of maize genotypes (based on antibiosis index, per cent preference and LDR of *C. partellus*) placed them into five different groups (Fig. 9). The resistant (CML 442) and susceptible (UMI 1210) checks were placed in separate groups. The test maize genotypes AI 518, PML 105, AI 142 [R] and AI 540 were found susceptible and grouped with susceptible check, while CML 565, AI 525, AI 125, AI 546 and AI 1116 were placed with resistant check, hence found to be resistant to *C. partellus* (Fig. 9).
- The maize genotypes AI 125, AI 546 and CML 442 were found to express antibiosis and nonpreference mechanisms of resistance against both *S. frugiperda* and *C. partellus.*

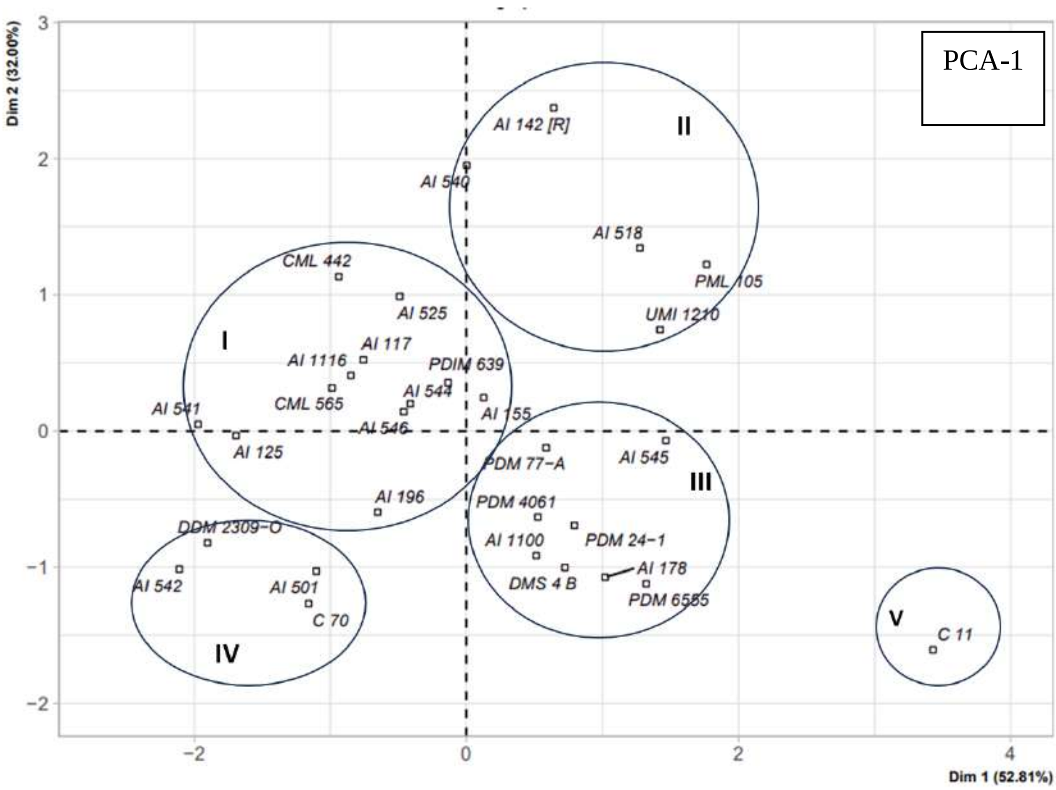

Fig. 9. PCA of maize genotypes based on antibiosis index and preference of *C. partellus* and leaf damage rating of maize genotypes

Explore the contribution of different biochemical factors for resistance to *Spodoptera frugiperda* and *Chilo partellus:* Thirty maize genotypes along with resistant and susceptible checks were estimated for constituted and insect damage-induced changes in 15 different biochemical constituents, and derived per cent change in induced biochemicals in response to damage by *S. frugiperda* and *C. partellus* in the test maize genotypes.

- ***Spodoptera frugiperda:*** The principal component analysis of *S. frugiperda* damage induced changes in different biochemical constituents in the maize genotypes placed them into four different groups (Fig. 10). The test maize genotypes AI 196, DMS 4 B, AI 525, AI 1116, PDM 6555, AI 546, AI 117, PDIM 639, AI 544 and PML 105 were placed with resistant check (CML 442), hence having similar basis of biochemical defense against *S. frugiperda* (Fig. 10). The leaf damage rating and antibiosis index of *S. frugiperda* was significantly and negatively, while larval preference positively correlated with induced total antioxidants, total tannins, catalase, PAL and TAL in the test maize genotypes. Further, the multiple linear regression indicated that the test induced biochemical constituents contributed to 74.3, 67.6 and 77.6% variation of antibiosis index, leaf damage rating and preference of *S. frugiperda*, respectively. The stepwise regression suggested that induced total antioxidants, ascorbate peroxidase, and catalase contributed to 50.0% variability in antibiosis index; FRAP alone contributed to 33.0% variability in leaf damage; and total tannins, PAL, TAL, chlorophyll A, chlorophyll B, total chlorophyll, and total carotenoids contributed to 66.0% variability in preference by *S. frugiperda*.

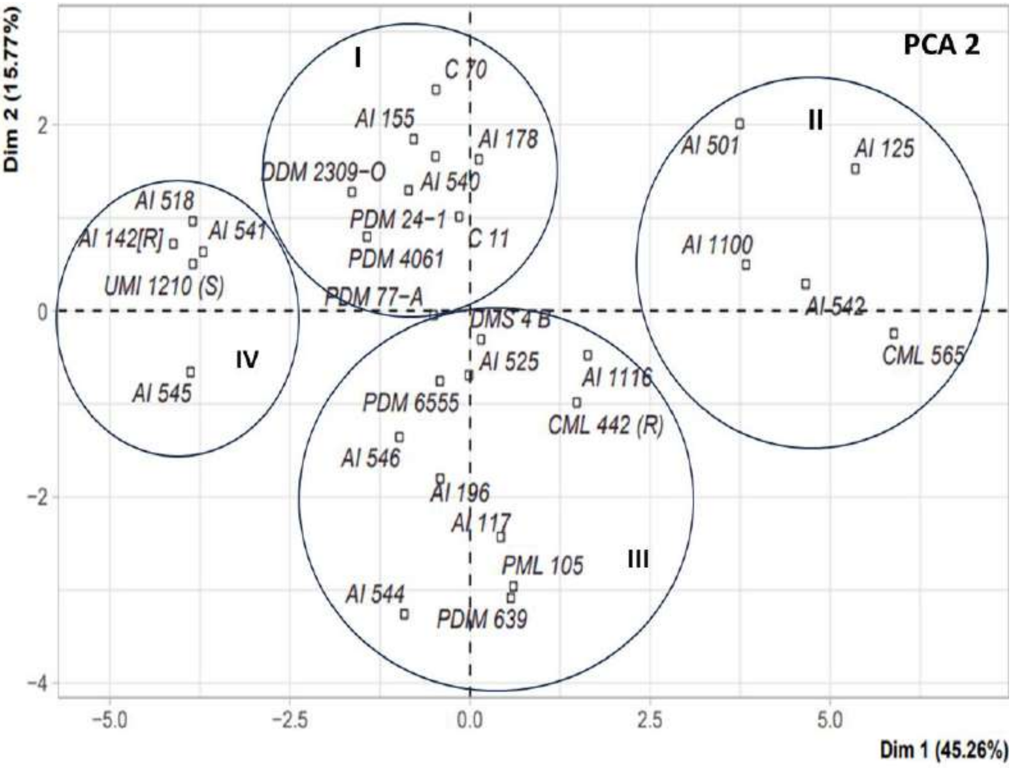

Fig. 10. PCA of maize genotypes based on percent change of various biochemical components of maize genotypes due to *S. frugiperda* feeding.

- ***Chilo partellus***: The principal component analysis of *C. partellus* damage induced changes in different biochemical constituents in the maize genotypes placed them into four different groups (Fig. 11). The test maize genotypes AI 501, AI 546, AI 525, AI 540, AI 142 [R], AI 178, PML 105, PDM 4601, DDM 2309-O and C 70 were placed with resistant check (CML 442), hence having similar basis of biochemical defense against *C. partellus* (Fig. 11). The leaf damage rating by *C. partellus* was significantly negatively correlated with total phenols, and positively correlated with chlorophyll A and total chlorophyll; larval preference was significantly and negatively correlated with FRAP, ascorbate peroxidase and PAL; and antibiosis index significantly and negatively correlated with total tannins, FRAP and ascorbate peroxidase activity in the insect-damaged test maize genotypes. Further, the multiple linear regression indicated that the test induced biochemical constituents contributed to 61.0, 51.0 and 54.0% variation of antibiosis index, larval preference and leaf damage. However, the stepwise regression suggested that the induced total tannins and FRAP together contributed to 39 % variability in antibiosis index, FRAP, ascorbate oxidase and ascorbate peroxidase to 40.0% variability in larval preference, and chlorophyll A contributed to 15.0% variability in leaf damage by *C. partellus*.
- The maize genotypes AI 525, AI 546 and PML 105 and CML 442 were found to express similar biochemical basis of resistance against both *S. frugiperda* and *C. partellus*.

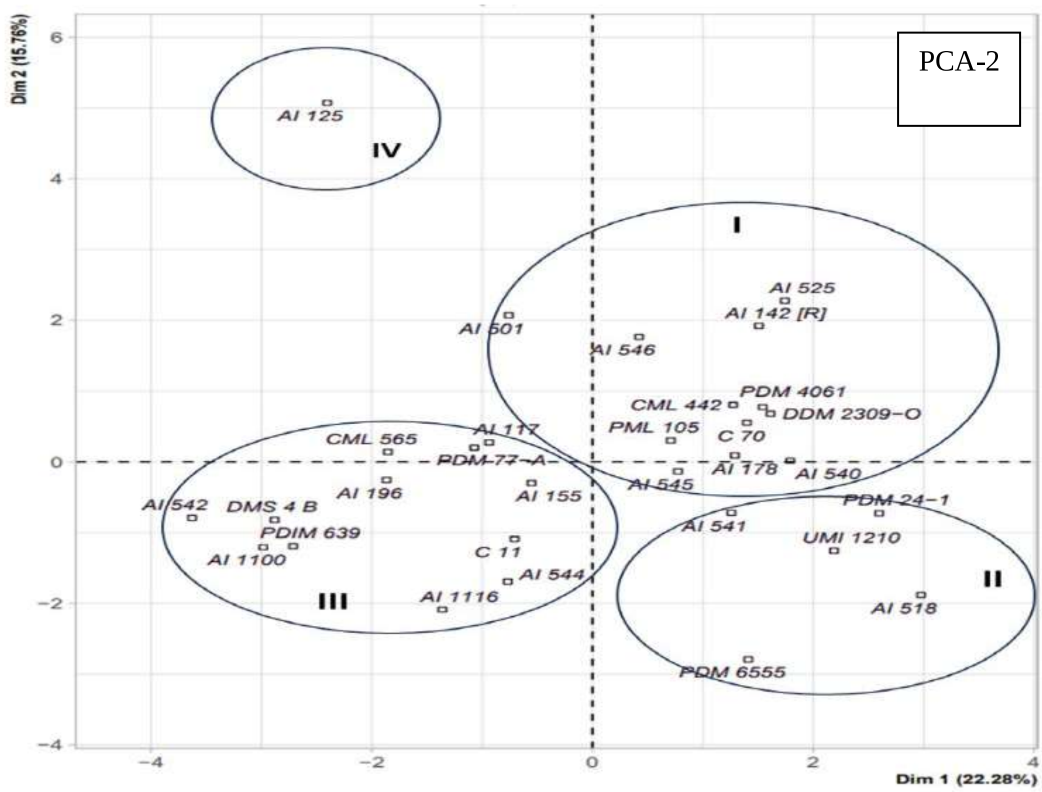

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Fig. 11. PCA of maize genotypes based on percent change of various biochemical components of maize genotypes due to *C. partellus* feeding.

Comparative Metabolomics Profiling of Chickpea Genotypes against Gram Pod Borer, *Helicoverpa armigera* (Hubner): Investigations were carried out to profile the biochemical metabolites *viz*., specific non-enzymatic compounds (Hydrogen peroxide, malondialdehyde and flavonoids content), nutritional compounds (sugar and protein content) in the leaves of different chickpea genotypes *viz*., AKG-1303, GL-15017, GL-15026, GL-17020, GL-16056, CSJ-956, ICC-3137 (susceptible check) and ICCL-86111(tolerant check) with four treatments (Control, Mechanical damage, insect infestation, and both insect infestation and mechanical damage) at 48 h time interval (Fig. 12a). Pre-starved third instar larvae of *H. armigera* were released on four-week-old chickpea plants @ one larva per plant and were allowed to feed for 48 hours and were removed. Non-infested plants were considered as control for respective genotypes. In mechanical damage, leaves were wounded with a punch machine until 15–20% of leaf area was removed. The results revealed that primary nutritional compounds, specifically protein content were significantly higher in GL-15017, ICCL-86111 (resistant check) and lower in ICC-3137 (susceptible check) and Non-enzymatic compounds (Hydrogen peroxide, Flavonoids) were significantly higher in GL-15017 followed by AKG-1303 under all four treatments indicating the antibiosis mechanism of host plant resistance against *H. armigera* (Fig. 12 b). These genotypes can be utilized as potential tolerant donors in breeding chickpea varieties with stable resistance against gram pod borer.

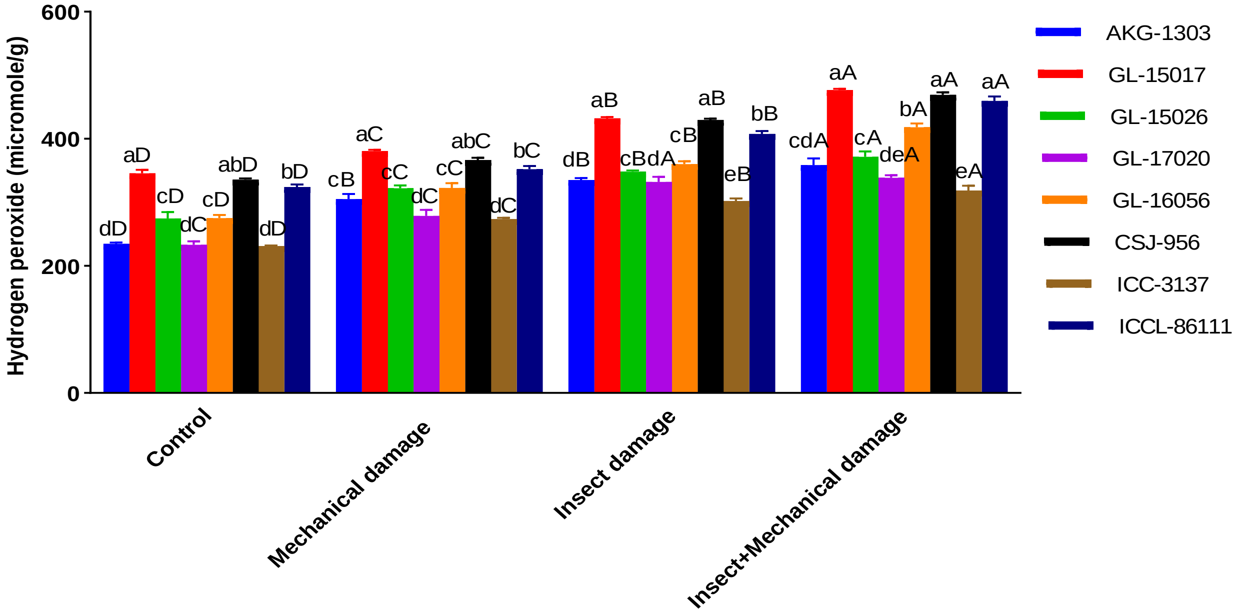


Fig. 12a: Hydrogen peroxide (H_2O_2) content (µmol /g FW) in response to damage by *Helicoverpa armigera* in leaves of chickpea genotypes

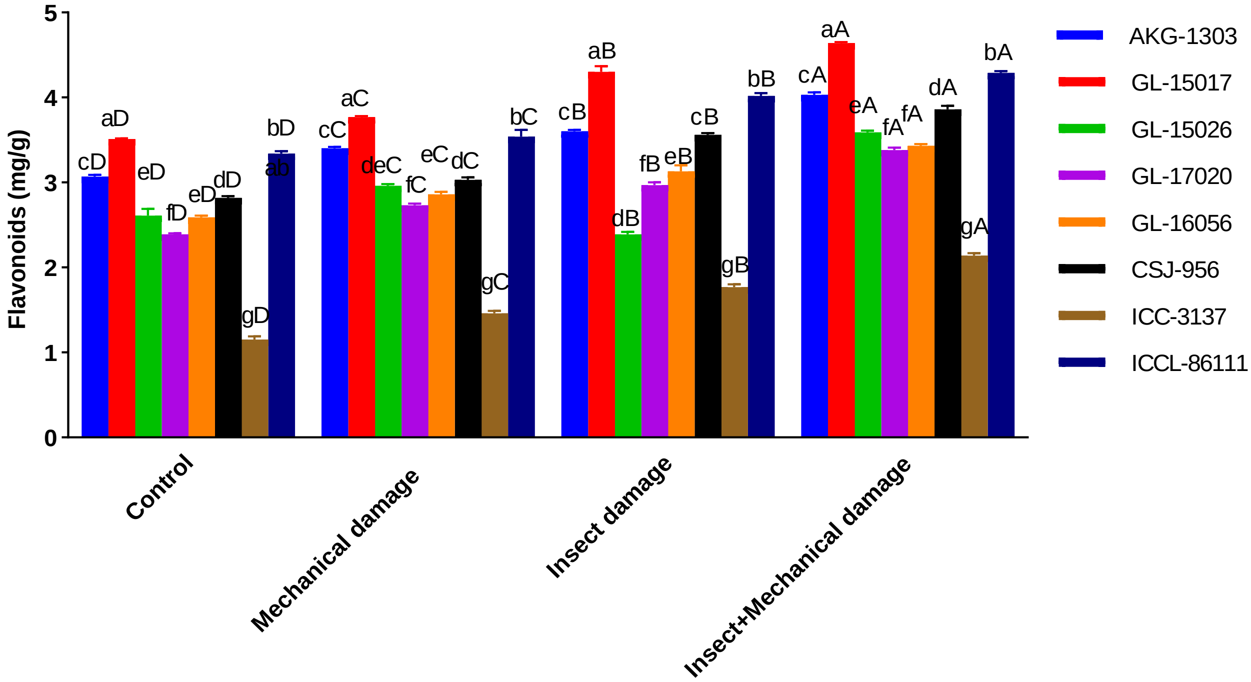


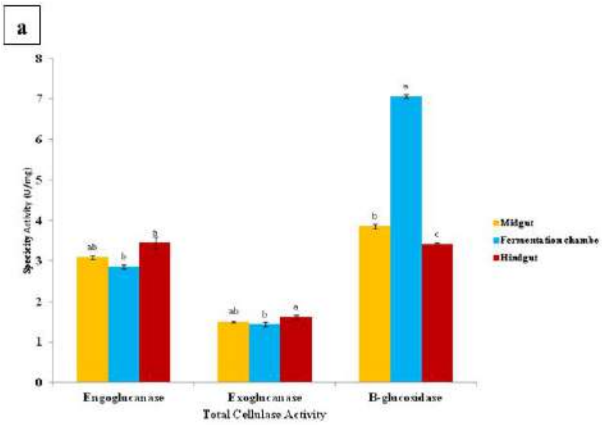
Fig. 12b: Flavonoids content (mg/g FW) in response to damage by *Helicoverpa armigera* in leaves of different chickpea genotypes

Post-mating transcriptional changes in female moths of fall armyworm, *Spodoptera frugiperda* (J.E. Smith): Investigations on mating-induced transcriptional changes in fall armyworm (*Spodoptera frugiperda*, Noctuidae, Lepidoptera) female moths through RNA-Seq analysis revealed that 13,207 differentially expressed transcripts were identified, with 846 transcripts exhibiting significant expression 24 hours post-mating. It is noteworthy that transcriptional changes were subdued immediately after mating, reaching their peak at 24 hours. The differential gene expression analysis, involving 89 upregulated and 757 downregulated genes, sheds light on the intricate molecular mechanisms triggered by mating. Mapping against the reference genome revealed the involvement of these genes in diverse biological processes, cellular components, and molecular functions. Key upregulated genes include cathepsin B, cytochrome P450 6B1, ecdysone oxidase, ribosome-binding protein-1, play essential roles in egg development, detoxification, hormone synthesis, and protein production, all of which are critical for successful reproduction. Conversely, genes related to the immune system, such as serine-protease inhibitor dipetalogastin-like, attacin, lysozyme, were downregulated. This suggests a strategic trade-off between allocating resources for successful reproduction and maintaining an effective immune defense. Orphan genes also demonstrated significant regulation, highlighting the complexity of the FAW's transcriptional landscape. Functional enrichment analysis revealed that upregulated genes were associated with reproduction-related terms and pathways, while downregulated genes were linked to immunity-related terms. This research emphasizes the importance of understanding the role of mating in influencing female traits and behaviours for effective pest management. By identifying specific genes and pathways involved in post-mating transcriptional changes, this study provides a foundation for innovative and sustainable strategies in FAW control, offering potential solutions to mitigate crop losses, enhance agricultural productivity, and contribute to the global effort for food security.

The post-mating transcriptional changes has been documented and developed as transcriptome database, "***FAW Transcriptomic Atlas***" (http://faw.iari.res.in/) on mapping the post mating transcriptional journey in female moths of invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) with more than 2000 users/visitors

Sublethal effects of heat shock on fall armyworm, *Spodoptera frugiperda* (J. E. Smith): Sub-lethal effects of heat stress on fall armyworm were studied to observe the changes in reproductive fitness of *S. frugiperda.* Heat shock treatments were given at the larval stage ranging from 40-49^{0}C in temperature and humidity-controlled incubator and LT_{25}, LT_{50}, LT_{75} values were calculated. Sub-lethal (LT_{25}, LT_{50}, LT_{75}) effects of heat shock on different reproductive parameters of *S. frugiperda* was undertaken by exposing the larvae to LT_{25} (44.9ºC) LT_{50} (45.4ºC) LT_{75} (45.8ºC) separately in BOD while control population were maintained at 27±1°C. This stress consisted of only one time exposure and the larvae were provided with a meridic diet to rule out the possibility of starvation stress. After heat treatment, the treated insects were maintained at optimal conditions (27±1°C, 65±5% RH) until adult emergence. Adults emerged from each treatment were paired in diallel fashion (CM*CF, CM*TF, TM*CF, TM*TF) and different parameters like pre-oviposition, oviposition and post-oviposition period, total fecundity, F_1 egg hatching percent, mating success and mating frequency was recorded in all the mating combinations. Results showed that sub-lethal heat shock negatively affects the pre-reproductive and post-reproductive parameters in *S. frugiperda.* Heat stress had a significant impact on mating frequency and hatching percentage, when treated at LT_{50} and $LT_{75.}$ However, the LT_{25} treatment does not show much effect on the mating frequency and F_1 egg hatching percentage. An altered sex ratio was observed due to heat stress treatment with an increase in the number of females due to sublethal heat stress treatment.

Functional characterization of gut bacteria of white grub, *Anomola dimidiate*: This study utilized cultivable methods and 16S amplicon sequencing to compare taxonomic profiles and functional potential of gut bacteria in the scarab beetle, *Anomola dimidiata*, under cellulose-enriched conditions. Filter paper degradation assay was used as an enrichment technique for isolation of cellulolytic bacteria from the gut of *A.dimidiata*. Eight culturable cellulolytic gut bacteria were isolated from the midgut and hindgut of the scarab larvae, respectively. Specific activity of total cellulase, endoglucanase and β-glucosidase activity were used as markers for isolation of cellulolytic gut bacteria (Fig. 13a). 16S amplicon sequencing evinced that the most represented taxonomic profiles at the phylum level in the fermentation chamber and midgut were Bacillota (71.62 and 56.76%), Pseudomonadota (22.66 and 36.89%) and Bacteroidota (2.7 and 2.81%). Bacillota (56.74 and 91.39%) were significantly enriched in the midgut with the addition of cellulose. In contrast, Bacillota and Psedomonadota were significantly enriched in the fermentation chamber. Carbohydrate metabolism was up-regulated in the midgut, while nitrogen and phosphorus metabolism were up-regulated in the fermentation chamber, suggesting these symbionts' possible metabolic roles to the host. An analysis of total cellulases as well as amplicon sequence variants indicated that the gut bacteria belonging to *Acinetobacter*, *Bacillus*, *Brucella*, *Brevibacillus*, *Enterobacter*, *Lysinibacillus* and *Paenibacillus* are involved in nutrition provisioning (Fig. 13b). These results have provided additional insights into the gut bacteria associated with cellulose digestion in *A. dimidiata* and created a platform for bioprospecting novel isolates to produce biomolecules for biotechnological use, besides identifying eco-friendly targets for its management.



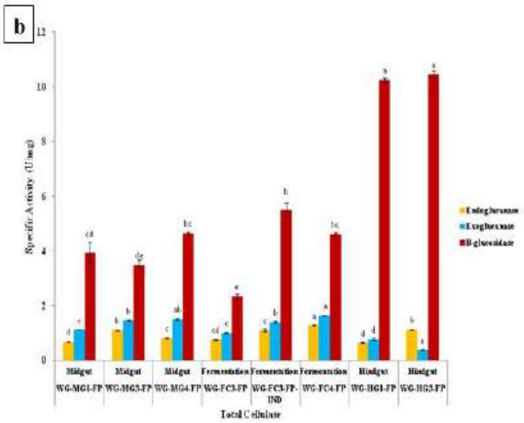


Fig. 13a. Cellulolytic activity of enriched cell-free culture digestome fluids from *A. dimidiata*. Means with at least one letter common are not statistically significant using TUKEY's Honest Significant Difference.

13b. Cellulolytic activity (mean U/mg) of cellulose-degrading gut bacteria from *A. dimidiata*. Means with at least one letter common are not statistically significant using TUKEY's Honest Significant Difference.

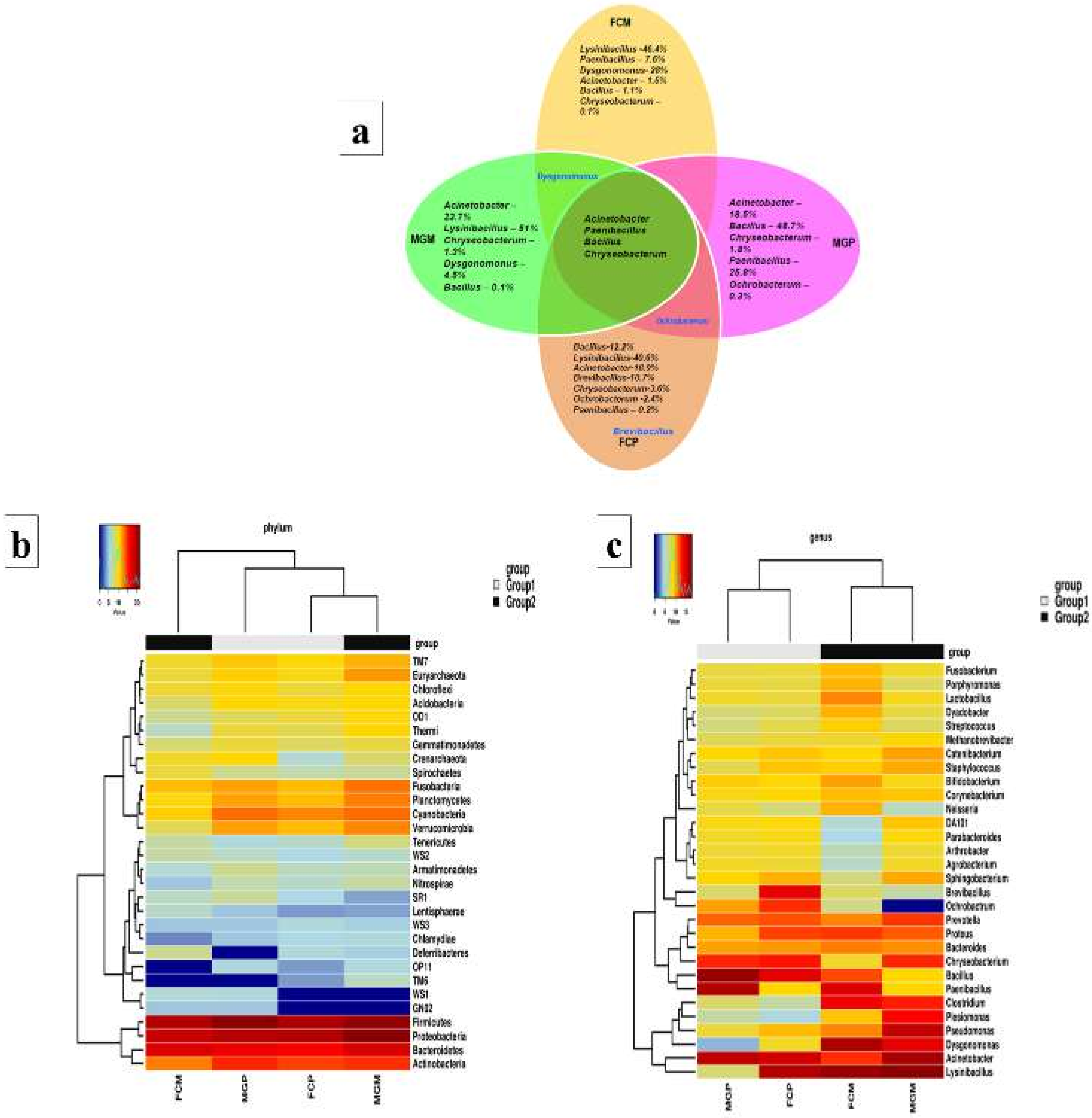


Fig. 14a. A Venn diagram analysis of normal and enriched gut sections highlights cellulolytic gut bacteria enriched under cellulose enriched and those unique to particular gut sections and those shared between sections. Different colours represent the different gut sections. MGM=normal midgut; MGP=cellulose enriched midgut; FCM=normal fermentation chamber; FCP=cellulose enriched fermentation chamber.

14b. Heat map analysis of the abundance distribution of bacterial phyla associated with *A. dimidiata* larvae. The taxonomic relationship of the bacterial species is shown in the rows. In contrast, the clustering of the phyla is shown in the columns. Higher intensities of the colour indicate higher abundances of the phyla (Group 1= cellulose enriched; Group 2= normal guts).

14c. Heat map analysis of the abundance distribution of bacterial genera associated with *A. dimidiata* larvae. The taxonomic relationship of the bacterial species is shown in the rows. In contrast, the clustering of the genera is shown in the columns. Higher intensities of the colour indicate higher abundances of the genera. (Group 1= cellulose enriched; Group 2= normal guts).

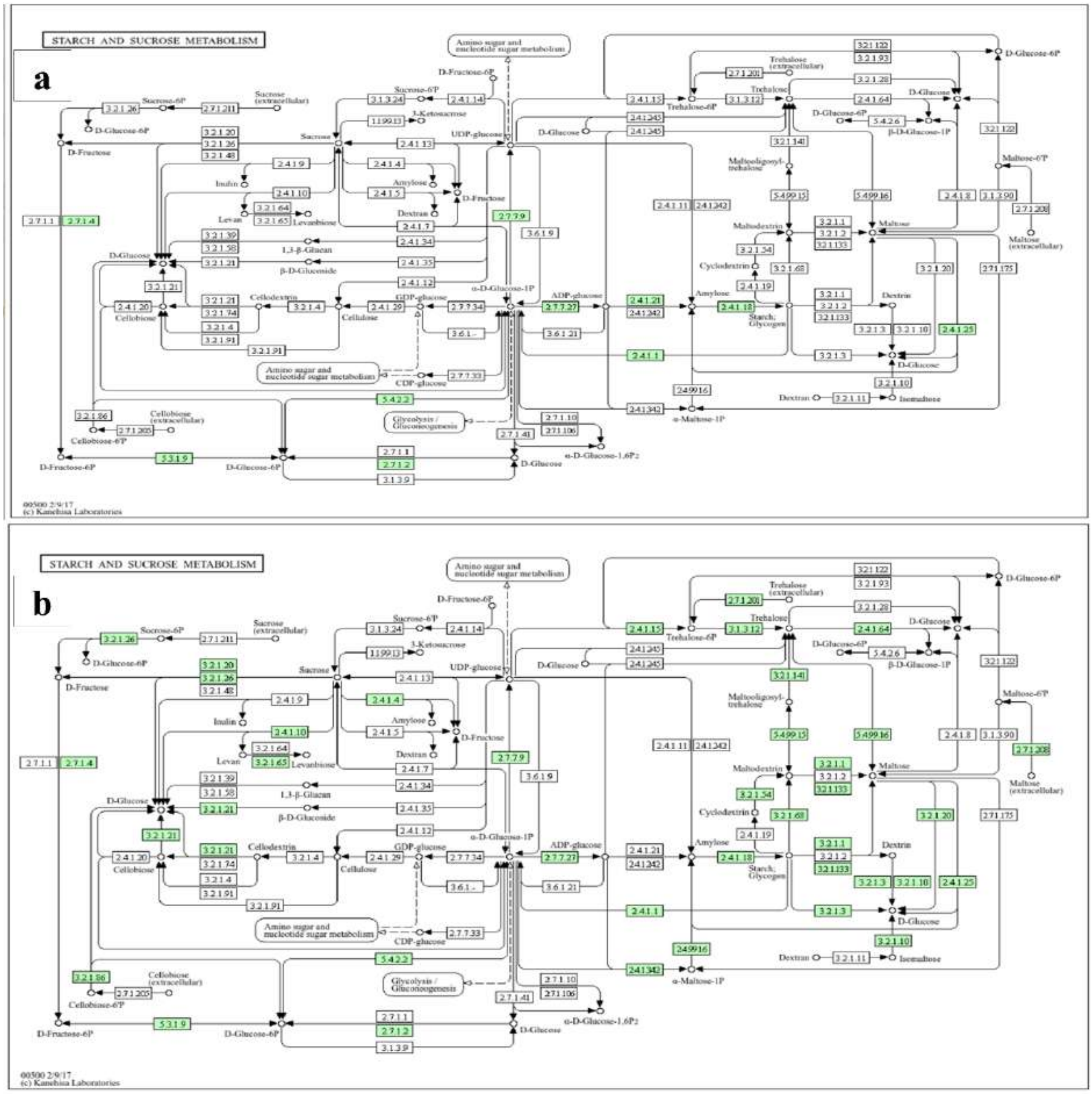


Fig. 15a. Starch and sucrose metabolism pathways in normal fermentation chamber midgut. The pathway points highlighted in green show the enzyme with which the gut bacteria of scarab beetles may supplement the endogenous metabolism. **15b.** Starch and sucrose metabolism pathways in enriched fermentation chamber midgut. The pathway points highlighted in green show the enzyme with which the gut bacteria of scarab beetles may supplement the endogenous metabolism**.**

Expression of Chemosensory proteins in the developmental stages of whitefly *B. tabaci*: We explored the expression patterns of CSPs throughout their developmental stages through diagnostic PCR and Realtime q-PCR. Significant differences in expression patterns were observed for the 14 CSPs in developmental stages of *B. tabaci* Asia II-1 revealed that the CSP genes 2, 4, 6, 7, and 10 were found to be present throughout all the growth stages of *B. tabaci* Asia II-1. The 1st nymphal stage contained the lowest number of genes, with six, while the 2nd and 3rd nymphal stages had nine genes each. The 4th nymphal instar stage had the highest number of CSP genes, with a total of 12. The presence of all the OBP/CSP genes were detected in the male and female adults of *B. tabaci* (Fig. 16).

The RT-qPCR analysis carried out using gene-specific primers showed variation in the expression levels of CSP genes across the developmental stages.

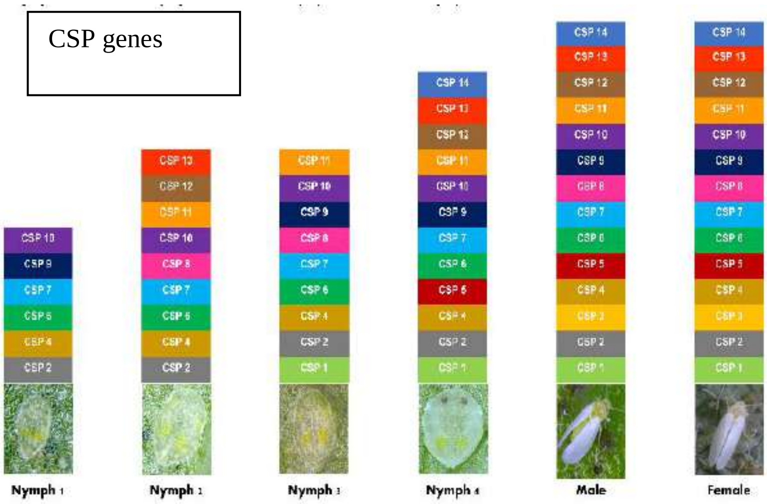


Fig 16. Detection of CSP genes across developmental stages of whitefly *B. tabaci*

The CSPs 4, 6, and 7 exhibited relatively higher expressions in first, second and third instars respectively. While, CSP4 exhibited significantly higher expression during the fourth instar, CSP1 was showing the highest expression in the adults. Notably, CSP 4 had shown consistently higher expression than all other CSP genes across the nymphal stages and CSP 2 was showing the least expression across all life stages of *B. tabaci* Asia II-1. The heatmap representation (Fig. 17**)** depicts the relative levels of expression of CSP genes in different life stages of *B. tabaci* Asia II-1. Among the CSPs, the CSP4 showed progressive increase in gene expression through the nymphal stages.

–	Log_2 Nymph 1	Log_2 Nymph 2	Log_2 Nymph 3	Log_2 Nymph 4	Log_2 Adult
CSP 1	0.32	0.55	0.56	1.18	16.00
CSP 2	0.33	0.41	0.51	0.30	0.35
CSP 3	0.32	1.51	0.58	7.20	9.50
CSP 4	15.00	1.51	1.00	16.00	2.78
CSP 5	0.50	0.60	0.70	8.20	2.10
CSP 6	0.50	10.00	0.70	7.00	2.10
CSP 7	0.50	1.00	5.50	5.70	8.50
CSP 8	0.50	6.00	3.00	0.50	8.00
CSP 9	8.70	0.50	3.00	1.50	6.00
CSP 10	0.70	0.30	0.22	0.16	8.00
CSP 11	0.10	4.00	3.00	5.10	7.50
CSP 12	0.30	4.30	0.22	4.98	5.50
CSP 13	0.11	3.20	5.10	0.65	7.70
CSP 14	0.11	0.50	0.30	5.50	6.20

Fig 17. Heat map based on the expression profile of CSP genes across life stages of *B. tabaci* Asia II-1. The values are the respective fold changes of that gene in that particular stage. A colour scale was employed to denote significant expression levels, where red indicates low expression, yellow indicates moderate expression, and green signifies high expression.

Functional characterization of gut microbes of honey bees *Apis mellifera*: This research investigates cellulolytic and pectinolytic activities in gut bacteria from forager and hive bees within an Indian *Apis mellifera* colony. The study reveals that cellulolytic and hemicellulolytic bacterial isolates, mainly from γ-Proteobacteria, Actinobacteria, and Firmicutes, have significant potential for crop residue management. Some genera, like *Aneurinibacillus*, *Bacillus*, *Clostridium*, *Enterobacter*, *Serratia*, *Stenotrophomonas*, *Apilactobacillus*, *Lysinibacillus*, and *Pseudomonas*, are very good at breaking down cellulose and hemicellulase. Notable cellulose-degrading genera include *Cedecea* (1.390±0.57), *Clostridium* (1.360±0.86 U/mg), *Enterobacter* (1.493±1.10 U/mg), *Klebsiella* (1.380±2.03 U/mg), and *Serratia* (1.402±0.31 U/mg) [Table 1]. The gut bacterial isolates, *Aneurinibacillus* (1.213±1.12 U/mg), *Bacillus* (3.119±0.55 U/mg), *Enterobacter* (1.042±0.14 U/mg), *Serratia* (1.589±0.05 U/mg), and *Xanthomonas* (1.156±0.08 U/mg) excel in hemicellulase activity. Specific isolates with high cellulolytic and hemicellulolytic activities are identified, highlighting their potential for crop residue management.

Table 1. Cellulolytic index and Fpase (mean U/mg ± SE) activity of gut bacteria from forager and hive bee of *A. mellifera*

Page	Bacteria	Gut compartment	Cellulolytic index(cm)	Specific enzyme activity (U/mg=μmol min^{-1} mg^{-1})
Forager bee				
1	*Aneurinibacillus aneurinilyticus* isolate HAmf01	Foregut	0.68	0.757±0.01
2	*Aneurinibacillus migulanus* isolate HAmf02	Foregut	0.62	0.733±0.03
3	*Bacillus* tropicus isolate HAmf16	Foregut	0.56	0.782±0.10
4	*Bacillus anthracis* isolate HAmf07	Foregut	0.58	0.748±1.10
5	*Clostridium botulinum* isolate HAmf21	Foregut	0.67	0.750±0.31
6	*Enterobacter ludwigii* isolate HAmf28	Foregut	0.68	0.750±0.56
7	*Stenotrophomonas* sp. HA1f43	Foregut	0.32	0.464±0.12
8	*Bacillus altitudinis* isolate HAmf05	Foregut	0.75	0.831±0.03
9	*Enterobacter asburiae* isolate HAmf25	Foregut	1.37	1.493±1.10

10	*Salmonella enterica* subsp. *Enterica* serovar *Tshiongwe* isolate Hamf36	Foregut	0.51	0.750±0.07
11	*Serratia marcescens* isolate HAmf39	Foregut	0.21	0.388±0.06
12	*Bacillus amyloliquefaciens* isolate HAmf06	Midgut	0.45	0.596±0.08
13	*Bacillus subtilis* subsp. *stercoris* isolate HAmf13	Midgut	0.52	0.750±1.67
14	*Clostridium combesii* isolate HAmf22	Midgut	0.92	1.360±0.86
15	*Cedecea davisae* isolate HAmf19	Midgut	1.01	1.390±0.57
16	*Enterobacter cloacae* isolate HAmf26	Midgut	1.13	1.369±0.96
17	*Enterobacter hormaechei* isolate HAmf27	Midgut	1.10	1.290±0.25
18	*Serratia ureilytica* Isolate HAmf42	Midgut	1.21	1.402±0.31
19	*Serratia nematodiphila* isolate HAmf40	Midgut	1.12	1.365±0.68
20	*Clostridium sporogenes* isolate HAmf24	Hindgut	0.95	1.240±0.10
21	*Serratia nematodiphila* isolate HAmf41	Hindgut	1.12	1.384±0.23
22	*Klebsiella aerogenes* isolate HAmf46	Hindgut	1.02	1.380±2.03
Hive bee				
23	*Klebsiella aerogenes* isolate HAmh14	Foregut	0.98	1.24±0.54
24	*Serratia marcescens* isolate HAmh22	Foregut	1.11	1.27±1.78
25	*Apilactobacillus helveticus* isolate HAmh30	Foregut	0.58	0.95±1.95
26	*Apiactobacillus alvei* isolate HAmh31	Foregut	0.41	0.73±0.36
27	*Bacillus subtilis* subsp. *inaquosorum* isolate HAmh08	Midgut	1.35	1.37±0.74
28	*Lysinibacillus macroides* isolate HAmh16	Midgut	1.10	1.17±0.45
29	*Pseudomonas aeruginosa* isolate HAmh21	Midgut	1.42	1.38±1.20
30	*Serratia* sp. isolate HAmh23	Midgut	1.12	1.30±0.91
31	*Clostridium sporogenes*	Midgut	0.98	1.17±0.34

	isolate HAmh27			
32	*Bacillus subtilis* subsp. *stercoris* isolate HAmh09	Hindgut	0.53	0.81±0.22
33	*Bacillus tequilensis* isolate HAmh10	Hindgut	0.46	0.47±0.35
34	*Bacillus tequilensis* isolate HAmh28	Hindgut	0.56	0.52±0.07
35	*Bacillus amyloliquefaciens* isolate Hamh29	Hindgut	0.47	0.57±0.12
	Mean			0.998
	p-Value			0.001
	CV			0.342
	SE(d)			0.360
	Tukeys HSD at 5%			S

The research explores gut bacterial compartmentalization in *A. mellifera*, emphasising role of gut physiology in cellulose and hemicellulose digestion. Pectinolytic activity is observed, particularly in the *Bacillaceae* clade (3.229±0.02), contributing to understanding the honey bee gut microbiome. The findings offer insights into microbiome diversity and enzymatic capabilities, with implications for biotechnological applications in sustainable crop residue management (Fig. 18).

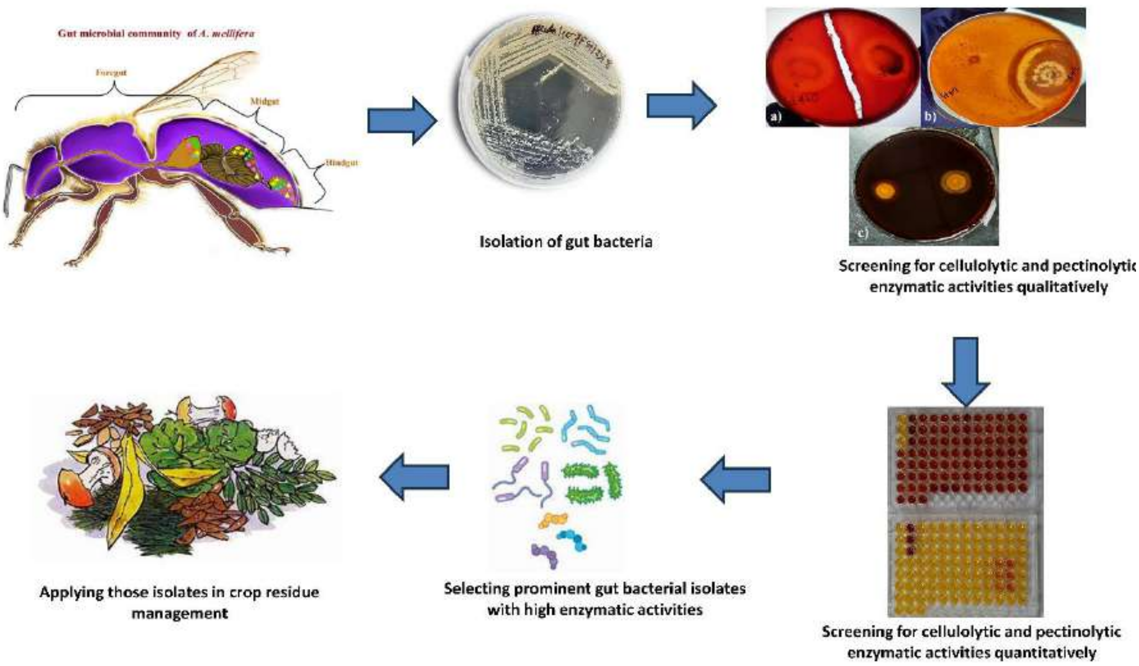


Fig. 18. A schematic illustration of functional characterization of gut bacterial isolates from hive and forager bees of *A. mellifera* for cellulase and hemicellulose activities which offer scope for utilization of these isolates for crop residue management

III. Biological Control

Mass production of *Metarhizium rileyi* on different substrates

Grains: All the substrates showed significant difference in conidial yield at different intervals. Barley was found to be the best treatment by recording 8.26$\times 10^8$, 15.18$\times 10^8$, and 17.51 $\times 10^8$ conidia/g of substrate at 15, 22 and 28 days after inoculation, respectively which proved superior over the rest of the substrates. Long rice (8.775$\times 10^8$ to 15.295$\times 10^8$ conidia/g of substrate) and sorghum (7.23 to 14.317 $\times 10^8$ conidia/g of substrate) were next to follow. In the order of supremacy maize wheat bajra and finger millet produced 11.535$\times 10^8$, 10.19$\times 10^8$, 7.44$\times 10^8$ and 6.69$\times 10^8$ conidia/g of substrate, respectively at 24 days of inoculation.

Solid media: *M. rileyi* Among the vegetables such as carrot, potato, sweet potato and banana tested, recorded the maximum spore production (8.7125 x 10^8 spores/ g) on carrot followed by Potato, Sweet potato and banana (7.23 x 10^8 6.7225 x 10^8 and 5.5175 x 10^8).

Liquid media: Spore production significantly affected by type of media. Among six liquid media tested SMYB supported maximum sporulation (9.6875 $\times 10^8$ spores mL^{-1}) followed by PDB and coconut water, 8.775 $\times 10^8$ and 8.26 $\times 10^8$ spores mL-1, respectively. The results indicated that SMYB medium is a suitable liquid medium as it produced maximum biomass and spores.

Diphasic system: Results indicated that SMYB +Barley (7.7 to 19.9 $\times 10^8$ spores/g), PDB + Barley (7.4 to 18.6 $\times 10^8$ spores/ g) and CDB + Barley (6.7 to 18.23 $\times 10^8$ spores/g) produced highest amount of spore in combinations followed by SMYB + rice (8.37 to 18.07 $\times 10^8$ spores/g), PDB+Rice (7.9 to 17.1 $\times 10^8$ spores/g) and CDB+ rice (7.3 to 16.5 $\times 10^8$ spores/g). Least production of spores are found in combinations of   SMYB + sorghum (6.2 to 16.28 $\times 10^8$ spores/ g), PDB + Sorghum (5.8 to 15.2), and CDB+ Sorghum (5.0 to 13.68 $\times 10^8$ spores/g).

Stage specific life-table studies of *Geocoris sp* at different temperatures viz., 27, 30, 33, and 36ºC under laboratory conditions: At egg stage the apparent mortality was observed maximum (28%) at 36ºC and minimum (12%) at 27ºC (Fig. 19). When a comparison was made between nymphal instars, the highest mortality was observed at Vth instar at 36ºC (21.053%). In most of the temperature regime the apparent mortality was relatively high in egg and early nymphal stages. Survival fraction was found to be maximum in the second instar nymph, when *Geocoris* sp. was reared at 27ºC. The least survival fraction was observed in egg stage (0.720) of *Geocoris* sp. when reared at 36ºC. Survival of *Geocoris* sp. at higher temperature was poor. With increase in temperature, egg and nymphal mortality also increased. The life cycle shortened with increase in temperature. Maximum mortality survival ratio is observed among the eggs across all the temperature regimes. It was found to be (0.389) at 36ºC followed by fifth instar nymphs (0.267) when reared at 36ºC. The least mortality survival ratio (5.00) is seen when reared at 30ºC. It was observed that indispensable mortality increased with increased temperature regimes. Highest indispensible mortality was 11.667 recorded in egg stage of *Geocoris* sp., when reared at 36ºC. Lowest indispensible mortality ratio was observed in the 2^{nd} instar nymphs (0.053) followed by IV^{th} instar nymphs (0.060) when reared at 27ºC. Higher k-values were observed in the egg stage of all the temperature regimes (0.056, 0.076, 0.097 and 1.43) when *Geocoris* sp. was reared at 27, 30, 33, and 36ºC respectively. The total generation mortality K was recorded maximum (0.5229) at 36ºC and minimum (0.2007) at 27ºC. Based on the above results it is concluded that *Geocoris* sp. can effectively survive slightly higher temperature of 30ºC with little adverse effect on its life cycle under field conditions.

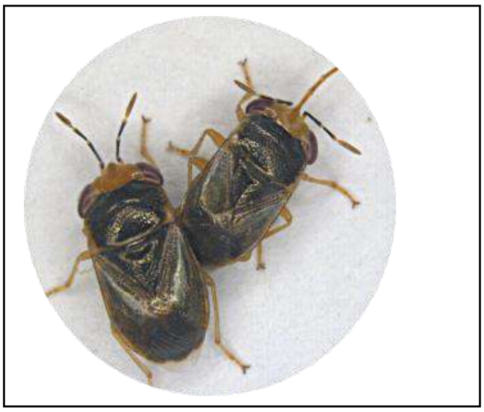
 

Fig. 19. Adult *Geocoris ocropterus*

IV. Insect Toxicology

Determination of diagnostic dose for selected insecticides and evaluation of bio-pesticides against *Spodoptera frugiperda* (J. E. Smith): Chlorantraniliprole 18.5%SC was the most potent insecticide followed by Emamectin benzoate 5%SG and Spinetoram 11.7%SC. The determined diagnostic dose can be used as practical surveillance tool for resistance management programmes. Entomopathogenic fungi can be useful in managing *S. frugiperda* but they are less effective if applied alone. Studied the co-toxicity/synergistic toxicities of selected insecticides and bio-pesticidal molecules against target insect. *M. anisopliae* and chlorantraniliprole exhibited synergistic effect on test-larvae. Insecticides like chlorantraniliprole showed synergistic effect in combination with *Metarhizium anisopliae* which can be the better option for reducing the insecticide load.

Impacts of sublethal concentrations of spinetoram on biological traits and nutritional parameters of *S. frugiperda:* This study was carried out to comprehend the sublethal effects of spinetoram (Delegate® 11.7%SC), CIBRC recommended broad spectrum lepidoptericide, against *S. frugiperda*. Spinetoram exhibited high toxicity against third instar larvae of *S. frugiperda* (LC_{50}=0.157ppm). Comparative analysis with control groups showed that sublethal doses of spinetoram at LC_{10} and LC_{25} significantly reduced pupation and adult emergence rates, fecundity, larval-pupal weight, and adult longevity. Additionally, it led to a concurrent increase in deformed adults and the duration of the larval and pupal stage. Sublethal doses of spinetoram had a notable impact on various nutritional indices, including a significant decrease in growth rate, consumption rate, efficiency of conversion of ingested food, and efficiency of conversion of digested food.

Life table study: The intrinsic rate of increase (r), finite rate of increase (λ) and net reproductive rate (R_0) of sublethal treatments were significantly lower than the control, Moreover mean generation time was significantly increased in control. It is inferred; sublethal concentrations of spinetoram adversely affected the population growth of S. frugiperda in reducing its survival, development, and reproductive capabilities. Such insecticide may help in reducing frequency of insecticidal application and thus reduce related hazards and environmental pollution.

Host specific comparative toxicity studies against whitefly *Bemisia tabaci* using selected safer insecticides*:* Five green label insecticides *viz*. clothianidin 50% WDG, spinetoram 11.7% SC, cyantraniliprole 10.26% OD, azadirachtin 1% EC, novaluron 10% EC and one yellow labelled insecticide (imidacloprid 17.8% SL) as check were assessed on eggs, nymphs and adults using the leaf-dip bioassay. The results revealed that four out of six insecticides show higher LC_{50} values on brinjal compared to those in tomato. It was observed that the test-leaf had no effect on the observed difference between tomato and brinjal population for LC_{50} values. Spinetoram demonstrated promising nymphicidal and adulticidal effects on both hosts. Novaluron, an IGR, was proved effective against nymphal stages, while it was very poor in managing egg and adult stages. The feeding potential (as implicated from honeydew excretion) and reproductive potential (oviposition rate and egg hatchability) were recorded higher on brinjal in comparison to tomato, indicating that brinjal is a more suitable host. The brinjal reared population exhibited higher specific activity of detoxification enzymes, *viz*. Cytochrome P450 monooxygenase, Glutathione S-transferase and Carboxyl-esterase, when compared to the tomato population. It was observed that all the three enzymes under investigation increased with rising insecticide concentration in both hosts. It is inferred that selected green-labelled insecticides are more effective in managing whiteflies as they exhibit superior ovicidal, nymphicidal and adulticidal properties compared to imidacloprid. While spinetoram, clothianidin, and novaluron are not currently registered for the management of whiteflies both in tomato and brinjal, but they show promising nymphicidal and/or adulticidal effects. Henceforth, they may be considered for label claim extension with further field evaluations.

Evaluation of phosphine and carbondioxide toxicity against Drugstore beetle, *Stegobium paniceum* (L.): Through experiments involving different concentrations and exposure durations the research reveals the synergistic effect of combining carbon dioxide and phosphine. The mixture demonstrates significantly increased toxicity compared to phosphine alone, with up to a 6.25-fold increase at 24h exposure, 3 times increase at 48h, and 2 times increase at 72h. Examining four populations from various Indian states, the study finds differences in tolerance levels. The Maharashtra (Kolhapur) population exhibits slightly higher tolerance, with 0.25mg/L, 33.5% and 0.03mg/L on exposure by phosphine, carbon dioxide and the mixture respectively. while other three populations display almost similar LC50 values for all fumigants. Detoxification enzyme activity is also explored in response to fumigant treatments, with phosphine-treated insects showing higher enzyme activity compared to carbon dioxide or phosphine-carbon dioxide combinations.

Evaluation of bioactivities of Carvacrol against pulse beetle, *Callosobruchus maculatus:*
Fumigation toxicity evaluations of carvacrol displayed dose-dependent reactions in both egg and adult stages of *C. maculatus*. The lethal concentration (LC_{50}) against adult in absence of food grains (LC_{50} 1.08 µl/L air) was lower than that with grains (LC_{50} 2.32 µl/L air). In contact toxicity, Carvacrol LC_{50} was 0.8% whereas for deltamethrin 2.5% WP it was 0.0002% for the same 24h exposure. Carvacrol also exhibited oviposition inhibition with ED_{50} values ranging from 0.03 to 0.02 µl/L air for 24-72 hours and ovicidal attributes with an LC_{50} of 3.2- 1.64 µl/L air for 24-72 hours exposure. Exploration of orientation behaviour unveiled carvacrol's repellent influence on *C. maculatus*.

Insecticidal activity of piper (*Piper longum*) essential oil and its extracts: The piper essential oil (*Piper longum*), fruit solvent extracts, and major pure compounds from the fruits of *P. longum* and leaves of *Azadirachta indica* were evaluated for their insecticidal activity against mustard aphid *Lipaphis erysimi*. Laboratory evaluation through leaf dip method revealed piper methanol extract as most effective with LC_{50} value of 67.48ppm followed by piper oil (LC50 97.93 ppm). Piper hexane extract was found to be most effective in pot experiments at 2000ppm concentration. Extracts of *A. indica* did not showed any promising insecticidal activity.

Fumigation and repellent activities of essential oils of *Juniperus macropoda* and *Cedrus deodara*: Essential oil from woods of *C. deodara* and leaves of *J. macropoda* was evaluated fumigation toxicity and repellence activity against *Tribolium castneum* and *Callosobruchus chinensis*. *J. macropoda* oil showed better fumigation toxicity against both insects. The lethal concentrations (LC_{50}) estimated were 16.12 µl/L air for *C. chinensis* adult beetles, 103.08 µl/ L air for *T. castaneum* larvae and 123.08 µl/ L air for *T. castaneum* adult beetles.

Field evaluation of whitefly Attractant trap and nano formulations VOCs against whitefly, *B. tabaci:* Four compounds and one blend showing good attractancy through Y-tube and net bioassay were validated under farmers' fields in Delhi, Rajasthan, Punjab and Haryana along with yellow sticky trap to ascertain their attractancy. Among these, compound 1 was found effective across the crop and locations with 76 to 339 per cent increase in attraction compared to conventional sticky trap. Based on experiments with large scale screening (using bulk populations of whiteflies in Net house &Cage bioassays), two compounds at a concentration of 0.1 % were identified as potential repellents with 74.59 and 69.13 % repellency, respectively. These two synthetic compounds (C1 &C2) were also found effective as ovipositional deterrents as they were showing 67.17 and 64.4 % reduction in oviposition and 76.60 and 74.13 %, reduction in egg hatching respectively.

Lethal and sublethal effects of triflumezopyrim on biological and biochemical parameters of parameters of brown planthopper: The study was undertaken by treating 3rd instar nymphs of brown planthopper (BPH) with LC_{10}, LC_{20}, LC_{30}, LC_{40} an LC_{50} of triflumezopyrim. In comparison with control, there was significant difference in fecundity (146.09±2.73), female longevity (12.34±3.121), and honeydew excretion (172 mm^2) in all treatments other than LC_{10}. There were variations in detoxification enzyme levels when treated with lethal and sublethal concentrations. The biochemical studies also confirmed the role of Cytochrome P450 monoxygenase and Glutathione S transferase in detoxification of Triflumezopyrim in BPH.

Monitoring insecticide resistance in Brown planthopper populations in North India: The brown planthopper populations collected from diffrerent locations from Delhi, Haryana, Uttar Pradesh and Chattisgarh states were evaluated against the recommended insecticides namely, imidacloprid, dinotefuran, pymetrozine, triflumezopyrim and flupyrimin. The results indicated comparatively lower level of susceptibility of Haryana (Bansa) populations to all the insecticides tested. Triflumezopyrim and flupyrimin were found to be best candidate insecticides for managing brown planthopper, with no significant difference between them considering the 95 % fiducial limit of lab reared susceptible population.

Determination of field dose of insecticides against economically important insect pests in rice: Field dose studies of newly registered insecticides against Brown planthopper (BPH) in rice: The efficacy of recently registered insecticides, triflumezopyrim 10 SC and flupyrimin 20 SC were studied against BPH in rice both in laboratory and field. The LC_{50} values of both the compounds were less than 0.1 ppm, showing its high efficacy compared to pymetrozine and dinotefuran. The newly registered compounds also showed high efficacy in half the recommended dose in New Delhi conditions. Control failure likelihood of chlorantraniliprole 18.5 SC (Coragen) against rice leaf folder and stem borer of rice during *Kharif* 2023 were also studied. The recommended dose of active ingredient chlorantraniliprole 18.5 % SC against rice stem borer and leaf folder in rice is 50 g a.i /ha. For both the insects, the recommended dose of the insecticide was lower than the lower threshold of the 95% fiducial interval of the LC_{80} of the insecticide for the tested insect population, indicating control failure of chlorantraniliprole 18.5 SC against rice stem borer and leaf folder populations collected from PUSA campus, New Delhi.

V. Insect Pest Management

Assessment of avoidable yield losses by mustard aphid in rapeseed-mustard: Three mustard genotypes viz., Radhika, Brijraj and PM 30 were grown in eight rows of 5 m row length per replication, and there were four replications in a Completely Randomized Block Design. There were two sets of experiments viz., one protected and another unprotected for each test genotype. The protected sets of experiments were sprayed when aphid population reached economic threshold level. The observations were recorded on number of aphids from (10 cm top twig)/10 plants per replication across the 4 replications before and after insecticide applications. The protected and unprotected trials were harvested and yields were recorded separately for each replication for each test genotype. Two insecticide sprays of Dimethoate 30EC @ 1 ml/lit followed by Imidacloprid 17.8SL @ 0.25 ml/lit water were given in the protected set of genotypes.

Before the insecticide application, the aphid population in protected and unprotected sets of Radhika, Brijraj and PM 30 varieties were 21.3 to 28.8 aphids/plant, 37.5 to 42.1 aphids/plant and 28.8 to 30.0 aphids/plant, respectively. There was significant reduction in numbers of aphids/plant on the test varieties viz., Radhika, Brijraj and PM 30 after both 1st and 2nd insecticide applications. After first insecticide application, there was 87.3, 92.1 and 93.8% reduction in aphid population in Radhika, Brijraj and PM 30, respectively. Before 2nd insecticide application, the aphid population varied from 8.3 to 625.0 aphids/plant, 18.3 to 877.5 aphids/plant and 12.0 to 837.5 aphids/plant in protected and unprotected sets of Radhika, Brijraj and PM 30, respectively. After 2nd insecticide application, there was 72.9, 54.0 and 51.1% reduction in aphid population in Radhika, Brijraj and PM 30, respectively. Yield loss assessment in Radhika, Brijraj and PM 30 revealed significantly higher seed yield and lower aphid population under protected as compared to unprotected conditions. The seed yields under protected condition were 1361.3, 1018.9 and 1100.0 kg/ha, while under unprotected conditions 1092.8, 704.8 and 799.4 kg/ha in Radhika, Brijraj and PM 30, respectively. Need based insecticide application resulted in 19.7%, 30.8% and 27.3% increase in seed yields of Radhika, Brijraj and PM 30, respectively.

Evaluation of rapeseed-mustard genotypes for resistance against mustard aphid, *Lipaphis erysimi*: A total of 193 *Brassica* genotypes comprising of 140 Initial Varietal Trial (IVT) and 53 Advanced Varietal Trial (AVT) 1 & 2 entries were evaluated for resistance to mustard aphid using the standard AICRP-RM aphid testing protocol and parameters, and the data and report were submitted to the AICRP-RM coordinating unit.

Initial varietal trial entries:

i. **At flowering:** There were significant differences among the initial varietal trial (IVT) *Brassica* test entries for aphid damage index, aphid population index, aphid resistance index, and percent plants with aphids at flowering stage of the crop. The aphid damage index, aphid population index, aphid resistance index and percent plants with aphids varied from 1.0 to 2.3, 1.0 to 2.5, 1.0 to 2.4 and 0.0 to 33.3 at flowering across the test genotypes, respectively. The test IVT entries *viz.*, 131 to 135 were recorded with zero percent plants with aphids, while the entries SBG 23-90, SBG 23-138, SBG 23-136, SBG 23-78, SBG 23-05, SBG 23-121, SBG 23-123 to 125, SBG 23-66, SBG 23-84, SBG 23-61, SBG 23-67, SBG 23-137, SBG 23-108, SBG 23-80, SBG 23-06, SBG 23-58, SBG 23-77 and SBG 23-109 with less than 10% plants with aphids.

ii. **At pod formation:** There were significant differences among the test IVT *Brassica* entries for aphid damage index, aphid population index, aphid resistance index and percent plants with aphids at pod formation stage. The aphid damage index, aphid population index, aphid resistance index and percent plants with aphids at pod formation varied from 2.3 to 5.0, 2.3 to 5.0, 2.4 to 5.0 and 45.0 to 100.0%, respectively. The aphid damage index, aphid population index and aphid resistance index were significantly lower (≤ 2.5) in entries SBG 23-71, SBG 23-94 and SBG 23-110 as compared to other test IVT entries.

iii. **Average aphid resistance index:** The differences in average aphid resistance index across different observation stages were significant among the test IVT test entries. Average aphid resistance index among the test genotypes varied from 1.9 to 3.6. The average aphid resistance index in test entries viz., SBG 23-78, SBG 23-80, SBG 23-71 and SBG 23-123 was significantly lower (≤ 2.0) as compared to other test IVT entries.

Advanced varietal trial entries:

i. **At flowering:** There were significant differences among the test advanced varietal trial (AVT 1 and AVT II) entries of *Brassica* for aphid damage index, aphid population index, aphid resistance index and percent plants with aphids at flowering stage of the crop. The aphid damage index, aphid population index and aphid resistance index varied from 1.0 to 2.3, while, percent plants with aphids varied from 6.0 to 37.3% across the test entries at the flowering stage. The test AVT entries viz., SAG 23-16, SAG 23-30, SAG 23-37, SAG 23-40,

SAG 23-46, SAG 23-33, SAG 23-34, SAG 23-45, SAG 23-47, SAG 23-03, SAG 23-28, SAG 23-32 and SAG 23-38 had ≤ 10.0% plants with aphids.

ii. **Evaluation of AVT entries at pod formation:** There were significant differences among the AVT 1 and AVT II entries of *Brassica* for aphid damage index, aphid population index, aphid resistance index and percent plants with aphids at pod formation stage. At pod formation, the aphid damage index, aphid population index, aphid resistance index and percent plants with aphids varied from 1.7 to 5.0, 1.5 to 5.0, 1.6 to 5.0 and 30.0 to 100.0%, respectively (Table 5.1B). Aphid damage index, aphid population index, aphid resistance index and percent plants with aphids were significantly lower in AVT entries viz., SAG 23-12, SAG 23-46, SAG 23-27, SAG 23-06, SAG 23-18, SAG 23-24, SAG 23-26 and SAG 23-40 as compared to other test AVT 1 and AVT II entries at pod formation stage.

iii. **Average aphid resistance index in AVT entries:** The differences for average aphid resistance index across different observation stages were significant among the test AVT 1 and AVT II test entries. Average aphid resistance index among the test AVT entries varied from 1.5 to 3.7. Average aphid resistance index was significantly lower in AVT entries viz., SAG 23-12, SAG 23-46, SAG 23-26 to 23-28, SAG 23-06, SAG 23-40, SAG 23-03, SAG 23-16, SAG 23-18, SAG 23-14, SAG 23-38, SAG 23-24, SAG 23-47 and SAG 23-33 (AARI ≤ 2.4) as compared to other genotypes.

Monitoring the incidence and dynamics of pigeon pea insect pests throughout crop season

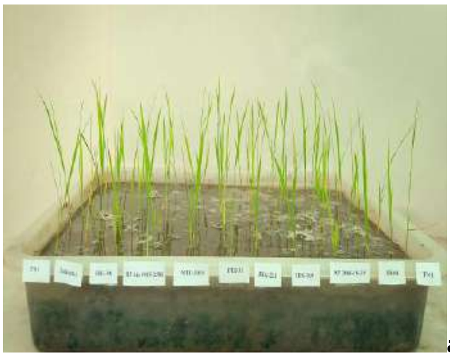
Incidence and Seasonal dynamics of insect pests of pigeon pea: The incidence and seasonal dynamics of pigeon pea insect pests were recorded during *kharif* 2023 at ICAR-IARI, New Delhi. Incidence of Spotted pod borer, *Maruca vitrata* and blister beetle were commenced on 38th SMW (Standard meteorological week). The peak population of *M. vitrata* (35.44 webs/plant) was recorded on 41st SMW whereas for blister beetle (0.67 beetles/plant) it was recorded on 42nd SMW. The population of pod bug and *Helicoverpa armigera* was negligible.

Monitoring of *Helicoverpa armigera* through pheromone traps: The pheromone traps (Funnel traps) @ 4 per acre were installed for monitoring *Helicoverpa armigera*. The trapped adult count was taken at weekly intervals. Pheromone trap catches were started in 35th SMW and maximum catches (10.09 adults/ trap) were recorded during 38nd SMW. The trap catches revealed the significant positive correlation with maximum temperature, minimum temperature and sunshine whereas significant negative correlation with morning relative humidity and wind speed.

Screening of pigeonpea genotypes against major insect pests: Six Early **(131-150 days)** AVT test entries were evaluated for its performance against insect pests. There was significant difference in number of *Maruca* webs/plant among different entries except 38th and 44th SMW. Significantly higher population was observed on all entries during 41st SMW except entry 106. Similarly, significant difference in blister beetle population was observed in all SMW's. The population of pod bug and *Helicoverpa armigera* was negligible. Total pod damage (post-harvest) due to *Maruca* and pod fly was found to be higher in 101 (29.98%) whereas 104 was found to be less susceptible (18.31%).

Development and commercialization of Pusa MeFly Kit: Methyl Eugenol based Kit 'Pusa MeFly Kit' was developed for fruit fly management. It is a low cost, do-it-yourself, easy to use, ecofriendly, kairomone based kit for fruit crops.

Host plant resistance studies in rice against Brown planthopper, *Nilaparvata lugens:* This study aimed to assess the resistance of eight diverse rice germplasm, including RP 2068-18-3-5, RP bio 4918-230S, Salkathi, IRG-309, IRG-221, IRG-98, IR-64, and MTU-1010 against BPH, keeping PTB 33 and TN-1 as resistant and susceptible check respectively (Fig. 20a). Among the tested varieties, RP 2068-18-3-5, and Salkathi showed the least damage, on par with the resistant check PTB 33, indicating high resistance to BPH. The resistant rice varieties showed higher nymphal settlement, feeding marks, and unhatched eggs by BPH compared to susceptible varieties (Fig. 20b). However, susceptible varieties exhibited higher honeydew production and fecundity by BPH. IRG-98 had the highest number of feeding marks (36.80±0.86), lowest number of nymphal emergences (32.40±4.83) and a greater number of unhatched eggs (95.40±4.07). Biochemical analysis demonstrated an increased superoxide dismutase (SOD) activity in all germplasm after BPH feeding, over 96 hours. At 96 hours, PTB 33 showed the highest SOD activity, followed by Salkathi and RP 2068-18-3-5 with no significant differences. Catalase (CAT) activity was lowest in resistant germplasm initially, while TN-1 consistently showed an increased CAT activity. Peroxidase (POD) and polyphenol oxidase (PPO) activities varied among germplasm, with IRG-98 followed by PTB-33 showing sustained increase up to 96 hours. RP 2068-18-3-5, Salkathi, and PTB 33 exhibited effective resistance against BPH. The study revealed RP 2068-18-3-5, IRG-98, and Salkathi as better germplasm on par with the resistant check.


a


b

Fig. 20a. Modified seedbox scoring of test genotype; 20b. Oviposition studies

Assessing Brown planthopper (BPH) damage by using hyperspectral remote sensing: Hyperspectral remote sensing study through glasshouse experiments during *Kharif* 2022 in three rice varieties, Pusa 1509, Pusa 1121 and TN 1, revealed that brown planthopper (BPH), *Nilaparvata lugens* infested plants to have higher reflectance in the visible (VIS) region and lower reflectance in the near-infrared (NIR) region in comparison to uninfested plants. Correlation coefficients (r) estimation between rice plant reflectance and number of BPH/tiller resulted in the identification of sensitive bands for all rice varieties at 20 and 40 days after infestation with BPH. Based on rice plant reflectance values corresponding to the sensitive wavelengths from glasshouse experiments, the BPH damage depicted a positive relationship with five spectral indices, *viz*., SIPI (Structure-insensitive pigment index), PSND CHL B (Pigment Specific Normalized Difference for Chlorophyll B), AIR1 (Anthocyanin Reflectance Index 1), PSSR A (Pigment Specific Simple Ratio for Chlorophyll A), and PSSR B (Pigment Specific Simple Ratio for Chlorophyll B). The Red edge value (REV) which is a highly sensitive wavelength region from 670-770 nm showed a high correlation with BPH severity in all the varieties studied (Fig. 21). Different biochemical parameters such as chlorophyll, carotenoid, protein, flavonoid, and relative water content were also estimated at a differential infestation of BPH in all varieties. The data generated were used for developing different models *viz.,* spectral data vs population model, spectral data Vs biochemical parameter model, and vegetative indices vs population severity models for predicting BPH severity. The Partial Least Square Regression (PLSR) models were satisfactorily validated using the spectral and biochemical data collected from the field. These models developed through the study can facilitate the assessment of BPH severity and change in biochemical parameters using spectral signatures.

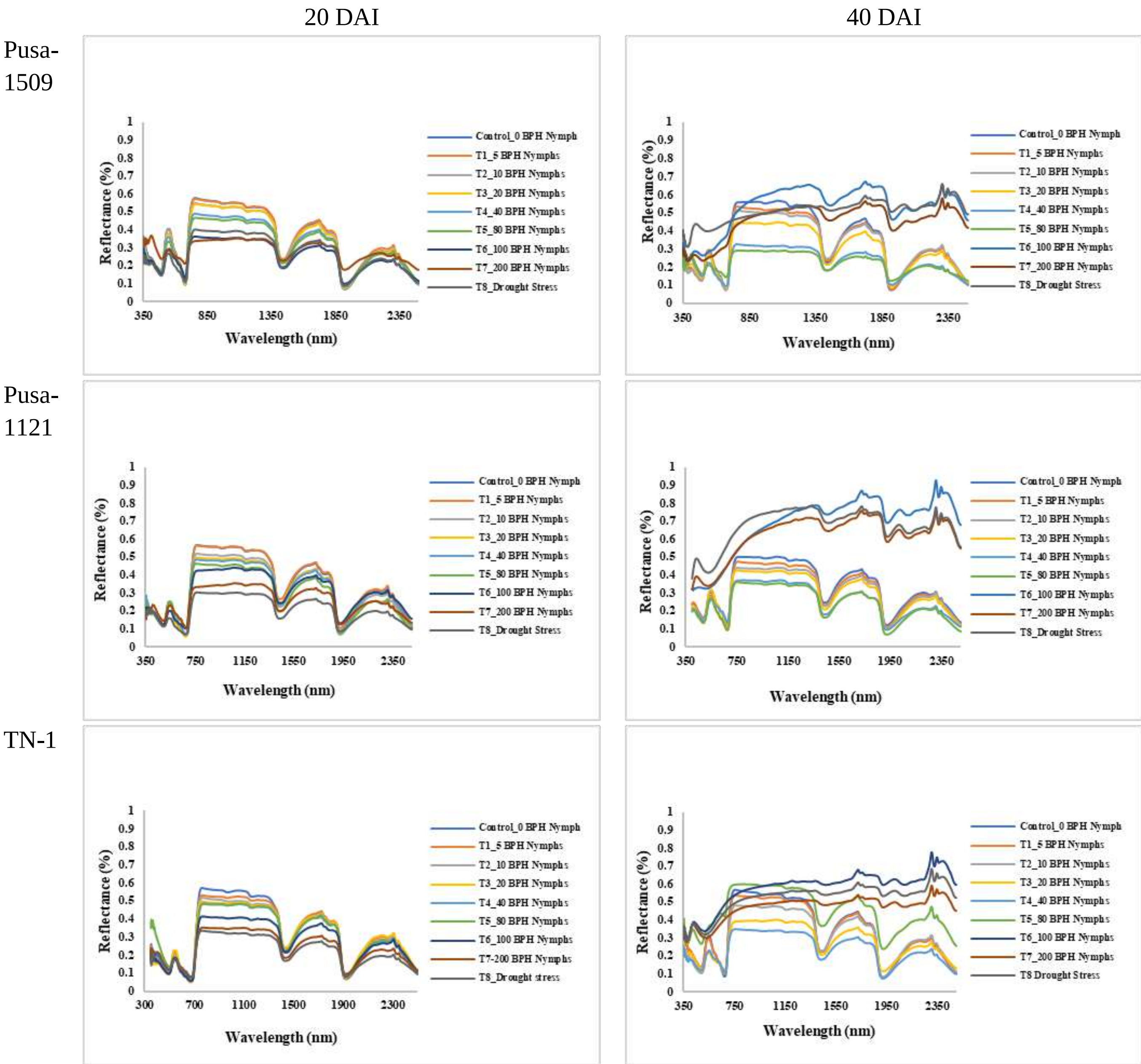


Fig. 21. Reflectance spectra of rice plants at different wavelengths in relation to variable BPH infestation in pot experiment for 20 and 40 Days after infestation (DAI)

Development and validation of predictive regression model for Brown planthopper damage in rice: A weather-based forecasting model was developed for predicting brown planthopper (BPH) infestation for three different transplanting dates *viz.*, early, normal and late. The field data spanning from 2017 to 2021 were utilized for the model development and was validated during the years 2022 and 2023.The results indicated that for early transplanted rice, there was a significant negative correlation with BPH infestation and minimum temperature (r=-0.462) as well as evening relative humidity (-0.387). Conversely, a significant positive correlation was observed with total sunshine hours (r=0.447). For normal transplanted rice, BPH population was significantly negatively correlated with minimum temperature (r=-0.526), evening relative humidity (r=-0.559) and rainfall (r=-0.411) while it was significantly positively correlated with sunshine hours (r=0.390). A significant positive correlation was observed between BPH population and sunshine hours (r = 0.355) in late transplanted crops. The models developed from the data for five years with three different transplanting dates at 15-day interval were validated well for two years, 2022 and 2023, especially for normal transplanting.

3. **Technologies and IP:** Copyrights, patents, Germplasm registrations, Technology Transfer, details of Seeds/planting material supplied, please indicate clearly if your division is the Lead developer/co-developer.

S.No.	Name of the Technology	Brief of the technology	TRL Level	Road map/ Time line for commercialization
	LEAD DEVELOPERS			
1.	Yield loss, economics and management of *Lipaphis erysimi* in Indian mustard	This technology depicts that control of aphids prevent 10.2 to 61.1% yield loss in Indian mustard. The alternate use of *B. bassiana* @ 2 g/l, dimethoate 30 EC @ 1 ml/l, imidacloprid 17.8 SL @ 0.25 ml/l, or thiomethoxam 25 WG @ 0.2 g/l water based on the extent of aphid population effectively manages *L. erysimi* in *B. juncea*. This technology has strengthened decision support for effective management of *L. erysimi*, and sustainable rapeseed-mustard production.	The technology has been approved by the ITMC, dated 24.03.2024 for commercialization & submitted for ICAR Certification	The technology is recommended to manage the aphids in *Brassica juncea* and prevent the yield losses, decision-support based insecticide application thus reduce insecticide cost and effects on natural enemies and pollinators
2.	**Pusa CueFly Kit:** A low cost, do-it-yourself, easy to use, ecofriendly, kairomone based fruit fly management kit for cucurbit crops	The demand of low-cost, efficient, environmentally safe, and user-friendly pest management technologies is increasing in India as a result of growing awareness about environmental impact of pesticides, lowering the cost of crop cultivation, and increase the farm income. The "Pusa CueFly Kit" technology is environmentally safe, involves no maintenance	The technology has been approved by the ITMC, dated 22.03.2024 for commercialization	The efforts will be made for the commercialization of this technology & subsequently submitted for ICAR Certification

		cost and user friendly.		
3.	Mustard Variety: **Pusa Double Zero Mustard 35**	Indian mustard Variety with low erucic acid and low total glucosinolates matures in ~132 days and its with average seed yield of 2148kg/ha.	Released for commercial cultivation in Zone-II [Notified by CVRC: Notification No. S.O. 1560(E) dated 26.03.2024]	Plants to progenies are raised for seed multiplication at ICAR-IARI, RS, Karnal
4.	Mustard Variety: **Pusa Double Zero Mustard 36**	Indian mustard Variety with low erucic acid and low total glucosinolates matures in ~131 days and its with average seed yield of 2049kg/ha.	Released for commercial cultivation in Zone-II [Notified by CVRC: Notification No. S.O. 1560(E) dated 26.03.2024]	Plants to progenies are raised for seed multiplication at ICAR-IARI, RS, Karnal
5.	Maize Hybrid: **Pusa Jawahar Hybrid Maize-2**	Maturity: Medium Suitability: *kharif* season, Area Adaptation: Madhya Pradesh state Identified by: SVRC Special feature: Kernels are Flint, Bold seed, orange color Specific gravity is 1.3 Oil content- 3.4% Protein content- 9.8% Stay Green Character Average grain yield: **8000** kg/ha Potential grain yield: **11398** Kg/ha.	Notified by CVRC [Notification No. G.No.4054 S.O 4222(E): 29, dated 25.09.2023]	Seed multiplication is in progress
6.	Maize Hybrid: **Pusa Early Hybrid Maize-6**	Suitable for: Kharif condition, CWZ Maturity: Early Moderate resistant reaction to TLB and MLB Average grain yield: 8.18 t/ha	Identified for release in the Central Zone	Seed multiplication is in progress
7.	Maize Hybrid: **Pusa Composite -5**	Suitable for: Kharif condition, CWZ Suitable for: Kharif	Identified for release in the Northern Hill	Seed multiplication is in progress

		Maturity: Early Moderate resistant to TLB Average grain yield: 7.0 t/ha	zone	
8.	Maize Hybrid: **Pusa Jawahar Hybrid Maize (R)-3**	Suitable for: Rabi season, MP Yield potential: 8-9 t/ha Maturity: Medium Resistant to FSR, moderately resistant to TLB and MLB	Identified for release in Madhya Pradesh state	Seed multiplication is in progress
9.	Maize Hybrid: **Pusa Shalimar Maize Hybrid-1**	Suitable for: Mid Altitudes areas of Jammu & Kashmir between 1550-1850 m MSL (irrigated/rainfed) Average yield: 6.5t/ha	Identified for release in Srinagar state	Seed multiplication is in progress
10.	Pigeon pea Hybrid: PAH 5	Short duration (140 days maturity) CGMS based 1st Pigeon pea Hybrid of ICAR-IARI, New Delhi	-	Released for cultivation in SVRC (Delhi State Release) (Notification: CG-DL-E-28032024-253429 dated 27-03-2024)
11.	Pusa Whitefly Attractant	• A novel Attractant trap has been developed for the management of whitefly, *B. tabaci*. • Thid attractant lure showed 66-200 % increased attractancy over conventional yellow sticky traps.	TRL 9	• Technology approved by ZTM for commercialization • Ready for commercialization • Three firms have evinced interest in commercialization of this technology
12.	Repellent formulation for whitefly management	A novel formulation to repel the whiteflies in crops	TRL 7	Identified candidate repellents/ovipositional deterrents (2No.) against whitefly *B. tabaci* Improved delivery mechanisms are to be through PPP mode.
13.	Ovipositional deterrent	A novel formulation to deter the egg laying of the whiteflies in crops	TRL 7	Identified an effective Ovipositional Deterrent against whitefly, *B. tabaci* It is proposed to develop a suitable

				formulation (Slow Release/ Gel) of this ovi-deterrent through PPP mode.
14.	A new species and new record of the genus *Pexicopia* (Lepidoptera: Gelechiidae) feeding on *Abutilon indicum* from India	A new species, *Pexicopia tungabhadrai* sp. nov. (Lepidoptera: Gelechiidae), feeding on *Abutilon indicum* is described herein from Karnataka, India.	T1 (Knowledge generation)	NA
15.	New species and new records	Discovery of a new species and six new records of subfamily Olethreutinae (Lepidoptera: Tortricidae) from India: The genus *Theorica* Diakonoff, 1966 is reported for the first time from India with the description of a new species *Theorica malnadense* Reddy and Shashank sp. nov. Six species namely, *Gatesclarkeana idia* Diakonoff, 1973, *Endothenia stibara* Razowski and Wojtusiak, 2012, *Olethreutes cerographa* (Meyrick, 1907), *Tetramoera isogramma* (Meyrick, 1908), *Fulcrifera boavistae* Razowski, 2015, and *Pammene peristictis* Meyrick, 1912, are recorded for the first time from India.	T1 (Knowledge generation)	NA
16.	New genome data	**Whole genome sequencing of invasive pest, *Phthorimaea absoluta*:** The long read whole genome sequencing of *P. absoluta*	T1 (Knowledge generation)	NA

		has been attempted for the first time with 25X coverage and will be useful genomic information to identify and elucidate genes responsible for various biological and physiological functions, and open new avenues for developing alternate techniques for the management of this pest. BioProject: PRJNA932016 BioSample: SAMN33142568 Accession: JARADA000000000.1		
17.	New genome data	**Whole genome sequencing of *Scrobipalpa atriplicella:*** The long read whole genome sequencing of *S. atriplicella* has been attempted for the first time with 37X coverage and will be useful genomic information to identify and elucidate genes responsible for various biological and physiological functions, and open new avenues for developing alternate techniques for the management of this pest. BioProject: PRJNA932016 BioSample: SAMN33142570 Accession: JARACY010000000	T1 (Knowledge generation)	NA
18.	New genome data	**Whole genome sequencing of *Keiferia lycopersicella:*** The long read whole genome sequencing of *K.*	T1 (Knowledge generation)	NA

		lycopersicella has been attempted for the first time with 10X coverage and will be useful genomic information to identify and elucidate genes responsible for various biological and physiological functions, and open new avenues for developing alternate techniques for the management of this pest. BioProject: PRJNA932016 BioSample: SAMN33142569 Accession: JARACZ010000000		
19.	More than 75 DNA barcodes for insects generated and deposited in public database	Most depositions are new to the database. Open access	T1 (Knowledge generation)	NA
20.	New species described	Four	T1 (Knowledge generation)	NA
21.	Zoobank Ids generated for the new species described	Four	T1 (Knowledge generation)	NA

4. Linkages and Collaboration

Intra-Institutional Collaborations: The Division actively collaborates across other divisions within the institute, including Plant Pathology, Genetics, Agricultural Chemicals, Microbiology, Plant Physiology, Nematology, and Agricultural Physics. These collaborations drive various in-house projects, externally funded initiatives, and flagship programs, ensuring a multidisciplinary approach to agricultural research and innovation.

Collaborations with Other Organizations and Institutes: The Division is engaged in numerous collaborative efforts with prominent organizations. A key project under the ICAR-NASF initiative, titled "Identification and Validation of Newer Approaches for the Management of Whitefly (*Bemisia tabaci*) (Hemiptera: Aleyrodidae)," is being conducted in collaboration with ICAR-NBAIR, ICAR-IIHR, and PAU, Ludhiana. Other significant projects include DST-SERB-funded studies on "Thermal Stress Vis-à-vis Reproductive Physiology in Invasive Fall Armyworm (*Spodoptera frugiperda*)" and "Taxonomic Studies of the Family Elateridae from North Eastern India (Coleoptera: Elateridae)." Additionally, the National Bee Board under NBHM, Ministry of Agriculture and Farmers Welfare, supports a project on “Exploration of Gut Microbiome for Sustainable Beekeeping.” Research collaborations also extend to institutions like ICAR-NIPB, ICAR-IASRI, ICAR-NBPGR, and ICAR-NCIPM, promoting synergistic research endeavors.

Industry Collaborations: The Division maintains strong partnerships with industry leaders, including Corteva Agrosciences, PI Industries, and UPL Ltd., through contract research programs. Notable projects include “Bio-efficacy of GF-4867 RB Formulation Against Fall Armyworm (*Spodoptera frugiperda*) in Maize,” “Baseline Study of PII 8007 20% SC Against Brinjal Shoot and Fruit Borer (*Leucinodes orbonalis*) and Fall Armyworm (*Spodoptera frugiperda*),” and “Baseline Sensitivity of Flupryrimin 10% SC Against Brown Planthoppers (*Nilaparvata lugens*) and White-Backed Planthoppers (Sogatella furciferra) in Paddy”, respectively.

5. Education

a) Summary of UG, PG education:

S. No	Course No.	Title of the Course	Credit hours	Semester
		M Sc Courses		
1.	ENT501*	Insect Morphology	2+1	I
2.	ENT502*	Insect Anatomy and Physiology	2+1	I
3.	ENT503*	Insect Taxonomy	2+1	I
4.	ENT505*	Biological control of insect pests and weeds	2+1	I
5.	ENT509*	Pests of field crops	2+1	I
6.	ENT511*	Post-Harvest Entomology	1+1	I
7.	ENT515	Techniques in plant protection	0+1	I
8.	ENT516	Apiculture	2+1	I
9.	ENT517	Sericulture	2+1	I
10.	ENT518	Lac culture	2+1	I
11.	ENT520	Plant quarantine, biosafety and biosecurity	2+0	I
12.	ENT521	Edible and therapeutic insects	1+1	I
13.	ENT522	Medical and Veterinary Entomology	1+1	I
14.	ENT523	Forest Entomology	1+1	I
15	ENT504*	Insect Ecology	2+1	II
16	ENT506*	Toxicology of Insecticides	2+1	II
17	ENT507*	Host Plant Resistance	1+1	II

18	ENT508*	Concepts of Integrated Pest Management	2+0	II
19	ENT510*	Pests of Horticulture and Plantation Crops	2+1	II
20	ENT512	Insect Vectors of Plant Pathogens	2+1	II
21	ENT513	Principles of Acarology	2+1	II
22	ENT514	Vertebrate Pest Management	2+1	II
23	ENT519	Molecular Approaches In Entomology	2+1	II
24	ENT524	Masters Seminar	0+1	II
PhD Courses				
16.	ENT601**	Insect Phylogeny and Systematics	1+2	I
17.	ENT603**	Insect Ecology and Diversity	2+1	I
18.	ENT604	Insect Behaviour	1+1	I
19.	ENT606**	Insect Toxicology and Residues	2+1	I
20.	ENT607	Plant Resistance to Insects	1+1	I
	ENT609	Acarology	1+1	I
21.	ENT609	Molecular Entomology	1+1	I
23.	ENT610	Integrated Pest Management	2+0	I
24.	ENT691	Doctoral Seminar	0+1	I
25.	ENT 602**	Insect Physiology and Nutrition	2+1	II
26.	ENT 605**	Bio inputs for Pest Management	2+1	II
27.	ENT 692	Doctoral seminar	0+1	II

b) No. of students admitted:

MSc- 10; Ph.D-13

c) Fellowships secured by the students (other than IARI Fellowship)

S.No.	Name of the student	Name of the Fellowship	Funding Agency
1	Ranjitha SM	ICAR-SRF	ICAR
2	Preeti Sharma	ICAR-SRF	ICAR
3	Rakesh V	DST-INSPIRE	DST
4	Tulasi B	ICAR-SRF	ICAR
5	Samreen	ICAR-SRF	ICAR

6	Sake Manideep	ICAR-SRF	ICAR
7	Marella Sain Manoj	ICAR-SRF	ICAR
8	Gouranga Saw	ICAR-SRF	ICAR
9	Sudipa Das	ICAR-SRF	ICAR
10	Keerthika	ICAR-SRF	ICAR
11	E Vidya Madhuri	ICAR-SRF	ICAR
12	Jagdam Sai Rupali	ICAR-SRF	ICAR
13	Arindam Kumar	ICAR-JRF	ICAR
14	Sourav Chakrabarty	ICAR-JRF	ICAR
15	K Anil Kumar	ICAR-JRF	ICAR
16	Rittik Sarkar	ICAR-JRF	ICAR
17	Prajwal G	ICAR-JRF	ICAR
18	Yuvaraj HM	ICAR-JRF	ICAR
19	Tanusree Ghosh	ICAR-JRF	ICAR
20	Divyashree KM	ICAR-JRF	ICAR
21	Bishal Sarkar	ICAR-JRF	ICAR
22	Bibek Mandal	ICAR-JRF	ICAR
23	Nandhini D	DST-INSPIRE	DST

d) Students awarded with degrees during 2023

Sl No	**M.Sc./Ph.D.**	**Name of the student & Roll No.**	**Chairperson**	**Title of the thesis**
1.	Ph.D	Rajgopal N.N. Roll No.: 10791	Dr Debjani Dey	Biosystematic studies of leafhopper tribe Scaphoideini (Hemiptera: Cicadellidae: Deltocephalinae)
2.	Ph.D	Satyapriya Singh Roll No. 10797	Dr S. Subramanian	Biochemical Characterization of Phosphine Resistance in *Tribolium castaneum* (Herbst)
3.	Ph.D	Venkatesh Y.N. Roll No. 10921	Dr Subhash Chander	Quantification of wheat aphid (*Rhopalosiphum padi* L.) damage through simulation and spectral signatures
4.	Ph.D	Nikhil Raj Roll No. 11019	Dr G. K. Mahapatro	Temperature-toxicity relationship 6studies of label c7laim insecticides against whitefly, *Bemisia tabaci* (Gennadius) in tomato (*Solanum lycopersicum* Mill)
5.	Ph.D	Ranjith H V Roll No.11235	Dr S. Subramanian	Molecular characterization and dynamics of certain enzymes in DLD multi-enzyme complex in lesser grain borer, *Rhyzopertha dominica*

6.	Ph.D	Arya P S Roll No. 11237	Dr Subhash Chander	Effect of Crop Phenology and Climate Change on Rice Leaf Folder (*Cnaphalocrocis medinalis* G.) incidence
7.	Ph.D	Gopalakrishnan R Roll No.11244	Dr Vinay K. Kalia	Development of cost effective bio-insecticide based on potential native *Bacillus* spp. against fall armyworm *Spodoptera frugiperda* (J. E. Smith)
8.	Ph.D	Anand Harshana Roll No.:11366	Dr Debjani Dey	Biosystematic studies on Ants (Hymenoptera)
9.	Ph.D	Jadhav Mahesh Mahadev Roll No. 11476	Dr Subhash Chander	Assessment of crop losses due to multiple pests and development of decision support tools in Wheat
10.	Ph.D	Santhosh Naik G. Roll No. 11479	Dr P.R. Shashank	Taxonomic studies on Superfamily Tortricoidea (Lepidoptera)
11.	Ph.D	Ashok Kumar Sau Roll No.	Dr M.K. Dhillon	Biochemical studies on hibernation in *Chilo partellus* (Swinhoe)
12.	Ph.D	Karshnal J. Roll No.11484	Dr Vinay K. Kalia	Colonization of Entomopathogenic bacteria in maize plant and their efficacy against fall armyworm, *Spodoptera frugiperda* (J.E. Smith), (Lepidoptera: Noctuidae)
13.	Ph.D	Anil Kumar S.T. Roll No.11486	Dr G. K. Mahapatro	Host specific comparative toxicity studies in whitefly *Bemisia tabaci* (Gennadius) against selected safer insecticides
14.	Ph.D	K. Chandrakumara Roll No.11759	Dr M. K. Dhillon	Elucidating biological and biochemical interaction between popular cultivars of Brassica juncea (L.) Czern & Cross. and Lipaphis erysimi (Kaltenbach)
15.	Ph.D	Hager Moustafa Mahmmoud Saleh Roll No.11925	Dr Debjani Dey	Biosystematic studies on hymenopterous parasitoids associated with insect pests of vegetables ecosystem
16.	M.Sc.	Asmita Das Roll No.21631	Dr S. M. Nebapure	“Bio-efficacy of carvacrol and underlying enzymatic activity for the management of pulse beetle, *Callosobruchus maculatus*”
17.	M.Sc.	Jessa Joseph Roll No.21632	Dr S. M. Nebapure	Toxicity of phosphine and carbon dioxide against Drugstore beetle, *Stegobium paniceum* (L.)”
18.	M.Sc.	Darshana Brahma Roll No.21633	Dr Subhash Chander	Investigations on host plant resistance against brown

				planthopper, *Nilaparvata lugens* (Stal).
19.	M.Sc.	Elika Pavan Venkata Kumar Roll No. 21634	Dr Kumaranag	Quantification of the role of insect pollination on yield parameters of bottle gourd, *Lagenaria siceraria* (Molina) Standly.
20.	M.Sc.	Eere Vidya Madhuri Roll No.21635	Dr Subhash Chander	Assessing Brown planthopper damage by using hyperspectral remote sensing
21.	M.Sc.	Jagadam Sai Rupali Roll No 21636.	Dr Sagar D.	Studies on post mating transcriptional changes in female moths of fall army worm, *Spodoptera frugiperda* (J.E. Smith)
22.	M.Sc.	Aashique Poon V.S. Roll no 21637	Dr P.R. Shashank	Taxonomic studies of the family Tortricidae (Lepidoptera: Tortricoidea) of northern Kerala
23.	M.Sc.	Arbud Lala Roll No.60100	Dr Jaipal Singh Choudhary	Population dynamics and bio-intensive management of insect pest complex in high-density mango orchards
24.	M.Sc.	Kiran Kumar H. Roll No.60101	Dr. Jaipal Singh Choudhary	Allelochemical and antixenotic resistance traits of litchi fruits against *Conopomorpha* spp. complex
25.	M.Sc.	Gouranga Saw Roll No.80012	Dr R.K. Murali Baskaran	Studies on Silicon mediated management of insect pests of black gram (*Vigna mungo* L.)
26.	M.Sc.	Marella Sai Manoj Roll No.80013	Dr K.C. Sharma	Studies on seasonal incidence and management of Fall armyworm, Spodoptera frugiperda (J. E. Smith) in Chhattisgarh plains
27.	M.Sc.	Archita Das Roll No.80014	Dr. Sridhar	Genotypic Characterization and population dynamics of *Bemisia tabaci* in vegetable crops in Chhattisgarh
28.	M.Sc.	Malawanthkar Rani Roll No. 80015	Dr K.C. Sharma	Studies on exogenous application of chemical elicitors for management of Lepidoptera pests of wheat and chickpea

e) **Research Scholars registered in different universities for Ph.D.**

S.No.	Name of the research scholar	Name of the Principal Investigator	Title of the Thesis	University at which registered
1	Jyoti Falswal	Dr Debjani Dey	Taxonomic studies on sweat bees (Hymenoptera: Apoidea: Halictidae) of North India	Delhi University

f) **Awards and Recognitions received by the students**

S.No.	Name of the student	Awards
1	Ranjitha S M	• Regional Champion in National Quiz contest at CFTRI, Mysore
2	Gouranga Saw	• Best Post Graduate Thesis Award at Third Biotic Science Congress (2023)
3	Keerthika N	• Best Poster Presentation in International Conference on Biotic and Abiotic stress of crop plants-2023
4	E Vidya Maduri	• Best Thesis Award in International Conference-2023 • Best oral presentation during Entomology Student Conclave-2024
5	Jagdam Sai Rupali	• NABARD-Professor VL Chopra Gold Medal- 2023 • Best Student of the Year-2023 during 62nd Convocation-2024
6	Nandhini D	• Entomology Students' Conclave ESC2024 -Best Oral Presentation
7	K. Chandrakumara	• Guruprasad Pradhan Gold Medal as Best PhD Student of the Division of Entomology
8	Neelakantaa Raja Rushi	• Entomology Students' Conclave ESC2024 -Best Oral Presentation
9	Jarpla Monika	• Entomology Students' Conclave ESC2024 -Best Oral Presentation

5. Awards and Recognitions received by the Scientists

Category wise

a) Fellowship of Professional societies of the relevant Discipline

S. No.	Name of the Scientist	Fellowship/ Associateship	Name of the Academy
1	Dr. M.K. Dhillon	Fellow	Royal Entomological Society, London, UK
2	Dr. S. Subramanian	Fellow	National Environment Science, India
3	Dr. S. Subramanian	Fellow	Plant Protection Association of India, India

b) Best Poster awards

S. No.	Detail of the poster (all authors, title)	Presented in	First/second/third
1	Dr. M.K Dhillon: India on “Millets for Food Security: Sustainable Resilience to Climate Change, Pests and Diseases”	Joint International Conference organized by CIMMYT, Mexico and Aligarh Muslim University, during 21-22 February, 2024 at Department of Plant Protection, Faculty of Agricultural Sciences, AMU, Aligarh, UP.	**First**

c) Other awards/recognitions

- Dr. M. K. Dhillon: Elected as Vice-President (Ex-Officio), Entomological Society of India, ICAR-IARI, New Delhi
- Dr. M. K. Dhillon: Member - Research Advisory Committee (RAC), Central Tassar Research and Training Institute (CTR&TI), Ranchi, Jharkhand
- Dr. M.K.Dhillon : Member - Technical Advisory Committee (TAC) on Vector Borne Diseases, Department of Health & Family Welfare, Ministry of Health & Family Welfare, Govt of India, New Delhi
- Dr. M.K. Dhillon : Best Poster Award (First): In Joint International Conference organized by CIMMYT, Mexico and Aligarh Muslim University, India on “Millets for Food Security: Sustainable Resilience to Climate Change, Pests and Diseases” during 21-22 February, 2024 at Department of Plant Protection, Faculty of Agricultural Sciences, AMU, Aligarh, UP.
- Dr. M.K. Dhillon: Member NAAS Journal Score Committee: Quantitative and qualitative assessment of non-IF Journals of Crop Protection done for assigning NAAS rating.
- Dr. G.K. Mahapatro: Elected as Vice President, IARI Alumini Association (IAA, 2024-26).
- Dr. G.K. Mahapatro: Best Oral presentation: Nikhil Kumar and GK Mahapatro (2023). In the DST-SERB sponsored National Symposium on "*Crop Health Management: Safeguarding Crop through Diagnostics and Innovations*", ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand, September 29-30, 2023
- Best oral presentation: Jarpla M., Nebapure S.M. and Rajna S. (2024). Factors influencing resistance of pigeon pea seeds against pulse beetle, *Callosobruchus chinensis* Linnaeus: A comprehensive study. In: 1st Entomology Students Conclave, 21st-23rd February 2024, UAS, GKVK, Bengaluru.
- Best oral presentation: Rajarushi, C. N., Nebapure, S. M., Rajna, S. and Subramanian, S. (2024). Contact toxicity of insecticides against Rice weevil, *Sitophilus oryzae* (Linnaeus) and underlying enzyme activity. In: 1st Entomology Students Conclave, 21st- Key Note Speaker, 6th International Conference on Advances in Agriculture Technology & Allied Sciences (ICAATAS 2023), Organised by SARSD, New Delhi & Loyala Academy, Secunderabad, Telengana (Hybrid mode, June 19- 21, 2023).

- Best oral presentation: Rajarushi, C. N., Nebapure, S. M., Rajna, S. and Subramanian, S. (2024). Contact toxicity of insecticides against Rice weevil, *Sitophilus oryzae* (Linnaeus) and underlying enzyme activity. In: 1^{st} Entomology Students Conclave, 21^{st}-23^{rd} February 2024, UAS, GKVK, Bengaluru.
- Dr Nithya C: Received Innovative Article Award for the article entitled "Modern approaches for management of fall armyworm (*Spodoptera frugiperda*)" from Trends in Agricultural Sciences (ISSN: 2583-7850) on October, 2023.
- Best Oral presentation: Nandhini D, Shashank P R, Reddy K M and Joshi R. (2024). Indian Gelechiidae (Lepidoptera: Gelechioidea): A taxonomic catalogue. *Entomology Students' Conclave ESC2024*, pp. 3. Bangalore.
- Dr. Nebapure S.M. conferred with ESI-Young Entomologist Award-2022 by Entomological Society of India, New Delhi
- Dr. Shashank P.R. was the Organizing secretary for First Entomology Student conclave ESC2024 held at UAS, Bengaluru from Feb 21- 23, 2024.
- Dr. Shashank P.R. awarded SERB International Travel Support (ITS) for attending 23rd European Congress of Lepidopterology & 11th Forum Herbulot 2023 on "Conservation, Ecology and Systematics of Lepidoptera in a changing world" in Orleans, France.
- Dr Rajna S was awarded Best oral presentation award on DST-SERB sponsored National Symposium on Crop Health Management: Safeguarding Crop through Diagnostics and Innovations On 29-30 September, 2023 Organized by ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora-263 601, Uttarakhand.

6. Budget Estimates

a) Head-wise budget received and expenditure under EFC

S.No.	Head	Allocation for 2023-24	Expenditure
1	**Research & Operational**		
i.	Research	25.66159	25.85059
ii.	Operational	0.18900	
2	**Infrastructure**		
i.	Security /Electricity/Water		
3	**Administrative Expenditure**		
i.	Communication		
ii.	Office Building		
iii.	Residential Building		
iv.	Minor Works	8.93821	8.93821
v.	Equipment/Vehicle etc		
vi.	Others (excluding TA)	12.78242	12.78242
4	**Miscellaneous**	8.09675	8.09675
i.	HRD	0.53	0.53
ii.	Pub. & Exhibition		

iii.	Guest house maintenance		
iv.	Misc.		
	Total (1+2+3+4)	56.19797	56.19797

b) Budget received from external grant

S.No.	Project Code	Project Title	Name of PI's	Name of Co-PIs	Project Duration		Sanction Budget	Total Grant Received 2023	Institutional Charges 2023-24
1	20-62	Identification and validation of newer approaches for the management of whitefly *Bemisia tabaci* (Hemipters: Aleyrodidae)	Dr. S. Subramanian	Dr. Suresh M. Nebapure	2020	2024	40.36	6.33	0.06
2	24-772	Exploration of gut microbiome for sustainable beekeeping in India	Dr. S. Subramanian	Dr. Sachin S Suroshe	2021	2024	134.21	13.00	nil
3	28-15	Studies on thermal stress Vis-à-vis reproductive physiology in invasive fall army worm, *Spodoptera frugiperda*	Dr. Sagar D	Dr. S. Subramanian	2022	2025	36.32	9.00	0.93
4	28-14	Taxonomic studies of family Elateridae from North Eastern India (Coleoptera: Elateridae)	Dr. Nithya Chandran	Dr. Shashank P R	2022	2025	42.13	8.00	1.04
5	79-161	Bio-efficacy of GF-4867 RB formulation against fall armyworm, *Spodoptera frugiperda* in maize	Dr. Suresh M. Nebapure	Dr. M.K. Dhillon	2022	2025	14.60	14.60	1.89
6	79-163	Baseline study of PII 8007 20%SC against brinjal shoot & Fruit Borer, *Leucinodes*	Dr. Suresh M. Nebapure	Dr. Rajna S	2022	2025	14.84	14.84	2.03

		orbonalis & Fall Armyworm, Spodoptera							
7	79-154	Baseline sensitivity of flupryrimin 10%SC against Brown planthoppers (*Nilaparvata lugens*-BHP) and white baked planthoppers (*Sogatella furciferra*-WBPH) in paddy	Dr. Rajna S.	Dr. Debjani Dey	2023	2024	16.28	16.28	1.14

c) Copus Fund allocated: 10 Lakhs
d) Total Budget: 148.24797 Lakhs
e) Revenue generated: Rs. 7.86 Lakhs

7. **PUBLICATIONS**

Only the publications from the Division should be listed. Papers from the Division as First author, corresponding author in papers from IARI. **In collaborative publications from other Institutes -** *where authorship is given to one or more authors from IARI in a paper published by other organization (e.g. DU, JNU, PAU, MoA, NPL, IFPRI, IRRI, IOWA, etc.),* ***the first author amongst all from IARI****, mentioned in the paper may be considered for reporting*)

1. Publications from the Division as first author or corresponding author

S. No.	**Publication**	**IF**	**NAAS Score**
1.	Arya P S, Chander S, Rajna S, Tenguri P and Yele Y. 2023. Population dynamics of the rice leaf folder *Cnaphalocrocis medinalis* Guenee: A life table study. *Indian Journal of Entomology* **86**(3): 945-947.	-	5.58
2.	Basavaraj N H, Kumaranag K M and Dey D. 2024. First report of nesting habits, nest architecture and foraging behaviour of the stingless bee, *Tetragonula* (*Tetragonula*) *ruficornis* (Smith) (Hymenoptera: Apidae: Meliponini) from India. *Sociobiology* **71**(2): e10114	0.9	6.9
3.	Chandrakumara K, Dhillon M K and Singh N. 2024. Aphid-induced phytochemicals in *Brassica juncea* (L.) Czern & Coss. afflicting host preference and bionomics of *Lipaphis erysimi* (Kaltenbach). *Journal of Applied Entomology* **148:** 465-477. DOI: https://doi.org/10.1111/jen.13241	1.90	7.90
4.	Chandrakumara K, Dhillon M K and Singh N. 2024. Tolerance in *Brassica juncea* cultivars vis-à-vis population buildup of mustard aphid *Lipaphis erysimi* (Kalt.). *Indian Journal of Entomology* **86**(2):	-	5.59

	409–413.		
5.	Chandrakumara K, Dhillon M K, Tanwar A K and Singh N. 2023. Constitutive phytochemicals in *Brassica juncea* (L.) Czern&Coss. in relation to biological fitness of *Lipaphis erysimi* (Kaltenbach). *Arthropod-Plant Interactions*. **18**(1): 1-13	1.60	7.60
6.	Chandrakumara K, Dhillon M K, Tanwar A K and Singh N. 2023. Phytochemicals in *Brassica juncea* distressing developmental and reproductive biology of mustard aphid (*Lipaphis erysimi). Indian Journal of Agricultural Sciences* **93**(10): 1139-1143.	0.40	6.40
7.	Chandrakumara, K, Ishwaryalakshmi K S and Dhillon M K. 2023. Impact of pesticide usage on biodiversity. *Annals of Multidisciplinary Research, Innovation and Technology* (AMRIT) **2**(2): 16-22.	-	-
8.	Chandran N A, Jaykumara K M and Saha T. 2024. *Sinelater perroti* (Fleutiaux) (Elateridae: Tetralobinae): New record for India. *The Coleopterists Bulletin* **78(**2): 1–3.	0.7	6.7
9.	Chandrashekar K, Saha S, Verma R, Tripathi S, Meena O P and Mahapatro G K. 2023. Selection-24 (IC640703; INGR21152), a natural dwarf variant of tomato (*Solanum lycopersicum* L.). *Indian journal of Plant Genetic Resources* **36** (3): 494-495	-	5.17
10.	Deeksha M G, Nebapure S M, Kalia V K, Sagar D, Bhattacharya R, Dahuja A and Subramanian S. 2023. Comparison of phenotypic and genotypic frequency of phosphine resistance in select field populations of *Tribolium castaneum* from India. *Molecular Biology Reports* **50**: 6569-6578.	2.74	8.74
11.	Falswal J and Dey D. 2023. Two new species of the subgenus *Lasioglossum* (*Hemihalictus*) (Hymenoptera: Halictidae) with a checklist of the species from India. *Zoosystematica Rossica* **32**(2): 200–210.	0.9	6.9
12.	Falswal J, Dey D and Kumar S. 2023. A new species of the cleptoparasitic genus *Sphecodes* (Hymenoptera: Halictidae) with an updated checklist and new geographical records from India. *Journal of Asia-Pacific Biodiversity* **17** (3): 497-504.	0.8	6.8
13.	Falswal J, Dey D, and Kumar S. 2023. First record of *Lipotriches* (*Rhopalomelissa*) burmica from India along with a checklist of species from India (Hymenoptera: Halictidae, Nomiinae). *Fragmenta Entomologica* **55** (2): 171–176.	0.3	6.3
14.	Gouda M R, Kumaranag K M, Ramakrishnan B and Subramanian S. 2024. Deciphering the Complex Interplay between Gut Microbiota and Crop Residue Breakdown in Forager and Hive Bees (*Apis* mellifera L.). *Current Research in Microbial Sciences* 6: 100233. https://doi.org/10.1016/j.crmicr.2024:100233	4.2	10.2
15.	Gouda M R, Subramanian S, Kumar A and Ramakrishnan B 2023. Microbial ensemble in the hives: Deciphering the intricate gut ecosystem of hive and forager bees of *Apis mellifera*. *Molecular Biology Reports* **51**: 262 https://doi.org/10.1007/s11033-024-09239-5	3.02	9.02
16.	Gouda M N R, Deeksha M G, Kumaranag K M, Sagar D and Subramanian S. 2023. Diversity of Gut Microbes in the Forager	0.65	6.65

	and Hive Bees of an Indian Population of *Apis mellifera*. *National academy Science Letters* 47: 23-28.		
17.	Guleria N, Nebapure S M, Kamala Jayanthi P D, Suby S B and Saravan Kumar P. 2024. Electrophysiological response of *Chilo partellus* to maize volatiles. *Indian Journal of Entomology*, 1–3. https://doi.org/10.55446/IJE.2024.1626.	-	5.59
18.	Hager M, Saleh M, Dey D and Tomar B S. 2023. The hymenopterous parasitoids of the diamond back moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) on cruciferous vegetables in Delhi, India. *Egyptian Journal of Biological Pest Control* **33**(1): 93. DOI: 10.1186/s41938-023-00735-7.	2.4	8.4
19.	Hager M, Saleh M and Dey D. 2023. New records of family Chalcididae (Hymenoptera: Chalcidoidea) on vegetable ecosystem from New Delhi, India. *Oriental Insects* 1-28 https://doi.org/10.1080/00305316.2024.2347233	0.5	6.5
20.	Harshana A and Dey D. 2024. First report of the trap-jaw ant genus *Anochetus* Mayr, 1861 (Hymenoptera: Formicidae) from Central India with redescription of three species. *Journal of Entomological Research* **47**: 1016-1020. DOI: 10.5958/0974-4576.2023.00189.5	-	5.6
21.	Harshana A and Dey D. 2024. New distributional records of ants of genus *Crematogaster* Lund (Hymenoptera: Formicidae) from India. *Indian Journal of Entomology* e24030. DOI: 10.55446/IJE.2024.2030	-	5.59
22.	Hitesh G R, Suroshe S S, Nebapure S and Keerthi M C. 2024. Behavioural response of *C. sexmaculata* to the volatiles from *B. brassicae* and cabbage. *Allelopathy Journal* **61**(1): 63-76	-	5.00
23.	Jadhav M M, Chander S, Saharan M S, Suroshe S S and Rajna S. 2023. Assessment of avoidable yield losses due to insect pests and diseases in wheat (*Triticumaestivum*). *The Indian Journal of Agricultural Sciences*, **93**(11): 1186-1190.	0.4	6.4
24.	Jadhav M M, Shashank P R, Rani A T, Mohanasundaram A, Rajgopal N N, Naik S, Patil R and Prakash N R 2023. DNA barcoding, morphological description and field diagnostics of *Eublemma amabilis* (Lepidoptera: Erebidae). *Indian Journal of Entomology* 96-100 (Special issue).	-	5.59
25.	Kumar A S T, Nikhil R M, Rajna S and Mahapatro G K. 2023. Comprehensive comparative toxicity study on tomato (*Solanumlycopersicum*) and brinjal (*Solanummelongena*) using green labelled insecticides against *Bemisiatabaci*. *Indian Journal of Agricultural Sciences* **93**(11): 1214–1219.	0.20	6.2
26.	Kumar S, Suby S B, Vasmatkar P, Nebapure S, Kumar N and Mahapatro G K. 2023. Influence of temperature on insecticidal toxicity and detoxifying enzymes to *Spodoptera frugiperda*. *Phytoparasitica* **51**: 533-545.	1.81	7.81
27.	Mogili Ramaiah, Meshram N M and Dey D. 2023. A new species of bamboo-feeding leafhopper genus *Mukariella* Viraktamath and Webb (Hemiptera: Cicadellidae) along with its morphological variant from India. *Zootaxa* **5239** (2): 289–295.	0.90	6.90
28.	Mogili Ramaiah, Meshram N M and Dey D. 2023. *Bambuphaga*, a	0.90	6.90

	new bamboo feeding-leafhopper genus (Cicadellidae: Deltocephalinae: Punctulini) from India. *Zootaxa* **5346** (3): 325–330.		
29.	Mogili Ramaiah, Meshram N M and Dey D. 2023. Integrative approaches establish colour polymorphism in Bamboo-feeding leafhopper *Mukaria splendida* Distant (Hemiptera: Cicadellidae) from India. *Insects* **14**,44. https://doi.org/10.3390/insects14010044	3.1	9.1
30.	Mogili Ramaiah, Naik S, Meshram N M, Bhagyashree S N and Shashank P R. 2023. First Host Report of Earhead Worm, *Autobasilicula* (Swinhoe, 1897) on Maize. *Indian Journal of Entomology* 187-191	0.79	5.59
31.	Nandhini D, Shashank P R, Joshi R and Reddy K M. 2024. A catalogue of Indian Gelechiidae Stainton, 1854 (Lepidoptera: Gelechioidea). *Zootaxa* **5420** (1), 1-121.	0.90	6.90
32.	Nayaka S N, Jailani A K, Ghosh A, Roy A and Mandal B. 2023. Delivery of progeny virus from the infectious clone of cucumber green mottle mosaic virus and quantification of the viral load in different host plants. *3 Biotech* **13**(6): 209.	2.8	8.80
33.	Nikhil R M, Anil Kumar S T, Subramanian S and Mahapatro G K. 2023. Protocol for temperature toxicity investigation on whitefly *Bemisiatabaci* (Gennadius). *Indian Journal of Entomology*. Online published *Ref. No*. e23355), DOI:10.55446/IJE. 2023.1355	-	5.08
34.	Padala V K, Ramya N, Kumar M, Rajna S, Rajashekhar M, Venkatesh Y N and Monobrullah M. 2023. Spatial distribution and optimum sample size for monitoring of water lily aphid Rhopalosiphum nymphaeae (L.) in Makhana Euryale ferox Salisb. *International Journal of Tropical Insect Science* **43**(6): 2167-2177.	1.2	7.2
35.	Padala V K, Venkatesh Y N, Rajna S, Ramya N and Chander S. 2024. Incidence of pest and natural enemies in direct seeded rice and transplanted rice. *National Academy Science Letters* 1-4.	1.1	7.1
36.	Padala, V K, Rajna S Venkatesh, Y and Chander S. 2024. Interactive effect of transplanting time and crop phenology on incidence of brown planthopper and spider population in rice (*Oryza sativa*). *The Indian Journal of Agricultural Sciences* **94**(2): 140-144.	0.4	6.4
37.	Prabhulinga T, Chander S and Subramanian S. 2023. Effect of silicon application to the rice plants on feeding behaviour of the brown planthopper, *Nilaparvata lugens* (Stål) under elevated CO2. *Silicon* **15**(13): 5811-5820. https://doi.org/10.1007/s12633-023-02480-w	2.94	8.94
38.	Prasanthi G, Rath P C and Dey D. 2023. First record of *Brachymeria excarinata* Gahan, 1925 (Hymenoptera: Chalcididae) as a hyperparasitoid of *Charops bicolor* (Szepligeti, 1906) (Hymenoptera: Ichneumonidae) from India. *National Academy Science Letters* **46**(2): 87-89. https://doi.org/10.1007/s40009-023-01204-3	1.1	7.1
39.	Pynhunlin N K D and Dey D. 2024 Description of a new species of the cleptoparasitic bee genus *Tetralonioidella* Strand, 1914 (Hymenoptera: Apidae: Melectini) from India. *Animal Taxonomy and Ecology* **70** (2): 109-122. DOI: 10.1556/1777.2024.12683	0.8	6.8
40.	Rajareddy G, Shashikala M, Jayanth B V, Udaykumar E and Paul B. 2024. Impact of thermal stress on biological parameters of	-	5.04

	Chrysoperla zastrowi sillemi (Esben Petersen) under laboratory conditions. *International Journal of Plant & Soil Science* **36(**4): 148-155.		
41.	Rajesh V, Jangra S and Ghosh A. 2023. Effect of silencing *Thrips palmi Btk29A* and *COL3A1* on fitness and virus acquisition. *Frontiers in Microbiology* **14** (1254246), DOI: 10.3389/fmicb.2023.1254246	5.2	11.20
42.	Rajesh V, Rakesh V, Jangra S and Ghosh A. 2023. RNA Interference in thrips vectors: A step forward toward sustainable management. *Indian Journal of Entomology*, 1-10.	-	5.59
43.	Rajgopal N N, Meshram N M and Dey D. 2023. A new species and some new records of leafhopper tribe Scaphoideini (Hemiptera: Cicadellidae: Deltocephalinae) from India. *Zootaxa* **5182**(4): 348-360.	0.1	7.1
44.	Rajna S, Mahapatro G K, Subramanian S and Chander S. 2024 Determination of insecticide resistance in cotton whitefly, *Bemisiatabaci* (Gennadius) in North India. *Indian Journal of Agricultural Science* **94** (4): 404–409	0.20	6.2
45.	Rajna S, Praveen K V and Nebapure S M. 2023. The global trend in pesticide research: A bibliometric analysis. *Pesticide Research Journal* **35**(2): 120-129.	-	5.55
46.	Rakesh V, Kalia V and Ghosh A. 2023. Diversity of transgenes in sustainable management of insect pests. *Transgenic Research* DOI: 10.1007/s11248-023-00362-w	3.0	9.0
47.	Ranjith H V, Subramanian S, Arya P S, Nebapure S M and Srivastava C. 2023. Sublethal exposure enhances susceptibility to phoshine and effects certain fitness traits in red flour beetle, *Tribolium castaneum* (Herbst). *Indian Journal of Entomology* DOI: https://doi.org/10.55446/IJE.2023.1243.	-	5.08
48.	Rupali J S, Ramya N, Sagar D, Padala V K, Vidya Madhuri E and Subramanian S. 2023. Reproductive behaviour in different aged adults of fall armyworm, *Spodoptera frugiperda* (J. E. Smith*) Current Science* **125**(3): 309.	1.17	7.17
49.	Saini V, Dey D and Meena N K. 2023. Diversity of Crabronid wasp fauna (Hymenoptera: Crabronidae: Crabronini) in the spice ecosystem. *Journal of Entomological Research* **47** (4): 797-800. DOI: 10.5958/0974-4576.2023.00146.9	-	5.6
50.	Samal I, Dhillon M K, Bhoi T K and Singh N. 2024. Biochemical basis of growth and development in *Lipaphis erysimi* (Kalt.) in *Brassica juncea*. *Phytoparasitica* **52**(4): 4. DOI: https://doi.org/10.1007/s12600-023-01115-5	1.40	7.40
51.	Samal I, Singh N, Bhoi T K and Dhillon M K. 2023. Pheno-morphological traits of diverse *Brassica juncea* (L.) genotypes determining variability in *Lipaphis erysimi* (Kaltenbach) population build-up. *Journal of Oilseed Brassica* **14** (2): 159-169.	-	4.78
52.	Sau A K, Dhillon M K, and Tanwar A K. 2024. Diapause-induced shift in the content of major carbohydrates in *Chilo partellus* (Swinhoe). *Journal of Experimental Zoology-A: Ecological and Integrative Physiology* 341: 193–202. https://doi.org/10.1002/jez.2774	2.80	8.80

53.	Sau A K, Tanwar A K and Dhillon M K. 2023. Hibernation induced biochemical changes in spotted stem borer *Chilo partellus*. *Indian Journal of Agricultural Sciences* **93**(12): 1344-1349.	0.40	6.40
54.	Shashank P R, Brandon M P, Rananaware S R, Plotkin D, Couch C, Lilia Yang G, Long T. Nguyen, Prasannakumar N R, Braswell W E, Jain P K and Kawahara A Y. 2023. CRISPR-based diagnostics detects invasive insect pests. *Molecular Ecology Resources* **24**(1), e13881. https://doi.org/10.1111/1755-0998.13881.	7.7	13.7
55.	Shashank P R, Rani A T, Devi S R and Meshram N M. 2023. Morphological Characterization of the Antennal Sensilla of the Legume Pod Borer, *Maruca vitrata* (Fabricius) (Lepidoptera: Crambidae). *Microscopy and Microanalysis* **29**(5): 1822-1836.	2.80	8.80
56.	Singh S, Nebapure S M, Taria S and Subramanian S. 2023 Current status of phosphine resistance in Indian field populations of *Tribolium castaneum* and its influence on antioxidant enzyme activities. *Scientific Reports* 13, 16497. https://doi.org/10.1038/s41598-023-43681-y	5.00	11.0
57.	Singh S, Taria S, Gambhir S and Subramanian S. 2023. Varied response of detoxification enzyme activities against lethal and sublethal exposures of phosphine in *Tribolium castaneum* (Herbst) populations (Article Id: 135614*). Indian Journal of Agricultural Sciences* **93** (6): 615–620.	0.37	6.37
58.	Thesnim P, Jangra S, Kumar M and Ghosh A. 2023. Effect of silencing *Bemisiatabaci* TLR3 and TOB1 on fitness and begomovirus transmission. *Frontiers in Plant Science* **14**: 1136262	5.6	11.60
59.	Thube S H and Mahapatro G K. 2023. In vitro evaluation of insecticidal seed treatments on maize, *Zea maize* L. *The Pharma Innovation Journal* **12**(9): 1069-1071.	-	5.23
60.	Thube S H and Mahapatro G K. 2023. Combinatorial efficacy and compatibility of insecticides, biofungicides and biofertilisers for seed treatment in selected major crops. *The Pharma Innovation Journal* **12**(9): 1088-1093.	-	5.23
61.	Thube S H and Mahapatro G K. 2023. In vitro evaluation of insecticidal seed treatments on soybean, *Glycine max* L. *The Pharma Innovation Journal* **12**(9): 1061-1063.	-	5.23
62.	Thube S H, Pandian R T P, Bhavishya A, Akash N, Vanitha P and Mahapatro G K. 2023. Comparative efficacy and residual toxicity of selective insecticides against *Helopeltis theivora* Waterhouse infesting cocoa. *Journal of Plantation Crops* **51**(3), 121–127.	-	4.66
63.	Thube S H, Pandian R T P, Jose C T, Bhavishya A, Santosh Kumar P, Omprakash N, Akash N and Mahapatro G K. 2023. A novel damage intensity index for Tea mosquito bug *Helopeltis*spp infestation in cocoa. *Indian Journal of Entomology* e23555. DOI:10.55446/IJE 2023.1555.	-	5.08

II. Collaborative publications

Sl.no.	Publication	IF	NAAS Score
1.	Hussain M, Kacho N F, Shashank P R, Ali M and Mir A H. 2024. First report of an invasive pest, *Pheosiaalbivertex* (Hampson 1983) (Lepidoptera: Notodontidae) on *Populus alba* (Salicaceae), from Ladakh, *Indian. Journal of Asia-Pacific Biodiversity* **17**(2): 321-326. https://doi.org/10.1016/j.japb.2023.12.007	0.80	6.80
2.	Iftikhar R, Ghosh A and Pappu H R. 2023. Mitochondrial genetic diversity of *Thrips tabaci* (Thysanoptera: Thripidae) in onion growing regions of the United States. *Journal of Economic Entomology* **116** (3): 1025-1032.	2.2	8.20
3.	Kalleshwaraswamy C M, Karthik C M, Meghana K J, Durga G, Madhu G A, Ratnakala B, Meghana A, Pavani P S, Adarsha S K, Mallikarjuna H B and Shashank P R. 2023. Outbreak of armyworm, *Leucania albistima* Moore on maize with notes on taxonomy and management. *Indian Journal of Entomology* 86(3): 857-866.	-	5.59
4.	Kedar S C, Gupta A, Shashank P R, Navik O and Patil J. 2023. The lepidopteran pest complex infesting menthol mint in India: Distribution during the crop development, species composition and associated parasitoids. *Crop Protection* **173**: 106382.	2.80	8.80
5.	Kiewhuo P, Trivedi N, Mozhui L, Dhillon M K and Kakati L N. 2023. Quantitative characterization of microbial load in wild-harvested edible insects of Nagaland, *Indian Journal of Environmental Biology* **44**: 587-593.	0.70	6.70
6.	Kiran B S, Yadav R K, Lata S, Sharma B B, Talukdar A, Ghosh A and Gupta N C. 2023. In vitro studies of epicotyl and embryo culture in cultivated, wild and inter-specific hybrids of okra (*Abelmoschus* spp.). *Plant Cell, Tissue and Organ Culture* (PCTOC) **156** (3):80	3.0	9.0
7.	Kumar A, Subramanian S, Nysanth N S, Ramesh K. B and Rana A. 2024. Diversity of Culturable Bacteria in Gut of White Grub *Maladera insanabilis* (Brenske). *Indian Journal of Entomology* 1–8. https://doi.org/10.55446/IJE.2024.1334	-	5.08
8.	Kumar M, Ghosh A, Jadon K S and Kaur B. 2023. Association of a novel begomovirus species with fenugreek yellow vein disease in India. *Molecular Biology Reports* 10.1007/s11033-023-08806-6	2.8	8.80
9.	Patidar P, Prasad L, Sagar S, Sirohi A, Saharan M S, Dhillon M K, Singh V K and Bag T K. 2024. Chemo-profiling of *Purpureocillium lilacinum* and *Paecilomyces variotii* isolates using GC-MS analysis, and evaluation of their metabolites against *M. incognita*. *PLoS ONE* **19**(2): e0297925. DOI: https://doi.org/10.1371/journal.pone.0297925	3.70	9.70
10.	Ramankutty R, Sagar D, Subramanian S, Kalia V K, Kumar H, and Muthusamy V 2023. Transgenerational effects of thermal stress on the reproductive physiology of fall armyworm, *Spodoptera frugiperda*. *Journal of Pest Science* **96**(4): 1465-1481. https://doi.org/10.1007/s10340-023-01660-2	5.74	11.74

11.	Saha S, Chandrashekar K and Kushwah S S. 2023. Evaluation of chilli genotypes for yield, quality traits and tolerance to thrips in Western Ghats agro-climatic region. *The Pharma Innovation Journal* **12**(9): 1644-1648.	-	5.23
12.	Saha S, Chandrashekar K, Kushwah, S S and Mahapatro G K. 2023. Genotypes performance, characterization and genetic variability studies of sweet pepper accessions for different traits. *International Journal of Bio-resource and Stress Management* **14**(12):1556-1562.	-	5.40
13.	Saleh H M M, Al-Khalaf A A, Alwail M A and Dey D D. 2024. First record of *Apanteles hemara* (N.) on *Leucinodes orbonalis* Guenée and biodiversity of Hymenoptera parasitoids on Brinjal. *PeerJ*. 12: e16870. https://doi.org/10.7717/peerj.16870	2.7	8.7
14.	Shivakumara K T, Keerthi M C, Shashank P R, Koma J, Polaiah A C, Ramya R S, Venkatesan T, Sagar D, Casini R, Moussa I M and O Elansary H. 2023. Detection and molecular characterization of *Copamyntis obliquifasciella* (Hampson, 1896) infesting medicinal plant, *Cassia fistula* L from India. *Indian Journal of Applied Research on Medicinal and Aromatic Plants*, **37**, p.100517.	3.90	9.90
15.	Weng Y M, Shashank, P R, Godfrey R K, Parker D P, Wist B M and Kawahara A Y. 2024. Evolutionary genomics of three agricultural pest moths reveals rapid evolution of host adaptation and immune-related genes. *Giga Science* **13**, p.giad103. https://doi.org/10.1093/gigascience/giad103	9.2	15.2
16.	Varnitha H, Hanchinal S, Shashank P R, Prabhuraj A, Bheemanna and M and Nidagundi J. 2023. A new species and new record of the genus *Pexicopia* (Lepidoptera: Gelechiidae) feeding on *Abutilon indicum* from India. *Zootaxa* **5323**(3): 423-428.	0.90	6.90
	Thube S H, Satpute V D, Nagre D S, Pawar S P and Mahapatro G K. 2023. In vitro evaluation of insecticidal seed treatments on groundnut. *The Pharma Innovation Journal* **12**(9): 1076-1078.	-	5.23

b) List of Books / Chapter in books/ Training Manual Chapters

1. Bhagyasree, S. N., Anokhe, A., Shashank, P. R. & Patel, C. H. 2023. Reduviid Predators. In Insect Predators in Pest Management (pp. 55-72). CRC Press.
2. Dey, D. 2023. Insect diversity vis-a vis pest management. In Training Manual on Integrated Pest Management for BIMSTEC participants (6 to 17 November 2023), Division of Entomology, ICAR-IARI, New Delhi, 110012.11-19 pp . TB ICN: 309/2023
3. Sagar, D., Rajna, S., Shubham Gambhir and S. Subramanian, 2023, Isolation of DNA from insect tissue. Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 109-110.
4. Rajna S, Sagar D., Shubham Gambhir and S. Subramanian, 2023, Extraction of RNA from insect tissues and cDNA synthesis for gene expression studies. Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 111-114.

5. Sagar, D., Archana Anokhe, Rajna, S. and S. Subramanian, 2023, Amplification and Visualization of DNA fragments. Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 115-118
6. Sagar, D. and Subramanian, S., 2023, Designing of Oligos (Primers). Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 119-123
7. Subramanian, S. and Sagar, D., 2023, Insect Preparation for Genomics studies. Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 128-133.
8. Rudra Gouda, M. N., Sagar, D., Rajna, S., Subramanian, S., 2023, Bioinformatic Analysis: A guide for handling, processing and submission of DNA sequences to NCBI GenBank. Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 134-141.
9. Sagar D., Dheerendra Pandey and S. Subramanian., 2023, Evaluation of dsRNA constructs against insect pests. Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 150-152.
10. Sagar, D., Rajna S, Rohini Sreevathsa and Subramanian, S., 2023, Gene expression analysis of insect RNA through qRT-PCR. Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 153-157.
11. Rajna S, Suresh Nebapure, Sagar D and Subramanian, S., 2023, Quantification of detoxification enzymes in insects. Training Manual on *"Genomic Approaches for Insect Pest Management"* during 12-22 September 2023 at Division of Entomology, ICAR-IARI, New Delhi. Pp. 158-160.
12. *S. Subramanian* Insect genomics- an overview Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 12-19.
13. Sagar D., Suresh M Nebapure and S. Subramanian, (2023). Preparation of buffers and reagents & calibration of pipettes. Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 107-110.
14. Rajna S, Sagar D and S. Subramanian (2023) Extraction of RNA from insect tissues and cDNA synthesis for gene expression analysis Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 113-116.
15. Sagar, D., Archana Anokhe, Rajna, S. and S. Subramanian. PCR techniques Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 121-124.
16. Sagar, D. and S. Subramanian Designing of Oligos (Primer). Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 125-128.
17. Rajna S, Suresh Nebapure, Sagar D and S. Subramanian Quantification of detoxification enzymes in insects. Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 129-131.

18. Subramanian S and Sagar, D. Insect preparation for Genomic studies. Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 132-136.
19. Rajna S, Sagar, D and S. Subramanian Gene expression analysis of Insect RNA through qRT-PCR. Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 150-154.
20. Rudra Gouda, M. N., Sagar D., Rajna S, and S. Subramanian Bioinformatic Analysis: A guide for handling, processing and submission of DNA sequences to NCBI GenBank Training Manual on "Plant Health Management using Genomic Tools" during 21st November to 1st December, 2023 at Division of Entomology, ICAR-IARI, New Delhi.P.162 (TB-ICN: 308/2023). Pp. 155-161.
21. Dhillon, M.K., Rajna, S., Saharan, M.S., Chander, S. and Dey, D. 2023. Compendium on Integrated Pest Management for BIMSTEC participants (6 to 17 November 2023), Division of Entomology, ICAR-IARI, New Delhi, 110012. Pp. 299. (TB ICN: 309/2023)
22. Chava N.R., Nebapure SM, Thakur S. (2023) Pests and Diseases of Millets. In: *Pest Management Strategies in Pulses and Cereal Crops*. (ISBN: 978-81-19149-06-3). P. 24-37.
23. Nebapure S. M. and Subramanian S. (2023) Genotyping of insecticide resistance in Red flour beetle, *Tribolium castaneum* In: Genomic approaches for insect pest management. pp. 124-127.
24. S Ramesh, Amalendu Ghosh*. 2024. Relationship of insect vectors with plant viruses infecting Capsicum. In book: Pepper Virome, 253-276. Elsevier. https://doi.org/10.1016/B978-0-443-15576-5.00017-4
25. V Rajesh, V Rakesh, A Jeevalatha, Amalendu Ghosh*. 2024. Potato Virus Transmission by Thrips, Hoppers, Beetles, Nematodes, and Fungi. In book: Approaches for Potato Crop Improvement and Stress Management. ISBN978-981-97-1222-9. Springer
26. V Rakesh, V Rajesh, A Jeevalatha, Amalendu Ghosh*. 2024. Exploring the Relationship of Potato Viruses with Aphid and Whitefly Vectors. In book: Approaches for Potato Crop Improvement and Stress Management. ISBN978-981-97-1222-9. Springer
27. Saha, T. Nithya, C and Goswami, T.N. 2023. Pests of apple and their management. In: Pests of Fruit Crops, Nripendra Laskar and Victor Phani. New India Publishing Agency (NIPA), New Delhi, pp. 313-30 (ISBN:978-93-94490-70-3).
28. Devi, L. J., Grewal, S., Rajna, S., & Jose, S. (2024). Sustainable moth repellent finishing for wool. In *The Wool Handbook* (pp. 341-356). Woodhead Publishing.
29. Sahoo K.C., Divija S.D., Ramya N., Snehasish R., Arunkumar C.G., Mogili Ramaiah., Ipsiat Samal and Jhansi Laxmi V. 2024. Emerging insect pests in Agriculture-Management Practices (Submitted)
30. Nithya Chandran**,** Sushma C and P.R. Shashank. 2023. Insects collection and preservation. Training manual on DNA Barcoding of Insects, 18-20 December 1–6. TB-ICN:315/2023.

d) List of Popular article(s) (based on first authorship only)

1. Dhillon, M.K. 2023. Integrated pest management: Concept and tools. In**:** Compendium on Integrated Pest Management for BIMSTEC participants **(**Dhillon, M.K., Rajna, S., Saharan, M.S., Chander, S. and Dey, D**.,** Eds.). Division of Entomology, ICAR-IARI, New Delhi. Pp. 1-10.
2. Dhillon, M.K. 2023. Metablomic Approaches in Insect-Plant Interactions. *In*: Training Manual on NAHEP-CAAST training on Genomics Assisted Insect Pest Management (Subramanian, S., Sagar, D., Shashank, P.R., Nebapure, S.M. and Kumar, A., Eds.). Division of Entomology, ICAR-IARI, New Delhi. Pp. 73-80.
3. Dhillon, M.K. 2024**.** Role of host plant resistance in ecofriendly pest management". In: Recent Advances in Ecofriendly Management of Crop Pests" (Deepika, K., Saini, V., Rolania, K., Yadav, S.S. and Yadav, S., Eds.)" during from 24th January to 13th February, 2024, Organized by Centre of Advanced Faculty training, Department of Entomology, CCS HAU, Hisar-125004.
4. Dhillon, M.K. 2024**.** Role of antifeedant phytochemicals in insect pest management. In: Recent Advances in Ecofriendly Management of Crop Pests" (Deepika, K., Saini, V., Rolania, K., Yadav, S.S. and Yadav, S., Eds.)" during from 24th January to 13th February, 2024, Organized by Department of Entomology, CCS HAU, Hisar-125004.
5. आदित्य कुमार तंवर, मुकेश कुमार ढिल्लों, अर्चना अनोखे एवं राजेश. 2023. श्री अन्न का सामान्य परिचय. प्रसार दूत (श्री अन्न विशेषांक). जनवरी - दिसंबर 2023: 1-4.
6. आदित्य कुमार तंवर, मुकेश कुमार ढिल्लों, अर्चना अनोखे एवं राजेश. 2023. श्री अन्न या मिल्लेट्स सम्बंधित नाशी किट का प्रबंधन. प्रसार दूत (श्री अन्न विशेषांक). जनवरी - दिसंबर 2023: 5-13.
7. Shashank P.R. 2023. Guidelines and SOPs for Research on Genetically Engineered Insects 2023 released by DBT, GOI. Indian Entomologist (https://www.indianentomologist.org/post/guidelines-and-sops-for-research-on-genetically-engineered-insects-2023-released-by-dbt-goi)
8. Santhosh Naik, G. and Shashank, P.R. 2023. Big Butterfly Month: Celebrating Nature's Winged Wonders. Indian Entomologist (https://www.indianentomologist.org/post/big-butterfly-month-celebrating-nature-s-winged-wonders)
9. P.R. Shashank, Babita Yadav, Mukesh Dhillon, 2023. Rastria pusa sangrah: Krishi-sambandi mahatwapoorna keedo ke leye bharat ka sabse poorana aur sabse bada keet sangrah. Pusa Surabhi (April-October 2023), 39-41. (In Hindi)
10. Subramanian : Pusa Samachar (Tamil) - A digital initiative for dissemination of innovative agricultural technologies In Knowledge Report - 8 th Edition SICCI Agri Summit 2024
11. Kumar H., D. Sagar and Nebapure S. M. (2023). SPLAT: A green technology for insect pest management. Insect Environment, 26(3): 369-374
12. रजना एस, संजीव रंजन सिन्हा एवं सुरेश नेबापुरे (2023). फसलों में सफेद मक्खियों की समस्या और उसका प्रबंधन। प्रसार दूत, मार्च-दिसम्बर- 2023: 34-37
13. Chava N. R., Nebapure S. M**.**, Sagar D. and Padala V. K. (2023). Social immunity in insects. Indian entomologist, 4(2): 68-73.

14. Saha, T., Nithya, C and Rima, K. 2023. Modern approaches for management of fall armyworm (*Spodoptera frugiperda*). Trends in Agriculture Science, 2(10): 857–862 (ISSN: 2583-7850).
15. Sankar R.K. Saha, T. and Nithya C. 2024. Biological control approaches against the invasive pest, fall armyworm, *Spodoptera frugiperda* in maize. AgroScience Today, 5(3): 778–782.
16. Rajna, S. Raghavendra, K. V., Reshma, R., and Arya, P. S. 2023. Good agricultural practices in insect pest management of field crops. Indian Entomologist, 5(1):42-46.
17. रजना एस, सुरेश नेबापुरे, बबिता यादव, रणधीर कुमार.2023.फसलों में कीटों के प्रबंधन के लिए प्रवीण कृषि पद्धतियाँ. Vikaspedia.
18. रजना एस, संजीव रंजन सिन्हा एवं सुरेश नेबापूरे. 2023. फसलों मे सफ़ेद मक्खियों की समस्या और उसका प्रबंधन। Prasaad Doot, 34-37.
19. Vidya Madhuri E, Darshana Brahma, Vinod Kumar Padala and Rajna S*. 2023. Brown Planthopper: A Threat to Rice Cultivation in India. 4(3): 82-87.
20. Neelakanta Rajarushi Chava, Suresh M Nebapure, Rajna S. 2023. Minimise disturbance, maximise control. Vol. 26 (1): 40-47.
21. Raghavendra K.V., Rajna S., Rekha Balodi, S.K. Singh, Subhash Chander. 2023. Options for Plant Protection under Natural Farming System. Kerala Karshakan, 11(3): 39-47.
22. Niraj Guleria, Nebapure S M, and Rajna S**.** 2023. Common Insect Pests of Crucifer Crops and their management. Vikaspedia.

8. Trainings/workshop/seminar organized

Sl. No.	Name of programme	Training/ workshop/ seminar	Duration	Nature of trainees (Students, Scientists, teachers, farmers, etc. Please specify)	Number of trainee (s)		
					Male	Female	Total
1.	Online Training programme on “Integrated Pest Management” for BIMSTEC Country Participants (ICAR, New Delhi) (course Director: Dr Mukesh Kumar Dhillon)	Training	6-17 November, 2023	Scientific and extension staff	13	25	38
2.	Three-Day Training On "DNA Barcoding of Insects" to the Staff of Central Pollution Control Board, New Delhi (Division of Entomology, ICAR-IARI, New Delhi**)**	Training	18-20 December, 2023.	Scientific staff	2	3	5

4.	NAHEP- CAAST Training programme *Genomic Approaches for Insect Pest Management* at Division of Entomology, ICAR-IARI, New Delhi [Course Director : Subramanian S]	Training	12-22 September 2023	Post Graduate Students across India	13	14	27
5.	NAHEP- CAAST Training programme *“Plant Health Management using Genomic Tools”* at Division of Entomology, ICAR-IARI, New Delhi. [Course Director**:** Subramanian S]	Training	21st November to 1st December, 2023	Post Graduate Students across India	15	15	30

9. Participation by scientists in scientific meetings, etc.

S.No.	**Detail**	**Number only**	**Detail/description of each item**
(i)	**<u>In India</u>**		
	Seminars	13	1. Dr. M.K. Dhillon delivered Invited lecture on “Integrated Pest Management: Concept and Tools” in Online training on “Integrated Pest Management for BIMSTEC participants” during 6 to 17 November 2023 by Division of Entomology, ICAR-IARI, New Delhi. 2. Dr. M.K. Dhillon delivered Invited lecture on “Metablomic Approaches in Insect-Plant Interactions”, in World Bank-ICAR funded NAHEP-CAAST training on “Insect Metabolomics” during 12-22 September 2023 at the Discovery Centre/Division of Entomology, ICAR-IARI, New Delhi. 3. Dr. M.K. Dhillon: Two invited lectures delivered in CAFT training during 24 January to 13 February, 2024, organized by Department of Entomology, CCS HAU, Hisar. 4. S. Subramanian (2024). Genomic Approaches for Plant Health management

			Lead lecture devivered in 6th Jammu and Kashmir Agricultural Science Congress: Diversification of Agricutlural Self Reliant Mountain Agriculture held during 8-10 February, 2024 at SKAUST, Jammu 5. S. Subramanian (2024). Metagenomics and its applications in Lecture delivered in Winter School “Training on recent advances in molecular diagnostics of insect species including invasive and their natural enemies” during 18 January – 7 February 2024 at ICAR-NBAIR, Hebbal, Bengaluru. 6. S. Subramanian and M.N. Rudra Gouda (2023). Omics Approaches in Insect Pest Management. Lead lecture on National Symposium Crop Health Management: Safeguarding Crop through Diagnostics and Innovations on 29-30 September, 2023 at ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora-263 601, Uttarakhand Almora 7. S. Subramanian (2023). Fumigation for safe storage In: a 10 day Training Programme on ‘Integrated Pest Management’ for BIMSTEC country participants from 06th – 17th November 2023 through virtual mode. 8. S. Subramanian (2023). Gut Microbiome of honey bees and their functional role Delivered a lecture on Apiculture in the Faculty Development Program (FDP) titled "Unveiling Apiculture: Exploring the Art and Science of Beekeeping Methods and Applications." Organized by Miranda House in collaboration with Dyal Singh College, University of Delhi and supported by ICAR-All India Coordinated Research Project on Honey Bee and Pollinators (AICRP-HB&P) and GAD-TLC, SGTB Khalsa College, Ministry of Education, PMMMNMTT, Govt of India. 9. Sagar D, Sweta Verma, Ramya N, Mohd. Sarim & Kumar H. 2023. Sublethal effects of heat shock on fall armyworm, *Spodoptera frugiperda* (J. E. Smith): Implications for Pest Management and Ecological Impact. In:

			The Proceedings of the DST-SERB sponsored National Symposium on Crop Health Management: Safeguarding Crops through Diagnostics and Innovations held during 29-30 September 2023 organized by ICAR- VPKAS, Almora. Pp.57 10. Sagar D. 2023. Decision Support System for the Prediction of Chickpea Pod Borer, *Helicoverpa armigera* in Northern India. In: The Proceedings of the International Conference on Plant Health Management ICPHM 2023: Innovation and Sustainability" during 15-18 November 2023 organized by Plant Protection Association of India, ICAR-NBPGR Regional Station, Hyderabad at Professor Jayashankar Telangana State Agricultural University, Hyderabad. 11. Reshma R, Sagar D and Subramanian S. 2023. Parental effect of heat stress on progenies reproductive biology of invasive fall armyworm, *Spodoptera frugiperda*. In International Conference on Plant Health Management ICPHM 2023: Innovation and Sustainability" during 15- 18 November 2023 organized by Plant Protection Association of India, ICAR-NBPGR Regional Station, Hyderabad at Professor Jayashankar Telangana State Agricultural University, Hyderabad. 12. Dr. Shashank, P.R. Attended International Firefly webinar organized by Environmental Management and Policy Research Institute (EMPRI), Bangalore on 21 and 22 July 2023. 13. Dr. GK Mahapatro delivered Key Note Speaker, 6th International Conference on Advances in Agriculture Technology & Allied Sciences (ICAATAS 2023), Organised by SARSD, New Delhi & Loyala Academy, Secunderabad, Telengana (Hybrid mode, June 19- 21, 2023). 14. P. R. Shashank 2023. Revision of Genus *Mythimna* (Lepidoptera: Noctuidae): Taxonomy and distribution in India. Oral presentation (online) in Noctuoidea

			Research Group Meeting 2023 held from June 2–June 3, 2023. (Oral presentation) 15. Dr. Suresh Nebapure delivered lecture on "Insect pest of stored Food grains" in training on "Post Harvest Management of Stored food grains, 19-23th June 2023" organized by Food Corporation of India, Institute of Food Security, Gurugram on 22nd June 2023 16. Dr. Suresh Nebapure delivered lecture on "Protecting Honey Bees from Pesticide Poisoning" in Faculty Development Programme on Beekeeping Jointly organized by Miranda House in collaboration with Dyal Singh College, University of Delhi, ICAR-All India Coordinated Research Project on Honey Bee and Pollinators (AICRP-HB&P) and GAD-TLC, SGTB Khalsa College, Ministry of Education, PMMMNMTT, Govt of India, 10-16th October 2023.
	Scientific meetings	1	1. Attended 3rd Group Monitoring Workshop of PAC Organismal and Evolutionary Biology – Animal Sciences (OEB-AS) held during 19-20 March, 2024 at Kolkata.
	Workshops	1	1. Dr. Nithya Chandran completed the training programme on 3rd Pedagogy Development Programme training programm held from 20-24 November 2023 at NAAS complex organised by the National Academy of Agricultural Sciences, New Delhi.
	Symposia	2	1. Dr Rajna S. attended DST-SERB sponsored National Symposium on Crop Health Management: Safeguarding Crop through Diagnostics and Innovations On 29-30 September, 2023 Organized by ICAR-Vivekananda Parvatiya Krishi AnusandhanSansthan, Almora-263601, Uttarakhand. 2. Dr Sagar D attended DST-SERB sponsored National Symposium on Crop Health Management: Safeguarding Crop through Diagnostics and Innovations On

			29-30 September, 2023 Organized by ICAR-Vivekananda Parvatiya Krishi AnusandhanSansthan, Almora-263601, Uttarakhand.
	Any other	3	1. P. R. Shashank participated in 'Noctuidea Research Group Meeting' (online) held from 2–3 June, 2023 and delivered lecture on the topic Revision of Genus *Mythimna* (Lepidoptera: Noctuidae): Taxonomy and distribution in India. 2. P. R. Shashank 2023. Attended 10 days online training on "Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues" organized by ICAR- National Bureau of Plant Genetic Resources, New Delhi, India and funded by DBT from September 4-14, 2023. 3. Dr Rajna S attended Training workshop to the NARS scientists on 'Crop simulation modelling for managing agriculture under changing climates' under UN Environment-GEF project 'Mainstreaming agro-biodiversity conservation and utilization in the agricultural sector to ensure ecosystem services and reduce vulnerability' from 22-26th May, 2023.
(ii)	**<u>Abroad</u>**		
	Symposia	1	1. P. R. Shashank. 2023. CRISPR-based diagnostics successfully detects invasive insect pests. Oral presentation (Physical) in 23rd European Congress of Lepidopterology & 11th Forum Herbulot 2023 on "Conservation, Ecology and Systematics of Lepidoptera in a changing world" Orleans, France. (Oral presentation)

10. **Extension activities:**

1. Pusa Krisi Vigyan Mela – 2023: All the scientists associated with the arrangements of thematic pandal of the Division of Entomology

2. Dr. S. Subramanian has done coordination of Pusa Samachar (Tamil): Pusa Samachar (Tamil), a Youtube channel of ICAR- IARI. Regular webcasting of news capsules on alternate Wednesdays of every month since April 2023.

3. Dr. G.K. Mahapatro founded the Whatsapp group, Vegetable Farmers Forum during covid lockdown (2020-April). Through this we are addressing the farmers' problem throughout the country.

4. Dr. G. K. Mahapatro: Maintenance of web-portal on termites www.termitexpert.in (till-date 15 lakh hits)

4. Dr Suresh Nebapure: A training film recorded on "storage insects' pests and related research facilities" in collaboration with Warehousing Development and Regulatory Authority (WDRA) on 23rd September 2023.

5. Field days: Division scientists attended the crop field days organized by Division of Genetics for different crops during the year 2023-24**.**

6. Farmer Visitors at the Division: Scientists attended the farmers and other visitors visited the division with insect related problems and imparted their appropriate solutions.

7. Insect Pests Monitoring: Monitored insect pest problems in maize and mustard in the IARI fields and appropriate control measures were suggested to the concerned scientists.

9. Dr. Shashank P. R: Distributed IARI seeds and vegetable kits under Institute Mera Goan Mera Gaurav (MGMG) Programme of Cluster No. 123 and SCSP Scheme (Rajpura, Block Khair, Aligarh (Uttar Pradesh, India) on 03/06/2023

11. Dr. Shashank P. R: Visited cucumber mosaic virus (CMV)-affected banana plantations in Madhya Pradesh and Maharastra and provided advisory to farmers

12. Dr. Shashank P. R: Participated in Pusa Kisan Mela 2024 at Simdega, Jharkhand (10.03.2024 to 12.03.2024).

13. Dr. Shashank P.R: Presented expert talk on "Integrated Pest management in Rice" in "Farmers' training on improved cultivation of paddy and seed distribution programme" at Rajpura, Block Khair, Aligarh (Uttar Pradesh, India) on 03/06/2023.

14. Dr. Rajna S: Attended Training workshop to the NARS scientists on 'Crop simulation modelling for managing agriculture under changing climates' under UN Environment-GEF project 'Mainstreaming agrobiodiversity conservation and utilisation in the agricultural sector to ensure ecosystem services and reduce vulnerability' from 22-26th May, 2023.

15. Dr. Rajna S: Delivered a talk on 'Insect pest forecasting with respect to climate change' in a training program ICT in Plant Protection organized by ICAR – NCIPM, New Delhi and MANAGE Hyderabad during 06th – 10th November 2023.

16. Dr. Rajna S: MGMG village visit to Cluster No.141, Neemka village (District G B Nagar) for distribution of wheat seeds during November 2024

17**.** Dr. Rajna S: part of the Team who visited farmer field at Aurangabad, Bulandshahar, Uttar Pradesh for addressing issues related torice cultivation on 19.09.2023.

18. Dr. Nithya Chandran: Attended farmer's field day at Turkpur Village, Sonepat, Haryana as an expert on the eve of World Soil Day-2023 organised by the Indian Society of Soil Science, New Delhi on 10th December, 2023.

19. More than 15 groups have visited the National Pusa Collection (NPC) from different organizations and scientists at NPC have explained about importance of insect collection and repositories.

11. Staff Position

	Cadre strength	**Current Position**
Scientist	22	12 *
Technical Officers	--	09 **
Administrative Staff	8	2
Supporting Staff	--	18***

* Two Scientist working in other Division/Units
** One Technical officer working in other Division
*** Two supporting staff working in another Division/Unit

12. Divisional Committees

a) DBRC

1.	Dr. Mukesh Kumar Dhillon, Head	Chairperson
2	Dr. Debjani Dey, Pr. Scientist	Member
3.	Dr. Subramanian S, Pr Scientist	Member
4.	Dr. Shashank P. R, Sr. Scientist	Member
4.	Dr. Nithya Chandran, Scientist	Member
5.	Dr. Rajna S, Sr. Scientist	Member Secretary

b) BOS

1.	Dr. Debjani Dey, Pr. Scientist	Chairperson
2	Dr. Sarbashish Chakraborty, Pr. Scientist	Member
3.	Dr. Amalendu Ghosh, Sr. Scientist	Member
4.	Dr Shashank P. R, Sr. Scientist	Member Secretary

5.	Ms. Ishwarya Lakshmi, Student	Student Representative

c) Deputation Committee

1.	Dr. Mukesh Kumar Dhillon, Pr. Scientist	Chairperson
2	Dr. G. K. Mahapatro, Pr. Scientist	Member
3.	Dr. Shashank P. R., Sr. Scientist	Member
4.	Dr. Rajna S, Sr. Scientist	Member
5.	Sh. Alam Singh, Asstt Admn Officer	Member Secretary

d) Technical Cell

1.	Dr. Suresh M Nebapure, Sr. Scientist	Chairperson
2	Dr. Dr. Shashank P. R., Sr. Scientist	Member
3.	Dr. Rajna S, Sr. Scientist	Member
4.	Dr. Nithya Chandran, Scientist	Member

e) Other committees

1. Purchase Technical Specification Committee

1.	Dr. S. Subramanian. Pr. Scientist	Chairperson
2	Dr. Suresh M Nebapure, Sr. Scientist	Member
3.	Dr. Shashank P. R., Sr. Scientist	Member
4.	Dr. Rajna S, Scientist, Sr. Scale	Member
5.	Sh. Alam Singh, Asstt Admn Officer	Member Secretary

2. Hindi Rajbhasha Committee

1.	Dr. Dr. Mukesh Kumar Dhillon, Head	Chairperson
2	Dr. Babita Yadav, Technical Officer	Member
3.	Dr. Aditya Kumar Tanwar, Sr. Tech. Asstt.	Member
4.	Sh Sanjeev Kumar, Assistant	Member
5.	Sh. Alam Singh, Asstt Admn Officer	Member Secretary

3. Annual Report Compilation Committee and Publication Team

1.	Dr. Mukesh Kumar Dhillon, Head	Head
2	Dr. G. K. Mahapatro, Pr. Scientist	Member
3.	Dr. Suresh M Nebapure, Sr. Scientist	Member
4.	Dr. Shashank P. R., Sr. Scientist	Member
5.	Dr. Rajna S, Sr. Scientist	Member
6.	Dr. Mogili Ramaiah, Scientist	Member

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