(NCEEA-2025)

SOUVENIR

National Congress on
ENTOMOLOGY AND EMERGING AGROTECHNOLOGIES

June 27-29, 2025

In Alpine Meadows of Sanasar

Organized by:
Entomological Science Academy (ESA)
In collaboration with
SKUAST-Jammu & IIT-Jammu

www.entomologicalscienceacademy.org

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Message

Dr. B. N. Tripathi
Vice Chancellor
SKUAST-Jammu

It is with great pleasure that I welcome all esteemed delegates, researchers, and participants to the National Conference on Entomology and Emerging Agrotechnologies (NCEEA-2025), being organized at SKUAST-Jammu. This conference is a significant milestone in our collective effort to explore innovative, sustainable, and region-specific solutions for the evolving challenges in Indian agriculture.

In the context of Jammu & Kashmir, agriculture is not only a primary livelihood but also deeply intertwined with the region's socio-economic fabric and ecological balance. The diversity of agro-climatic zones in J&K offers immense potential for crop diversification, yet it also presents unique challenges related to pest dynamics, climate variability, and resource management. Addressing these issues through cutting-edge research in entomology and the application of emerging agrotechnologies is critical for enhancing productivity, reducing crop losses, and promoting resilience among farming communities.

On a national scale, India stands at the cusp of an agricultural transformation where the integration of science, technology, and traditional knowledge systems will determine our ability to ensure food and nutritional security. Technologies such as remote sensing, AI-driven pest forecasting, drone-based applications, and precision farming are no longer futuristic—they are the need of the hour. However, these innovations must be grounded in the realities of smallholder farming and tailored to regional contexts, such as those in Jammu & Kashmir.

I commend the organizing committee for bringing together a diverse group of scientists, policymakers, and practitioners for meaningful dialogue and knowledge sharing. I am confident that the insights generated through NCEEA-2025 will pave the way for impactful research and actionable strategies, not only for our region but for Indian agriculture at large.

I wish the conference great success and fruitful deliberations.

(B. N. Tripathi)

डॉ. पूनम जसरोटिया
सहायक महानिदेशक
(पादप संरक्षण एवं जैव सुरक्षा)

Dr. Poonam Jasrotia
Assistant Director General
(Plant Protection and Biosafety)

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Message

It gives me an immense pleasure that the Entomological Science Academy (ESA) and Division of Entomology, SKUAST-Jammu is jointly organizing "National Conference on Entomology and Emerging Agrotechnologies (NCEEA-2025)" during June 27-29, 2025 at the Sanasar, Patnitop, Jammu and Kashmir.

In today's rapidly evolving agricultural landscape, we are faced with complex challenges such as increasing biotic stresses, stagnating crop yields, and the imperative of achieving long-term environmental sustainability. Entomology plays a fundamental role in addressing these issues, particularly through its contributions to integrated pest management, pollinator health, and maintaining ecological balance. At the same time, the advent of emerging technologies including precision agriculture, artificial intelligence-based pest monitoring, remote sensing, and smart delivery systems has opened up unprecedented possibilities for innovation in pest surveillance, crop protection, and sustainable farm management.

I hope that NCEEA-2025 will serve as a dynamic platform for researchers and stakeholders to exchange innovative ideas and share advancements on emerging issues in crop pest management through cutting-edge tools. The insights and recommendations derived from this meeting will culminate in a valuable document, offering guidance for stakeholders to implement effective strategies for safeguarding plant health from insect pests.

I extend my heartfelt greetings and commendations to everyone involved in organizing this conference, and I wish the event great success.

(Poonam Jasrotia)

Message

Dr. Shahid Iqbal Choudhary
Secretary to the Government of J&K
Science & Technology Department

I am delighted to extend my warm greetings and best wishes to the organizers, delegates, and participants of the *National Congress of Entomology and Emerging Agrotechnologies*. This timely and significant event brings together leading scientists, researchers, academicians, and industry experts to deliberate on the pivotal role of entomology in advancing sustainable agricultural practices.

In Jammu and Kashmir, agriculture forms the backbone of rural livelihood and economic resilience. The challenges posed by climate change, emerging pests, and changing cropping systems demand innovative solutions. Entomological research, coupled with emerging agrotechnologies such as precision farming, biological pest control, and AI-driven monitoring, holds immense potential to enhance productivity while preserving ecological balance.

I am confident that the deliberations of this congress will contribute meaningfully to policy formulation, capacity building, and the promotion of farmer-centric technologies. The Department of Science & Technology, J&K, remains committed to supporting scientific initiatives that align with the goals of sustainable development and technological self-reliance.

I congratulate the organizing committee for their dedication and vision in hosting this important event and wish the Congress great success.

(Dr. Shahid Iqbal Choudhary)

Message

Prof. Sushil Kumar Gupta
Director Research
SKUAST-Jammu

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In the context of Jammu & Kashmir, agriculture is not only a primary livelihood but also deeply intertwined with the region's socio-economic fabric and ecological balance. The diversity of agro-climatic zones in J&K offers immense potential for crop diversification, yet it also presents unique challenges related to pest dynamics, climate variability, and resource management. Addressing these issues through cutting-edge research in entomology and the application of emerging agrotechnologies is critical for enhancing productivity, reducing crop losses, and promoting resilience among farming communities.

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I commend the organizing committee for bringing together a diverse group of scientists, policymakers, and practitioners for meaningful dialogue and knowledge sharing. I am confident that the insights generated through NCEEA-2025 will pave the way for impactful research and actionable strategies, not only for our region but for Indian agriculture at large.

I wish the conference great success and fruitful deliberations.

Message

Prof. Anil Kumar
Dean, Faculty of Agriculture
SKUAST-Jammu

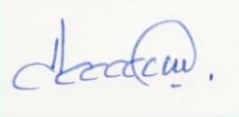
It gives me immense pleasure to convey my warm greetings to all the participants and organizers of the National Conference on Entomology and Emerging Agrotechnologies (NCEEA-2025). This academic gathering reflects our shared commitment to strengthening agricultural research, education, and innovation in a time of unprecedented environmental and technological change.

The Faculty of Agriculture at SKUAST-Jammu has always strived to provide a strong foundation in both fundamental and applied agricultural sciences. As we move forward, it becomes increasingly important to align our educational strategies with emerging trends such as integrated pest management, precision farming, climate-smart agriculture, and digital agri-technologies. Conferences like NCEEA-2025 offer a unique opportunity for students, scholars, and faculty to engage with cutting-edge developments and to understand how science and technology can be harnessed to solve real-world problems.

Entomology, as a core discipline in agriculture, not only contributes to crop protection but also plays a vital role in biodiversity conservation and ecological sustainability. The integration of entomological knowledge with emerging agrotechnologies is essential for equipping our future scientists and professionals with the skills required to address both current and future agricultural challenges.

I encourage all young minds attending this conference to actively participate, network, and explore interdisciplinary collaborations. I am confident that the knowledge shared here will not only enrich academic pursuits but also inspire innovative thinking and lifelong learning.

I congratulate the organizing committee for this visionary initiative and wish the conference grand success.



Message

Dr. R. K. Gupta
President
Entomological Science Academy (ESA)

It is with great pride and optimism that I extend my warmest greetings to all participants of the National Conference on Entomology and Emerging Agrotechnologies (NCEEA-2025). Organized in collaboration with Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-Jammu), this conference stands as a testament to our shared commitment to advancing scientific understanding and fostering innovation in the field of entomology and allied agricultural sciences.

As agriculture faces mounting challenges due to climate change, emerging pest threats, and the urgent need for sustainable practices, the role of entomology is more vital than ever. The integration of classical entomological research with emerging agrotechnologies—such as precision agriculture, AI-based pest monitoring, and biotechnological tools—offers promising solutions to strengthen ecological resilience and productivity.

The Entomological Science Academy is proud to support platforms like NCEEA-2025 that encourage the exchange of ideas, interdisciplinary collaboration, and forward-looking research. This conference not only enables academic enrichment but also connects research to real-world applications, especially in agro-climatic regions like Jammu & Kashmir.

I take this opportunity to extend my heartfelt congratulations to all the distinguished awardees and newly inducted Fellows of the Academy. Your achievements are a reflection of dedication, excellence, and meaningful contributions to the scientific community. May your work continue to inspire future generations of researchers and practitioners.

I commend the organizing committee for their tireless efforts in putting together this impactful event and wish NCEEA-2025 great success in achieving its goals.

Message from ESA Honorary Fellows

We are delighted to extend my warm greetings and best wishes to all participants, organisers and stakeholders of the National Conference on Entomology and Emerging Agro-technologies (NCEEA-2025). This timely initiative, organised at Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, underscores the growing importance of integrated plant health management, biosecurity, and technological innovation in Indian agriculture. It is with great pride and enthusiasm that we welcome all esteemed delegates, researchers, academicians, industry experts, and students to the National Conference on Entomology and Emerging Agro-technologies.

Dr. H. C. Sharma

The National Conference on Entomology and Emerging Agrotechnologies (NCEEA-2025), organized by the Entomological Science Academy, will serve as a vital platform to promote sustainable crop protection through scientific innovation. Advances in molecular biology and biotechnology—such as genetic transformation, gene editing (CRISPR-Cas), and RNAi—are revolutionizing pest management by enabling the development of insect-resistant crops and reducing chemical pesticide use. The integration of non-Bt genes, inducible resistance systems, and functional genomics is broadening the scope of eco-friendly pest control. Techniques like marker-assisted selection, DNA barcoding, and RIDL are enhancing crop resilience and pest monitoring. Moreover, genetic improvements in biocontrol agents and entomopathogens are reshaping biological control strategies. These breakthroughs underscore the urgent need to translate cutting-edge research into practical, field-level solutions for food security and environmental sustainability.

Dr. T.V.K. Singh

The integration of ecological principles into emerging agro-technologies is essential for long-term sustainability. Practices like intercropping, agroforestry, ecological engineering, and organic farming can be enhanced with digital monitoring tools, decision-support systems, and precision inputs. This synergy will enable Indian farmers to manage pests effectively while safeguarding the environment and biodiversity. I applaud the efforts of the organizing committee of NCEEA-2025 for curating a scientific platform that not only showcases recent advancements but also fosters interdisciplinary collaboration among researchers, students, extension professionals, and policymakers. The recognition of outstanding scientists and fellows further reflects the spirit of excellence and innovation that drives entomological research forward.

Dr. Mani Chellappan

Plant protection is transitioning from input intensive pest control to integrated pest management (IPM) that incorporates biological control agents, biopesticides, ecological engineering, and emerging molecular tools. With climate change influencing pest dynamics and emerging transboundary threats, there is an urgent need to strengthen pest surveillance systems, predictive modeling, and biosecurity frameworks across regions.

The integration of emerging agrotechnologies, such as remote sensing, AI-driven pest forecasting, RNAi tools, and precision diagnostics, promises to revolutionize both plant protection and animal health systems. These technologies must be localized and made accessible to farmers through participatory extension systems.

R. S . Baloda

Given the increasing challenges of climate change, land degradation, and declining soil health in Indian agriculture, it is crucial to integrate soil arthropod management into our broader strategies for sustainable crop production. Maintaining beneficial arthropod community is one of the themes of conference while managing the problematic one with minimal use of chemical inputs Addressing the emerging issues to help create a biologically active and

resilient soil environment for their growing role in integrated pest and nutrient management is necessary. Integrating their ecological functions into mainstream agricultural research and extension will be critical for building sustainable and scalable agroecological models suited to Indian farming systems.

Dr. D. M. Firake

Insects contribute immensely to ecosystem services that sustain agricultural productivity and environmental balance. These services include pollination, natural pest regulation, decomposition, and nutrient cycling. Recognizing and preserving these insect-mediated functions is essential for promoting sustainable and resilient farming systems.

IIn the context of Indian agriculture, where biodiversity is rich yet vulnerable, understanding insect ecosystem services helps in devising strategies that support beneficial insects while managing pest populations effectively. Conservation of pollinators and natural enemies is key to reducing chemical pesticide dependence and enhancing crop yields.

Emerging research and agrotechnologies aimed at protecting and augmenting insect ecosystem services can pave the way for eco-friendly and sustainable agriculture.

Dr. Vandhana Tripathy

Pesticide residues remain a critical concern in agriculture, impacting food safety, environmental health, and trade. While pesticides are essential for protecting crops, their judicious use is necessary to minimize residues in food and the environment. Ensuring residue levels remain below permissible limits protects consumer health and maintains export competitiveness.

Addressing pesticide residues requires a multi-disciplinary approach involving robust residue monitoring, promotion of safer and bio-based alternatives, strict adherence to pre-harvest intervals, and farmer education on responsible pesticide use. Advances in residue detection technologies and integrated pest management practices offer promising solutions to reduce chemical loads while maintaining crop productivity.

I commend the organizers for prioritizing this important topic and congratulate the awardees and fellows for their outstanding contributions. I hope the deliberations at NCEEA-2025 will foster innovative strategies towards residue-free, sustainable agriculture

that safeguards health and environment for future generations.

Dr. S. Senthil-Nathan

Molecular entomology has revolutionized our understanding of insect biology, ecology, and interactions with host plants. Techniques such as gene editing, RNA interference, and genomics enable precise targeting of pest species and the development of novel, environmentally friendly pest management strategies. These molecular tools are pivotal in unraveling insect resistance mechanisms, identifying pest biotypes, and enhancing biological control agents.

In the Indian context, integrating molecular entomology with t raditional pest management approaches can accelerate the development of resistant crop varieties, reduce pesticide reliance, and promote eco-friendly agriculture. Continued research and collaboration are essential to harness the full potential of these technologies.

M K Dhillon

Insect physiology, as a foundational discipline, provides critical insights into the behavior, development, and interactions of insect pests and beneficial species. Understandingthephysiological mechanisms enables the development of innovative pest management strategies that are environmentally safe, targeted, and efficient. India's vision in insect physiology is firmly aligned with integrating advanced research tools such as molecular biology, genomics, and metabolomics to address challenges in pest control, pollinator health, and ecosystem sustainability.

As we face complex challenges like pesticide resistance, climate change, and biodiversity loss, the role of insect physiology becomes ever more significant in designing next-generation agro- technologies. The integration of physiological knowledge with emerging technologies—including precision agriculture, bioinformatics, and artificial intelligence—will be key to achieving resilient and productive farming systems.

Dr. Sachin S. Suroshe

India, with its rich biodiversity and diverse agro-climatic zones, is home to a remarkable variety of honey bees and pollinators, India hosts 800 plus species of Apoids out of 2000 spp. distributed all over the globe. These unsung heroes of agriculture play a pivotal role in sustaining food production, supporting ecosystems, and enhancing the livelihoods of millions of farmers. It is presumed that pollinators contribute more than 1.5 lakh crores annually through pollination services in our country. In recent decades, the importance of pollination services has gained widespread recognition, especially in the context of declining pollinator populations due to habitat loss, climate change, pesticide use, and harmful farming practices.

Dr. P.K. Mehta

Host-plant resistance remains a cornerstone in integrated pest management, offering an eco-friendly and cost-effective approach to managing insect pests. Developing and deploying resistant crop varieties reduces the dependency on chemical pesticides, thus minimizing environmental contamination and enhancing farmer profitability.

In India's diverse agro-climatic zones, breeding for host-plant resistance against major insect pests is crucial to safeguard crop yields and ensure food security. Advances in molecular biology, genomics, and phenotyping tools have accelerated the identification and incorporation of resistance traits into high-yielding varieties.

Integrating host-plant resistance with other pest management strategies such as biological control, cultural practices, and judicious pesticide use will lead to more resilient and sustainable farming systems.

Ajay Sood

Pest management in protected cultivation represents a sustainable pathway to address pest challenges while safeguarding crop quality and environmental health. Emerging technologies, such as automated pest monitoring, AI-based diagnostics, and precision application systems, hold immense potential to improve decision-making and minimize pesticide use. Training growers and stakeholders in these innovations is crucial for the successful implementation of IPM in protected cultivation.

I wholeheartedly congratulate the organizing committee of NCEEA-2025 for recognizing the relevance of these themes and providing a vibrant platform for the exchange of knowledge.

J.P Singh

It is with great pride and enthusiasm that we welcome all esteemed delegates, researchers, academicians, industry experts, and students to the National Conference on Entomology and Emerging Agro-technologies.

This conference comes at a pivotal time when the integration of advanced technologies with entomological research is unlocking new pathways in pest management, biodiversity conservation, agricultural sustainability, and public health. From precision agriculture and genomic tools to AI-driven pest diagnostics, the intersection of technology and entomology holds immense promise for addressing some of the most pressing challenges of our time. The integration of entomological insights with emerging agrotechnologies-such as drones, AI/ML based pest surveillance and predictive modelling-offers a transformative approach to plant protection.

Indian agriculture is as diverse as its dynamic, and the unique challenges faced by various agro-ecological zones, including those in Jammu & Kashmir, call for zone specific strategies.

Dr. Mohammad Monobrullah

Productive insects, including pollinators, natural enemies, and beneficial soil arthropods, play an indispensable role in enhancing agricultural productivity and ecosystem health. Pollinators like bees and butterflies ensure fruit set and seed production in many crops, while natural enemies help regulate pest populations, reducing the dependence on chemical pesticides.

In the context of Indian agriculture, where diverse cropping systems prevail, the

conservation and promotion of productive insects are vital for achieving ecological balance and improving crop yields sustainably. Enhancing habitat diversity, adopting integrated pest management practices, and minimizing pesticide misuse are key strategies to protect these beneficial insect communities.

Emerging agrotechnologies such as precision farming, biopesticides, and digital monitoring tools provide new avenues to support productive insect populations and maximize their benefits for farmers.

Dr. M. Raghuraman

Nanotechnology is emerging as a revolutionary tool in entomology, offering novel solutions for pest management and crop protection. The application of nanoscale materials and formulations enhances the efficacy, targeted delivery, and environmental safety of pesticides and bioinsecticides. Nanotechnology also holds promise for developing innovative diagnostic tools and smart delivery systems for sustainable pest control.

Incorporating nanotechnology into entomological research can address challenges such as pesticide resistance, environmental pollution, and non-target effects, thereby promoting safer and more efficient pest management strategies.

In the Indian agricultural context, nanotechnology-based approaches can significantly contribute to increasing crop productivity while safeguarding ecosystem health. Continued research, regulatory frameworks, and stakeholder awareness are essential to realize the full potential of nanotechnology in sustainable agriculture.

Subhash Chander

Esteemed members and delegates of the National Congress on Entomology and Emerging Agrotechnologies (NCEEA-2025), I extend a cordial greeting. May this assembly foster insightful discourse and collaborative innovation, propelling advancements in entomological science and sustainable agrotechnological practices for the benefit of our nation.

Crop protection is a critical component of crop production systems, essential for ensuring safe food production, environmental conservation, and increased farmer income through Good Agricultural Practices (GAP). Integrated Pest Management (IPM) has been the Government of India's core policy for crop protection since 1985. However, the adoption rate of IPM remains less than satisfactory, as its implementation requires in-depth knowledge of crop loss assessment, diagnostics, surveillance, forewarning techniques, and pest suppression tools. Simulation techniques also prove more efficient for pest forewarning *vis-a-vis* regression approach. Pest identification requires revamping in terms of human resource and complementarity between morphological and molecular techniques

such as DNA barcoding, and AI based techniques. Surveillance is backbone of IPM and it can be made more efficient by leveraging geo-spatial techniques like remote sensing and GIS, and drone application. Strong networking at national level is need of the hour to ensure quick detection and containment of invasive species.

Pest suppression tactics such as host plant resistance, and biological and cultural control are fundamental to pest management due to their economic and ecological benefits.Conservation biological control and mass production of natural enemies deserve greater attention. Likewise, there is ample potential for entrepreneurship in rural youth in production of bio pesticides. In view of changing climate, thermo-tolerant sources of host plant resistance and natural enemies are needed. Similarly, limited availability of semio-chemicals like pheromones to farmers demands addressal. Safe use of chemicals is to be encouraged with emphasis on safety of growers and consumers, and pollinators and other non-target organisms. Besides, synergy among various crop protection agencies is required to create awareness among various stakeholders for need of IPM adoption in the country.

Uma Shankar
Secretary, ESA

Esteemed delegates and research scholars, the National Congress on Entomology and Emerging Agrotechnologies (NCEEA-2025) is a forum dedicated to advancing sustainable agricultural development through effective pest and pollinator management. This congress serves as a vital platform for educating future generations on innovative applications within entomology, emphasizing the beneficial roles insects fulfill within our ecosystems and society. A core objective of NCEEA-2025 is the conservation of insects across both terrestrial and aquatic environments, exemplified by initiatives such as Butterfly gardens and pollinator parks. By prioritizing ecologically based integrated pest management and actively supporting pollinator populations, we can secure the long-term plant health and productivity of the agricultural sector, thereby fostering a more sustainable future for all. Active engagement, shared expertise, and collaborative development of strategies that integrate ecological principles into agricultural practices are strongly encouraged.

Acknowledgement

We are deeply grateful to **all the esteemed institutions, organizations, and sponsors** whose generous support and collaboration have made the National Congress on Entomology and Emerging Agrotechnologies (NCEEA-2025) a reality.

We extend our sincere thanks to Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-Jammu) for its academic leadership and unwavering commitment to agricultural research and education. A special note of appreciation is due to the faculty, students, and research scholars of the Division of Entomology, **SKUAST-Jammu**, whose dedication, hard work, and active involvement have been instrumental in the successful planning and execution of this conference.

We also acknowledge Indian **Institute of Technology (IIT) Jammu** for its scientific collaboration and support in fostering interdisciplinary innovation.

Our heartfelt appreciation goes to **J&K Bank** and **State Bank of India (SBI)** for their financial sponsorship and continued commitment to supporting rural and agricultural development through banking and credit services. Their contribution to strengthening the agricultural ecosystem is invaluable.

We sincerely thank **Bayer Crop Science**, a global leader in agricultural innovation, for its support in promoting sustainable crop protection through advanced technologies and integrated pest management solutions. We also acknowledge **Godrej Agrovet**, a major contributor in the fields of animal feed, crop protection, and agri-services, for their commitment to farm sustainability.

We are grateful to **JKSTIC (Jammu & Kashmir Science, Technology & Innovation Council)** for promoting science-driven agricultural practices in the region. Our thanks also go to **Gharda Chemicals**, known for their role in agrochemical innovation and pest control solutions.

We express our appreciation to **Power Grid Corporation of India Ltd.** for their CSR initiatives supporting agricultural empowerment. We thank **Somany Ceramics Ltd.** for their generous sponsorship and commitment to community development, and **Saraswati Group**, a leader in educational publishing, for aiding knowledge dissemination.

We also recognize **Solar Industries India Ltd**., a key player in defense and industrial solutions, for their support in research initiatives. Our sincere thanks to **PY Resort**, our hospitality partner, for ensuring a comfortable and welcoming environment for all attendees.

Finally, we extend our gratitude to **Ramesh Traders**, a reliable agri-input distributor, for their logistical support and close association with the farming community.

Together, your contributions have played a pivotal role in making this conference a success and advancing the shared vision of sustainable agriculture, scientific excellence, and food security. We look forward to continued collaboration in the years ahead.

Theme-1

Emerging Issues in Pest Management

&

Biological Invasions

Theme-1

Redefining Education and Prioritizing Research on Entomology for Viksit Bharat

Poonam Jasrotia [1] R, K. Gupta [2], Mudasir Gani [3]

[1]Indian Council of Agricultural Research [2]Division of Entomology, Faculty of Agriculture, Sher-e-Kashmir University of Jammu, [3]Division of Entomology, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, J & K, India

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Preface

Entomology is experiencing a profound transformation in India, driven by a confluence of educational reforms, advancements in technology, and a rising tide of innovation and entrepreneurship. Aligned with the national vision of Viksit Bharat@2047, the discipline of insect science is evolving beyond its traditional boundaries of pest management and crop protection. It is now making significant inroads into biotechnology, public health, environmental conservation and industrial applications. Across India, the modern entomologist is equipped with tools ranging from molecular biology and genomics to AI-driven pest surveillance and biotechnological solutions for sustainable agriculture. With growing concerns about insecticide resistance, pollinator decline and vector-borne diseases, entomology is becoming central to addressing agro-ecological resilience, biosecurity, and food security. Major institutions such as the Indian Council of Agricultural Research (ICAR) and universities across the country are spearheading curriculum reforms and interdisciplinary research. Initiatives like the National Mission on Sustainable Agriculture, Startup India and One Health Approach are also encouraging entomological innovations from biopesticide production and insect-based protein feed to genetically engineered vectors for disease control.

Entrepreneurship in insect science is thriving, with startups engaged in mass rearing of beneficial insects, silkworm-based biotechnology, entomo-nutrition, and pollination services. Digital platforms and mobile apps are being used for pest diagnosis, real-time surveillance, and extension education, making entomological services accessible even in remote rural areas. In the Union Territory of Jammu & Kashmir, the ecological diversity ranging from temperate Kashmir Valley to subtropical Jammu provides a rich niche for diverse insect fauna and associated research opportunities. The region's agriculture, horticulture and forest ecosystems face unique insect pest management challenges and opportunities for biological control and advanced solutions for pest management. Institutions like SKUAST-Kashmir and SKUAST-Jammu are increasingly integrating modern entomological research into local contexts, with a focus on biological control, conservation of pollinators, promotion of sericulture, lac cultivation and addressing the threat of invasive pests.

There is a growing push to link entomology with tribal empowerment, eco-tourism and rural livelihoods through the Tribal Sub Plan, Krishi Vigyan Kendras (KVKs), and entrepreneurship programs that encourage youth and women to participate in mass production of biocontrol agents, beekeeping, sericulture and lac cultivation. The evolution of entomology in India and its regional innovation in Jammu & Kashmir is emblematic of how traditional sciences can be revitalized through a combination of policy support, technology and local knowledge. Insect science holds immense potential to contribute to India's goals of climate-smart agriculture, public health preparedness, bioeconomic development, and global scientific leadership. With continued investment in research, education, and rural innovation, entomology is poised to become a key enabler in India's journey toward Viksit Bharat@2047.

Modern Entomology in India: Reforms, Innovations and Opportunities

Entomology is witnessing a dynamic transformation in India, driven by progressive educational reforms, technological innovation, and growing entrepreneurial interest. Under the national vision of *Viksit Bharat@2047*, insect science is evolving into a multidisciplinary domain with expanding applications in biotechnology, integrated pest management, public health, environmental sustainability and rural development. In this new paradigm, entomology is no longer limited to pest management; it now intersects with critical sectors such as food security, climate change mitigation, biodiversity conservation, and bioresource utilization. Universities and research institutions across the country are reorienting their curricula to include cutting-edge areas like insect biotechnology, molecular diagnostics, biological control, pollinator health, and bioeconomy development.

The Union Territory of Jammu & Kashmir exemplifies the potential of this transformation. With its unique agro-climatic diversity, rich biodiversity and growing emphasis on sustainable livelihoods, J&K presents a fertile ground for deploying insect-based technologies. Initiatives in apiculture, sericulture, lac cultivation, and biocontrol are enhancing farmers' incomes, empowering tribal communities and contributing to ecological resilience. Strengthening entomology education and research in J&K could further support entrepreneurship, skill development and rural innovation aligned with the region's developmental goals. As India moves towards becoming a knowledge-based economy, the strategic integration of entomology into national and regional development frameworks offers immense potential to address contemporary challenges while unlocking new opportunities for growth and sustainability.

I. Educational Reforms and the NEP 2020 Push

The reorientation of entomology education in India is closely aligned with the National Education Policy (NEP) 2020, which promotes interdisciplinary learning, innovation and skill development. Universities across the country including agricultural and life science institutions are revamping entomology syllabi to include cutting-edge subjects such as insect biotechnology, genetic engineering, biosensors, RNA interference (RNAi), urban entomology, and bioinspired robotics (Rajashekara et al., 2022). In line with NEP, institutions are transitioning from rote learning to project-based, experiential,

and research-oriented pedagogy. Students are now encouraged to work on real-world problems, pursue internships, engage with industry, and explore opportunities in startup incubation and public-private partnerships. This has transformed entomology into a launchpad for cross-sectoral innovations. In Jammu & Kashmir, institutions like SKUAST-Kashmir and SKUAST-Jammu are adopting these reforms with region-specific relevance. Their focus includes high-altitude insect biodiversity, biological control of insect pests, conservation of endemic pollinators, and entomological solutions for horticulture and sericulture.

II. Entrepreneurship and Insect-Based Startups

A significant contribution to the entrepreneurial dimension of entomology comes from Dr. R.K. Gupta's seminal work, *"Entrepreneurship and Startups in Entomology: Innovations for Atmanirbhar Bharat"* (2021). Gupta outlines how the enormous potential of insects for pollination, pest management, food security, and pharmaceutical use can be translated into scalable businesses.

He presents case studies of Indian startups engaged in:

- Black soldier fly farming for organic waste valorization and animal protein feed.
- Cricket farming for human nutrition as alternative protein.
- Insect-based biopesticides for organic agriculture.
- Silkworm-derived biomaterials for biomedical applications.
- Insect-based waste management systems and eco-products.

Such startups are supported by incubators, government funding schemes (RKVY-RAFTAAR, BIRAC-BIG, DST-Start-Up India), and innovation ecosystems across the country. In J&K, this entrepreneurial surge has opened new vistas for rural employment. Silkworm-based enterprises, biocontrol agent production, beekeeping, and insect frass-based composting are emerging as viable livelihood avenues under programs like the Tribal Sub Plan and KVK-led training initiatives.

III. Innovations in Biomimetics, Biosensors and Defence Tech

Entomology's influence has extended into the realms of engineering, defence, and materials science. The microstructure of insect wings, compound eyes, and antennae are now models for designing:

- Surveillance drones and biorobots
- Multifunctional biosensors
- Smart textiles and camouflage materials

These bioinspired technologies are increasingly important in defence and disaster management sectors. In J&K's context, such innovations have strategic significance for terrain monitoring, border security, and climate-resilient infrastructure. Sensor technologies derived from insect physiology are also finding applications in agriculture and healthcare detecting crop diseases, pesticide residues, air quality, and even explosives (Chakraborty et al., 2022).

IV. Endosymbiosis and Microbiome Research

A rapidly emerging frontier in entomological research is the study of insect endosymbionts that reside within insect hosts and play crucial roles in regulating their physiology, reproduction, immunity and even behaviour. Among these, *Wolbachia*, *Buchnera*, and *Serratia* have garnered particular attention for their diverse and impactful interactions with insect hosts.

Research on these symbiotic microbes is revealing ground breaking applications, including:

- Vector control through reproductive manipulation, such as cytoplasmic incompatibility induced by *Wolbachia* to suppress mosquito populations;
- Gene drive and synthetic biology tools, where engineered endosymbionts can spread desirable traits through insect populations to control pest species or reduce disease transmission;
- Environmentally sustainable pest management, where symbiont-based strategies reduce dependence on chemical insecticides.

Dr. R.K. Gupta (2021), in his visionary work, outlines a strategic roadmap for harnessing insect microbiomes in agriculture and public health. He emphasizes the potential of microbiome manipulation to curb vector-borne diseases and pest outbreaks, especially in climate-sensitive regions like Jammu & Kashmir. With warming temperatures and changing precipitation patterns expanding the range of insect vectors in the region, microbial symbionts offer a targeted, eco-friendly alternative to conventional control measures. This innovative approach aligns with India's goals for biosafe, sustainable and next-generation pest management under the broader vision of Viksit Bharat@2047.

V. Conservation and Eco-Entrepreneurship

The ecological importance of insects as pollinators, decomposers, and regulators of food webs is gaining increasing recognition in both academic circles and public discourse. With growing awareness of biodiversity loss and pollinator decline, insect conservation is emerging as a national priority in India. Key initiatives include:

- Butterfly parks and bee sanctuaries, which serve as biodiversity reserves, educational hubs, and breeding sites for threatened pollinators;
- Pollinator pathways embedded within agricultural landscapes to enhance ecosystem services and crop productivity;
- Rewilding programs aimed at restoring habitats for rare and endemic insect species, particularly in forest and high-altitude ecosystems.

This conservation momentum is also driving eco-entrepreneurship. Innovative startups are monetizing insect biodiversity through services such as managed pollination, biodiversity audits for certification and eco-labelling of insect-friendly agricultural products. In Jammu & Kashmir, home to unique temperate and alpine ecosystems, these developments hold special promise. The region's rich insect diversity spanning endemic butterflies, wild bees, and forest-dwelling beetles offers opportunities for eco-tourism, community-based conservation education, and the sustainable branding of horticultural

and herbal products. Integrating insect conservation into development planning can thus support both livelihood security and ecological resilience. In this context, insect conservation is not just a biological imperative it is a pathway to sustainable development, climate adaptation and bio-cultural heritage preservation.

VI. Urban and Medical Entomology: Emerging Frontiers

Urbanization has brought new challenges like vector-borne diseases and household pests. Modern urban entomology uses:

- AI-enabled mosquito traps
- GIS-based vector surveillance
- RNAi and CRISPR-based vector control
- Mobile diagnostics for pest identification

Medical entomologists are collaborating with biotech firms on novel approaches to disease prevention, including Wolbachia-induced sterility in mosquitoes and gene-edited vectors for malaria and dengue control. These technologies are highly relevant for J&K's urban centers, which face seasonal mosquito outbreaks due to changing temperature and water storage patterns.

VII. Pharmaceutical Applications and Bioactive Compounds

Insects are increasingly being recognized as reservoirs of bioactive compounds with significant potential in human and veterinary medicine. This emerging field is placing entomology at the intersection of biotechnology, pharmacology, and regenerative healthcare.

Key research areas include:

- Silk fibroin, derived from the silkworm (*Bombyx mori*), is being explored for its exceptional biocompatibility and structural properties, making it ideal for wound healing, tissue scaffolding, and drug delivery systems.
- Bee propolis, a resinous substance produced by honeybees, exhibits potent antimicrobial, antioxidant, and anti-inflammatory properties and is being formulated into natural remedies for infections, oral care and skin conditions.
- Haemolymph-derived molecules, including antimicrobial peptides and immunomodulators from various insects, are under investigation for their ability to enhance immune responses and combat resistant pathogens.

These discoveries are driving a new wave of insect-based therapeutics, with biotech startups leading the charge in developing formulations for skin regeneration, wound dressings, veterinary supplements and natural health products. The shift toward sustainable, low-toxicity, and bio-compatible alternatives is accelerating interest in insect-derived biomolecules. As this bioresource frontier expands, entomology is gaining prominence as a critical contributor to future-ready healthcare solutions, reinforcing its role in personalized medicine, regenerative therapy and green pharmaceutical innovation.

VIII. Policy Support and Institutional Linkages

Dr. R.K. Gupta highlights the urgent need to strengthen the connections between academic research, entrepreneurship, and policy frameworks to fully harness the potential of entomology in India. He advocates for a systemic approach where knowledge generation translates into real-world impact through institutional support and strategic partnerships.

Key recommendations include:

- Establishing business incubation cells within entomology departments to support student-led innovations and startups.
- Introducing elective courses on intellectual property rights (IPR), agribusiness management, and science entrepreneurship to prepare students for a competitive bioeconomy.
- Creating mentorship networks by engaging industry leaders, experienced entrepreneurs and domain experts to guide early-stage ventures and innovations.

In the context of Jammu & Kashmir, where agriculture forms the backbone of rural livelihoods, these initiatives can play a transformative role. Linking entomology with agri-policies, startup funding mechanisms and export-driven innovation can create new opportunities for employment, local enterprise and sustainable development. By embedding scientific knowledge into policy and practice, entomology can emerge as a key driver of inclusive growth and ecological resilience in the region. Strengthening institutional linkages and ensuring targeted policy support will not only advance insect science but also contribute meaningfully to national goals under *Viksit Bharat@2047*.

Conclusion: Toward Viksit Bharat@2047 Through Insect Science

Modern entomology in India and in J&K in particular is no longer limited to classical taxonomy and pest management. It has transformed into a vibrant, future-ready discipline integrating biotechnology, ecology, engineering, medicine and enterprise. With strategic investments in education, research, and innovation ecosystems, entomology can play a pivotal role in achieving India's sustainable development goals and global competitiveness. As we look toward 2047, insect science is poised not just to solve problems but to spark a revolution of bioinspired solutions for a self-reliant and ecologically resilient India.

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Abstracts

Abundance of insect pest and visitation of beneficial insect fauna on safflower, *Carthamus tinctorious* L.

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Safflower (*Carthamus tinctorius* L.) is an important oilseed crop valued for its oil and medicinal properties. However, its cultivation is often ravaged by insect pests that significantly affect its yield and quality. A field trial was carried out during Rabi 2024-25 at experimental field of Entomology, SKUAST-Jammu to study the incidence of major insect pests and beneficial insects associated with safflower. The population of various insect pests and beneficial insects were recorded at weekly intervals during morning hours and weekly mean population were recorded and correlated with weather factors accordingly. The study revealed the occurrence of three major insect pests including safflower aphids (*Uroleucon carthami*), capsule borer (*Helicoverpa armigera*), and safflower weevil (*Larinus* sp.). Among these, the safflower **weevil was recorded for the first time in the Jammu region**, with infestation primarily occurring during the capsule formation stage 13th SW and maximum peak population was observed in 17th SW and lasts up to harvesting of crop. The assessment of damage potential by *Larinus* weevil was recorded approximately 12 per cent. Apart from insect pest, a diverse population of beneficial insects such as coccinellid beetles, green lacewings, syrphid flies, preying mantids, spiders, *Apis* bees, and Non-*Apis* bees, were recorded visiting the crop. The natural enemies including *Coccinella septumpunctata*, C. *transversalis, Menochilus sexmaculata, Chrysoperla carnea, Syrphus* spp., *Mantis religiosa* and *Archimantis* sp. and generalist predator spiders play a crucial role in biological control of aphids and other smaller insects like thrips and pollinators like *Apis cerana*, *A. dorsata*, *A. mellifera*, *Xylocopa fenestrata*, Nomia bee, Megachilid bee, Halictid bee aids in pollination and seed set. Correlation analysis revealed that abiotic factors, such as temperature, relative humidity, rainfall, bright sunshine hours, and wind velocity, influence the population dynamics of both pests and beneficial insects. These findings highlight the significance of understanding insect-weather relationships and conserving beneficial insect's effective pest management and pollination services for proper seed set in safflower cultivation.

Keywords: *Carthamus tinctorius*, **insect pest,** *Uroleucon carthami*, *Helicoverpa armigera*, and Larinus weevil, Natural enemy, Pollinators

Bio-efficacy of Anthocorid predator against major sucking pests of Cucumber under protected conditions

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One of the most commercially grown vegetable crop under protected conditions is cucumber. Despite the growing importance of cucumber cultivation under protected cultivation there are numerous hindrances that affect its production, the prevalence of plant pests and diseases is amongst other factors. Protected cultivation is an intensive method of crop production and offers protection to different plant growth stages from adverse environmental conditions which however, also provides a stable and congenial micro-climate, which is favourable for the multiplication of insect pests population to become one of the limiting factors for the successful cultivation of a crop.

Crop productivity threatened by pest infestations can cause yield losses of approximately 30–100% depending on the species and season. The management of sucking pests often relies on synthetic chemical pesticides; however, their excessive and improper application has led to numerous challenges, including pesticide residues on crops, the resurgence of pest populations, the development of resistance, biological imbalance, increased environmental contamination, the disruption of natural enemy populations and even human health hazards. These challenges underscore the need for alternative pest control strategies that align with integrated pest management (IPM) principles. Frequent rejection of export consignments due to pesticide residues highlights the importance of chemical–free methods.

Biological control using natural predators offers a sustainable, eco–friendly alternative, reducing reliance on chemicals while ensuring residue–free, healthier produce. *Blaptostethus pallescens* Poppius (Hemiptera: Anthocoridae), commonly referred to as the anthocorid bug, is a prominent predator of vegetable pests and has emerged as a promising biocontrol agent for managing a wide range of sucking pests, including mites, thrips, mealybugs, aphids, and stored–product insects. Owing to their high predatory efficiency, ability to congregate in areas with dense prey populations, and rapid reproductive potential when food is abundant, anthocorid bugs are considered effective biological control agents. *B. pallescens* can be cultured intensively without issues such as cannibalism or excessive handling, making it suitable for commercial mass production. Its broad prey spectrum further positions it as an ideal candidate for augmentative releases and large–scale rearing in subtropical regions.

The studies on bio efficacy of anthocorid bug, *Blaptostethus pallescens* against three sucking pests of cucumber, namely *Tetranychus urticae, Aphis gossypii and Trialeurodes vaporariorum* under protected cultivation revealed that the *B. pallescens* was most effiecient against mite, then aphids followed by whiteflies in terms of percent pest mortality. The use of *B. pallescens* at 150 bugs per plant led to a significantly higher level of percent mean mortality (77.75% in *T. urticae*, 75.11% in *A. gossypii* and

71.02 % in *T. vaporariorum*) than with 50 or 100 bugs per plant. Results suggest that above mentioned *T. urticae, A. gossypii and T. vaporariorum* can be effectively managed by the release of this anthocorid bug. *B. pallescens* as part of an IPM system for the management of pests on parthenocarpic cucumber grown under polyhouse.*B. pallescens* against

Leaching behaviour of tolfenpyrad in soil column under laboratory conditions

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Tolfenpyrad is a pyrazole-carboxamide insecticide that inhibits mitochondrial respiration by targeting Complex-I of the electron transport chain and performed better against the sucking pest complex of vegetables and is considered safer for natural enemies. Its low water solubility (0.087 mg/L), high organic solubility (7410 mg/L), and strong soil-binding potential suggest limited mobility in soil environments. To investigate its leaching behaviour, laboratory column studies were conducted using sandy loam soil treated with 5 ppm and 10 ppm doses under both field capacity and flooding conditions. Under 5 ppm field capacity, tolfenpyrad residues in the 0-15 cm soil layer declined from 4.62 mg kg^{-1} (0 day) to 0.27 mg kg^{-1} (35 day), accounting for 94.1 percent dissipation. Minimal residues (≤0.02 mg kg^{-1}) were observed at 15–30 cm depth, with only 0.00001 mg kg^{-1} detected in the leachate. Under flooding conditions, 5 ppm treatment resulted in 93.5 percent dissipation in the surface layer by day 35, with residues of 0.03 mg kg^{-1} at 15–30 cm depth. At 10 ppm under flooding, residues reached up to 0.05 mg kg^{-1} at 45–60 cm, though leachate still contained negligible residues (≤0.00005 mg kg^{-1}). Overall, more than 90 percent of tolfenpyrad residues remained confined within the upper 15 cm of soil across all treatments. The negligible detection of residues in leachate confirms its low leaching potential. These findings suggest that tolfenpyrad poses minimal risk to groundwater contamination when applied as recommended, supporting its environmental safety profile in vegetable crop protection.

Keywords: Tolfenpyrad, Leaching, Soil Column, Soil and Leachate.

Survey of Bio-diversity of Natural Enemies of Fall Armyworm *Spodoptera frugiperda* in Udaipur Region

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A survey of natural enemy species was conducted across five sites in Udaipur: Site 1 (Rajasthan College of Agriculture), Site 2 (Bedla), Site 3 (Rama), Site 4 (Vallabhnagar), and Site 5 (Dungarpur). At Site 1, *Trichogramma chilonis* (17.00) dominated the first visit, followed by *Coccinella septempunctata* (9.00) and *Chelonus formosanu* (8.00), while spiders and *Oxycetonia versicolor* were least abundant (4.00). By the second visit, *T. chilonis* increased (20.00), alongside rises in *Chelonus blackburni* (15.00) and *C. formosanus* (13.00). However, in the third visit, *Coccinella transversalis* (11.00) became dominant, while *T. chilonis* declined (6.00), and spiders were rarest (3.00). At Site 2, *C. blackburni* (19.00) and *Campoletis chlorideae* (16.00) were initially most prevalent, with *T. chilonis* rarest (3.00). Later, *C. chlorideae* (17.00) remained dominant, while *Cotesia flavipes* dropped (1.00). By the third visit, *C. formosanus* (15.00) led, with *T. chilonis* and *O. versicolor* least observed (2.00).

At Site 3, *C. blackburni* (14.00) dominated the first visit, while spiders were scarcest (1.00). Later, *C. formosanus* (15.00) and *Charops bicolor* (14.00) led, with *Exorista sorbillans* absent. By the third visit, *C. blackburni* (13.00) regained dominance, and *E. sorbillans* was rarest (1.00). At Site 4, *C. transversalis* (8.00) was most common initially, while *T. chilonis* and *C. flavipes* were rarest (2.00). Later, *C. formosanus* and *Forficula* sp. (7.00) dominated, with *C. bicolor* declining (1.00). Finally, *C. blackburni* and *C. transversalis* (8.00) were highest, while *E. sorbillans* was absent. At Site 5, *C. bicolor* (10.00) led initially, with *E. sorbillans* and *C. chlorideae* absent. Later, *C. bicolor* (14.00) remained dominant, while spiders fell (1.00). By the third visit, *C. bicolor* (12.00) stayed highest, and *C. flavipes* (1.00) was least observed.

Keywords: Biodiversity, *Chelonus formosanus*, *Cotesia flavipes*, *Chelonus blackburni*, Udaipur.

Assessment of DTPA-Extractable Micronutrient Status of Tomato-Growing Soils of Bilaspur District of Himachal Pradesh

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Micronutrients, though required in small quantities, play a vital role in the growth, development and productivity of tomato plants; therefore, their efficient management in tomato-growing soils is essential. Therefore, a survey of tomato growing soils of Bilaspur district of Himachal Pradesh was carried out to assess the micronutrients status of the soils and to work out the relationship between soil characteristics and available soil and leaf micronutrient contents. For this, 113 soil sampling locations were selected and 226 representatives surface (0-15 cm) and sub-surface (15-30 cm) soil samples were collected processed and analyzed for different micronutrients content. The tomato growing soils of the district varied from sandy loam to loamy sand in texture. The soils were neutral, slightly alkaline and slightly acidic in reaction and EC values of all the soil samples were under normal range. The soil micronutrient indices indicated that the soils of the study area were medium in DTPA-extractable Fe, Zn and Mn, whereas, high in DTPA-extractable Cu. Representative tomato leaf samples were collected at mid bloom stage from the same farmer's field and analyzed for micronutrients. Leaf nutrient status showed that all the samples were in medium in total Fe, Cu, Zn and Mn. Correlation studies showed that the leaf micronutrient contents had a highly significant and positive correlation with their respective availability in soil. The strong positive correlation observed between soil and leaf micronutrient contents highlights the direct influence of soil nutrient availability on plant nutrition, underscoring the need for targeted, site-specific micronutrient management in the tomato-growing soils of Bilaspur district.

Keywords: DTPA-Extractable Micronutrient, Tomato-Growing Soils

Large Scale Demonstration of Bio-Intensive Pest Management on Rice

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An experiment was conducted to study the efficiency of bio-intensive pest management practices in farmers' field at seven different locations of Jorhat, Golaghat and Sivasagar districts of Assam from the year 2022-2025. The results indicated that in all the three locations the dead heart (%), WEH (%) and LFDL (%) were significantly lower in BIPM and chemical control plot than control. The BIPM technologies were equally effective with chemical control in terms of dead heart (%), WEH (%) and LFD (%) damage. There was no significant difference of yield in between BIPM and chemical control

plot ranging from 4570.00 kg/ha to 4660.00 kg/ha in BIPM and 4740.00 kg/ha to 4780.71 kg/ha in chemical control plot. In all the seven locations, the BIPM plots showed significantly higher number of natural enemies' population. Total 16 numbers of spider species under 8 different families (Tetragnathidae, Lycosidae, Araneae, Oxyopidae, Araneidae, Salticidae, Attidae and Linyphidae) and 7 numbers of dragonfly species and 4 numbers of damselfly species were recorded from BIPM plots. In the year 2022-23, the yield of rice was recorded to be 4570.00 kg/ha and 4780.71 kg/ha in BIPM and chemical control plots, respectively, which were 25.91% and 29.18% more yield than control. Similarly, in the year 2023-24, the yield was 4650.00 kg/ha and 4740.00 kg/ha in BIPM and chemical plots, respectively, which were 26.11% and 27.52% more yield than control. In 2024-25, the yield of rice was recorded to be 4660.00 kg/ha yield and 4758.00 kg/ha in BIPM and chemical control plots, respectively, which were 26.59 % and 28.11% more yield than control.

Keywords: bio-intensive pest management, natural enemies, yield, biocontrol

Development and Standardisation of Artificial Diet for Mass Multiplication of Chrysoperla Zastrowi Sillemi (Esben- Peterson) (Neuroptera: Chrysopidae) in Assam Conditions

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The study on the standardisation of artificial diet for Chrysoperla zastrowi sillemi was conducted under laboratory conditions during the year 2023-24 at biological control laboratory, AAU, Jorhat. Three artificial diets were evaluated along with a standard and check diet in a respect of developmental and reproductive parameters. The results revealed that maximum larval period was observed in standard diet (12.90 days) followed by diet II (9.90 days). The highest pupation success (94%) and pupation percentage (95%) were recorded in diet II. The maximum pupal period was observed in diet III (6.90 days) and minimum in diet II (5.60 days). Growth index was found maximum in diet I (10.47). The maximum mating period (7.80 mins), fecundity (310.38 eggs/female), rate of oviposition (25.80 eggs/day/female), post oviposition period (3.31 days) and egg hatchability (88.09%) were recorded in diet II. Based on the duration of complete life cycle, diet II seemed to be the most suitable diet, on which the insect completed development in 38.50 days and shortest life cycle duration (20.90 days) was observed on diet III. Adult female lived longer than male irrespective of the diet and adult longevity was highest on diet II (male 19.80 days and female 22.60 days) and minimum on diet III (male 6.80 days and female 8.00 days). The highest values of food consumption and utilization parameters viz., CI (4.40 mg/day/mg body wt.), GR (0.29 mg/day/mg body wt.), AD (89.82%), and ECI (43.47%) and ECD (76.14%) were recorded on diet II, and the lowest values were recorded on diet III (CI 2.61 mg/day/mg

body wt., GR 0.08 mg/day/mg body wt., AD 63.52%, ECI 25.60% and ECD 51.90%). The highest larval and adult mortality was observed on diet III. Based on developmental and reproductive parameters of C. zastrowi sillemi as well as food consumption and utilization by the insect, the diets can be arranged in the following descending order of preference for C. zastrowi sillemi - diet II> diet I> standard diet> check diet> diet III.

Keywords: artificial diet, biology, mass production, growth, development

Four decades of the introduction of *Zygogramma bicolorata* for biosupression of *Parthenium hysterophorus* L in India: Indicators of partial success

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Congressgrass, *Parthenium hysterophorus* L. of Neotropical origin possibly entered India from the USA through imported grains or seed lots. Biological control efforts for bio suppression of this weed were initiated in India in 1983 and within three years of its introduction, the beetle became established. Since then, the area under beetle defoliation is steadily increasing (> 0.56 million Km^2) and dramatic weed suppression is evident in many parts of the country, both by natural spread of the beetle and deliberate introduction by farmers. Our findings on the post-release impact over four decades suggested that the mean weed cover density has been reduced to the extent of 30.3 percent with increased richness of native vegetation replacing this weed with desirable species during these years. Furthermore, the carrying capacity of grasslands in terms of native grass biomass has also increased by over 26.2 percent. The most interesting ecological indicator of the success of this beetle that emerged from public opinion was the recovery of 12 species of native plants. Among them *Cassia tora* was the most dominant. Weed plasticity and beetle diapause are two major limitations that need to be addressed. While diapause can be reduced in lab through day length and insulin treatment, augmentative releases of this beetle at early flushes of weed are necessary.

Key words: Biological control; post release impact; partial success

Ecologically Based Integrated Pest Management Strategies for Fruit Fly: A Perspective and Challenges

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Fruit flies (Diptera: Tephritidae), belongs to genus *Bactrocera*, are among the most destructive insect pests of horticultural crops, causing significance and economic losses and posing a great threat to fruit and vegetable production in India. Their destructive capabilities can lead to complete yield loss, jeopardizing food security and economic stability for farmers. The conventional reliance on chemical pesticides to manage these pests raises concerns regarding food safety and environmental health. Indian sub-continent is the bowl of horticultural crops wherein, more than 200 fruit fly species present in India. Out of 200, only dozen of fruit fly species are of economic significance at different locations or regions of India. Earlier, eight different types of fruit fly species were recorded from Jammu in different vegetable and fruit crops ecosystem. Ecologically Based Integrated Pest Management (EBIPM) strategies offer a sustainable solution, which include the deployment of trapping devices utilizing male annihilation technique (MAT) and bait application technique (BAT), the promotion of biological control agents exclusively *Dichasmimorpha longicaudata*, and the judicious application of selective chemical insecticides in targeted baits. A large number of parasitoids were recovered from fruit crops In Jammu regions showed its promise in mitigating the fruit fly maggots and thereby their adult formation. This spot application approach minimizes ecological impact while effectively controlling fruit fly populations, offering a more sustainable and environmentally responsible solution for safeguarding India's agricultural output.

Keywords: Fruit flies, EBIPM, MAT, BAT, *Dichasmimorpha longicaudata*, Spot application

Exploring the feasibility of mass multiplication of Trichogramma embryophagum on eggs of Philosamia ricini

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Trichogramma embryophagum, a crucial biological control agent, requires host eggs that are not only easily accessible but also remain suitable under a range of storage and operating conditions in order to be mass-reared efficiently. This study compares the suitability of eggs from the Eri silkworm Philosamia ricini and the rice moth Corcyra cephalonica at nine distinct age intervals (1-day-old to 16-

day-old eggs) for T. embryophagum development and performance under controlled laboratory conditions (27±5°Cand 70±5%) for mass multiplication. The parasitism, adult emergence, female emergence (per cent), and adult longevity (days) were among the important biological parameters evaluated. The findings showed that C. cephalonica eggs that were one-day-old supported the highest initial parasitism and emergence, their suitability drastically decreased as they grew older. Conversely, P. ricini eggs maintained 70.00±1.64per cent parasitism and 65.77±1.30 per cent emergence even at 16-day-old eggs, which were significantly higher than the 06.60±2.97per cent and 1.81±1.81per cent in C. cephalonica eggs, respectively. In addition, parasitoids reared on P. ricini exhibited consistently higher female proportions and extended adult longevity across all age groups. Moreover, evaluations of host searching ability showed that females originating from P. ricini eggs parasitized 92.4 percent of P. ricini eggs and 88.5 percent of C. cephalonica eggs in subsequent exposures; these differences were reflected in emergence and female progeny, with females of P. ricini origin producing 90.2 per cent adult emergence and 67.5 per cent female progeny, as opposed to 86.3 percent and 53.4 per cent, respectively, from C. cephalonica. This demonstrated that females developing on P. ricini eggs maintain greater biological vigour, host discrimination ability, and reproductive potential in the following generation. Using P. ricini eggs will also increase mass-rearing efficiency, decrease reliance on C. cephalonica, and make it easier to combine sericulture with biological control programs. In addition to encouraging environmentally friendly pest control methods and enabling sustainable, year-round Trichogramma production, this will improve rural livelihoods by implementing environmentally conscious pest management practices.

Keywords: host suitability, biocontrol, mass multiplication.

Population dynamics of mango fruit fly, *Bactrocera dorsalis* (Hendel) (Deptera: Tephritidae) and toxicity of certain insecticides against the pest

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An experiment was conducted to study the population dynamics and toxicity of three insecticides, namely imidacloprid, emamectin benzoate, and lambda-cyhalothrin at different concentrations, against the pest mango fruit fly (*Bactrocera dorsalis*) using methyl eugenol traps. Two peak populations were observed, with a mean value of 78.66 and 78, coinciding with the fruiting and harvesting periods of the fruit at standard mean weeks 14 and 23, respectively. The methyl eugenol trap, which enclosed a wooden piece for the diffusion of semiochemicals, proved to be more effective for collection purposes. The results revealed that after 24 and 48 hours of treatment with the insecticides, lambda-cyhalothrin

showed LC50 values of 0.44 and 0.02 ppm, respectively. Hence, the insecticide lambda-cyhalothrin can be included in IPM practices for both spraying and trapping in mango orchards to control the severe damage caused by the pest.

Keywords: *Bactrocera dorsalis***,** insecticides, toxicity, LC50 values

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

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Chickpea (*Cicer arietinum* Linn.) is a vital pulse crop widely cultivated across India, often threatened by the pod borer, *Helicoverpa armigera* (Hübner).The field experiment was conducted at the Agronomy Farm, Rajasthan College of Agriculture, Udaipur, during the Rabi season to evaluate the effectiveness of biological agents and eco-friendly methods for managing H. armigera in chickpea. Six treatments were tested, including pheromone traps with trap crops, entomopathogenic fungi (*Beauveria bassiana* and *Metarhizium anisopliae*), Bacillus thuringiensis, HaNPV, a chemical check (Novaluron 10% EC), and an untreated control. Two applications of the bioagents were made at pod initiation and pod formation stages. Results indicated that Novaluron treatment recorded the highest reduction in larval population (2.0 larvae/m row length) and lowest pod damage (9.33%), followed by bio- pesticide treatments. The maximum yield (18.20 T/ha) was also recorded in Novaluron, while
the untreated control yielded the lowest (6.10 T/ha). Among the bioagents, HaNPV and *B. bassiana* were effective alternatives. The study demonstrates the potential of biological control methods as environmentally safe and effective components in integrated pest management programs for chickpea.

Keywords: Chickpea, *Helicoverpa armigera*, pod borer, biological control, bio-pesticides, HaNPV, *Beauveria bassiana*, *Bacillus thuringiensis*, Novaluron, Integrated pest management (IPM).

An empirical study on seasonal abundance of insect pests in pecan (*Carya illinoinensis* (Wangenh. Koch) in J&K

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Pecan (*Carya illinoinensis* Wangenh. Koch) is a valuable nut crop cultivated internationally for its distinctive flavor and excellent nutritional profile. However, insect pest infestations pose a major challenge to pecan cultivation worldwide, leading to substantial losses. In Jammu & Kashmir (J&K), pecans are primarily grown in the Poonch district, which offers ideal climatic conditions for their growth. To best of our knowledge, there is hardly any documental evidence regarding the status of pest fauna of this nut crop in J&K. Based on this conception, the present study was designed to fill this gap and epitomize a comprehensive record of different insect pests associated with this crop. Sampling was done on weekly basis and insects were collected based on the visual observation and captured employing different techniques. The results of the investigation indicated that the pecan plants are attractive to a wide variety of insect pests. Most of the insect pests were found during late spring to early summer. Out of different insect species reported 42.85 per cent were Coleopterans, 42.85 per cent Hemipterans and 14.28 per cent Orthopterans. Among all the species reported, *Phyllophaga sp*., *Hieroglyphus banian* and *Myllocerus undecimpustulatus* were found to be more abundant and intense on the basis of occurrence and damage inflicted on the leaves. The results of the present investigation provide a valuable baseline for the development and implementation of management strategies for economically important insect pests of pecans.

Keywords: Pecans, Insect pests, Population, baseline**.**

Reduviid Predators: Eco-Friendly Warriors Against Crop Pests

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Reduviid bugs, commonly known as assassin bugs, are a diverse group of hemipteran insects belonging to the family Reduviidae. Renowned for their predatory efficiency, these insects play a vital role in regulating pest populations in natural and agricultural ecosystems. Equipped with piercing-sucking

mouthparts and highly developed sensory mechanisms, reduviids are capable of swiftly detecting, attacking, and subduing a wide range of soft-bodied arthropods, including caterpillars, aphids, beetle larvae, and other crop-damaging insects. Their ambush-style predation and nocturnal activity make them highly effective biological control agents, often operating unnoticed yet significantly contributing to pest suppression. One of the most notable traits of reduviid bugs is their ecological adaptability and minimal dependence on human intervention. Unlike chemical pesticides, which pose risks to non-target organisms and the environment, reduviids offer a natural, sustainable, and eco-friendly method of pest management. Species such as *Sycanus collaris*, *Rhynocoris marginatus*, and *Pristhesancus plagipennis* have shown promising results in integrated pest management (IPM) programs across various agro-ecological zones in India and abroad. Promoting the conservation and augmentation of reduviid populations through habitat management, avoidance of broad-spectrum pesticides, and farmer awareness can enhance their effectiveness in crop protection.

Keywords: Reduviid bugs, biological control, predatory insects, *Sycanus*, *Rhynocoris*, agro-ecosystems, IPM, natural enemies.

Role of sex-pheromone collected from *Spodoptera litura* for pest management strategies

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Spodoptera litura, the oriental armyworm, is a well-known agricultural pest that seriously damages crops all over the world. Knowing how chemicals communicate, especially sex pheromones, opens up exciting possibilities for integrated pest management (IPM). The purpose of this study is to determine how sex-pheromone glands extracted from *S. litura* can be used to create environmentally friendly pest control methods. In order to determine the primary elements in charge of mate attraction, pheromone glands from adult females were dissected, and the secretions obtained were examined using gas chromatography-mass spectrometry (GC-MS). For field testing, the discovered chemicals were synthesized and combined to create lures. The findings showed that these pheromone-based lures successfully drew male moths, which decreased the likelihood of mating and the population growth that followed. The results highlight the potential of using sex-pheromone glands to create species-specific, environmentally friendly pest management tools, which would reduce the need for chemical insecticides and support sustainable agriculture. Pheromone formulations and deployment techniques should be optimized in future studies to increase their effectiveness and suitability for use in various agro-ecosystems.

Efficacy and resistance mechanisms of a mesoionic insecticide, Triflumezopyrim against Brown planthopper, *Nilaparvata lugens* (Stal)

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Insecticides play an irreplaceable role in managing brown planthopper, *Nilaparvata lugens* in the field. The indiscriminative and overuse of these insecticides lower the susceptibility of the insect. In the present study, the brown planthopper populations collected from different locations in North India; Delhi (Pusa) (28. 3636°N, 77. 1348°E), Haryana (29.6036° N, 76.8339° E), Uttar Pradesh (28.5253° N, 77.9741°E) and Chattisgarh (20.3451° N, 81.48239° E) were evaluated against the recommended insecticides with different mode of actions, namely, imidacloprid, dinotefuran, pymetrozine, and triflumezopyrim. The results indicated comparatively lower level of susceptibility of Haryana (Bansa) populations to all the insecticides tested. Haryana population showed highest LC_{50} for imidacloprid, (287.41 ppm), dinotefuran (167.39 ppm), pymetrozine (78.34 ppm), and triflumezopyrim (0.15 ppm). Triflumezopyrim was found to be best candidate insecticides for managing brown planthopper, with no significant difference between the populations considering the 95 % fiducial limit of lab reared susceptible population. Studies were also conducted to understand the effect of triflumezopyrim on the biology of the pest, and results revealed decreased fecundity and nymphal survival after insecticide exposure. A significant difference in the detoxifying enzymes, *viz.*, cytochrome P450 monoxygenase, and GST was observed when treated with the LC_{50} of the triflumezopyrim. No significant difference was observed in esterase activity. Imidacloprid-treated insects showed a considerable difference in esterase and cytochrome P450 monoxygenase activity, whereas, no difference in GST was observed. The detoxifying enzyme estimation revealed a variation in the activity of the enzymes in insects exposed to imidacloprid and triflumezopyrim, thereby confirming different resistance development mechanisms. The susceptibility status of populations can be maintained in filed by rotating the insecticides with different mode of action.

Optimizing green technology for the production of *Pieris brassicae* Granulosis Virus (PbGV) infecting *Pieris brassicae*

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The optimization of insect viruses is essential to achieve higher production of virulent isolates. The experiment was conducted to enhance the yield of *Pieris brassicae* granulovirus (PbGV) by evaluating key biological and physical parameters: inoculum dose, larval age, incubation duration, and physical state of the larvae.By pre-inoculating and incubating the early third instar larvae of *P. brassicae*, the greatest yield (2.07×10^7OBs/insect) was obtained at a dosage of 7.2×10^4 OBs/larva. Larval age played a critical role, with early third instars showing the best susceptibility and viral replication. The potential to increase OBs through incubation yielded the highest OBs/larva in the harvested larvae and very less in moribund larvae. The results, to the best of our knowledge, demonstrate PbGV optimization technology at the commercial level.

Keywords: Granulosis virus, *In vivo*, Mass production, Optimization

Insecticidal Activities of Four Essential Oils and Their Combinations Against *Sitophilus oryzae* L. in Stored Wheat

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The laboratory experiment were conducted to find out the insecticidal activity of *Chenopodium botrys, Citrus reticulata, Lantana camara, and Pinus roxburghi* essential oils and their two component combination at 0.4 percent against *Sitophilus oryzae* L. (Coleoptera Curculionidae) in stored wheat variety DBW 14. The fresh leaves of *Chenopodium botrys, and Lantana camara* and fresh peel *Citrus reticulata* was used for extraction of essential oil by Clevenger apparatus in entomological laboratory, Bihar Agricultural University, Sabour, while essential oil of *Pinus roxburghi* purchased from Pantnagr. In fumigant toxicity test all selected essential oils completely suppress the feeding and breeding of *Sitophilus oryzae* as compare to untreated control. The essential oil of *Chenopodium botrys*, *Citrus*

reticulata, Lantana camara, and Pinus roxburghi caused the hundred percent mortality at 0.4 percent against *Sitophilus oryzae*. The two component combination of *Chenopodium botrys* and *Chenopodium botrys, Chenopodium botrys* and *Lantana camara, Chenopodium botrys* and *Pinus roxburghi, Citrus reticulate* and *Lantana camara, Citrus reticulate* and *Pinus roxburghi, Lantana camara* and *Pinus roxburghi* also caused hundred percent mortality at 0.2 percent each against *Sitophilus oryzae* as compare to untreated control. The percent infestation and percent weight loss in all tested essential oils either alone or in combination found 0.35 and 0.52 respectively which was very low as compare to untreated control in which 12.78 and 14.36 percent respectively. The all tested essential oils do not affect the germination attributes of wheat variety DBW 14 after eight month of storage. The repellent activity of *Chenopodium botrys, Citrus reticulata, Lantana camara, and Pinus roxburghi* essential oils and their two component combination at 0.4 percent showed the strong repellence percent mean tested essential oils repels hundred percent of *Sitophilus oryzae* population as compare to untreated control. The all tested essential oils has very good insecticidal activity e.g. fumigant toxicity and repellent activity against *Sitophilus oryzae* in stored wheat at 0.4 percent and they do not affect the germination attributes of wheat seed and may also utilize to manage other stored grain insect.

Comparative Efficacy of Cue-Lure and Methyl Eugenol Dispensers against Melon and Oriental Fruit Flies in Ladakh

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The present study, entitled "Comparative Efficacy of Cue-Lure and Methyl Eugenol Dispensers against Melon and Oriental Fruit Flies in Ladakh," was conducted at the research farms of KVK Leh and Kargil, SKUAST-K Ladakh, over two consecutive years (2023 and 2024), from the third week of July to the fourth week of October. The objective was to evaluate the efficacy of various cue-lure dispensers in attracting the melon fruit fly (*Bactrocera cucurbitae*) and Oriental fruit fly (*Bactrocera dorsalis*). Six types of dispenser blocks-strawboard, plywood, acacia wood, cotton wad, sponge, and rubber (each 5 × 5 × 1.2 cm)-were saturated with 50 ml of a mixture (Cue-lure/Methyl eugenol: Ethanol: Malathion 50 EC in a 6:4:1 ratio by volume) and deployed in traps. Weekly observations were recorded until a zero catch was observed for two consecutive weeks. Data analysis revealed significant differences in dispenser performance. For *B. cucurbitae*, strawboard recorded the highest average catch (8.0 flies/trap/week), followed by plywood (4.0 flies/trap/week), with rubber and sponge recording the lowest (1.3 flies/trap/week). The peak catch (23.0 flies/trap/week) was observed with strawboard during the 31st week. All cue-lure dispensers showed zero catches by the 40th week. For B. dorsalis, plywood

recorded the highest peak catch (14.0 flies/trap/week) during the 35th week, while rubber and strawboard had the lowest (2.0 flies/trap/week) during the 31st week. All methyl eugenol dispensers recorded zero catches by the 42nd week. The findings indicate that plywood and strawboard dispensers, once impregnated with lure mixtures, can effectively attract *B. cucurbitae* and *B. dorsalis* over extended periods under Ladakh conditions.

Key words: Monitoring, Lure dispensers, Cue-lure, Methyl eugenol, Tephritidae, Diptera, Integrated pest management (IPM).

Status and Eco-friendly Management of Sucking Pests under High Density Plantation of Apple

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The research work on "Status and Eco-friendly Management of Sucking Pests under High Density Plantation of Apple" conducted at SKUAST-Kashmir, Shalimar, Srinagar during 2019 revealed infestation of various sucking pests viz., Green apple aphid (*Aphis pomi*), European red mite (*Panonychus ulmi*), ,Wooly apple aphid (Eriosoma lanigerum) and San Jose scale (*Quadraspidiotus perniciosus*). The incidence of European red mite, *Panonychus ulmi* (Koch) commenced from 2nd week of April with an average population level of (0.16 mites per leaf) reached to its peak (24.74 mites per leaf) during 2nd week of July and then decreased and reached to (0.20 mites per leaf) during 4th week of October. The incidence of Green apple aphid, Aphis pomi commenced from1stweekof April with an average population level of (18.21aphids per terminal) reached to it speak (58.76 aphids per terminal during) 3rd week of July and then gradually decreased and reached (30.72 aphids per terminal) during 4th week of October. The incidence of woolly apple aphid, *Eriosoma langirum* commenced from 2nd week of April with an average population level of (0.38 aphids per twig) reached its peak level of (48.50 aphids per twig) during 3rd week of July and then decreased and reached (0.41 aphids per twig) during 4th week of October. Studies on evaluation of different treatments against green apple aphids indicated that Spinosad (45EC @ 0.30 ml/l) was an effective treatment followed by HMO (0.75% @ 7.5 ml/l) and Neembicidine (0.03% @ 5 ml/l) with respect to Green apple aphids, after standard check Dimethoate (30EC @ 1 ml/l). Against European red mites, Spinosad (45EC @ 0.30 ml/l) was found effective followed by Buprofezin (25% SC @ 0.80ml/l) and HMO (0.75% @ 7.5ml/l) after standard check Fenzaquin (10% EC @ 0.40 ml/l) and against Wooly apple aphids Neembicidine (0.03% @ 5ml/l) followed by Spinosad (45EC @ 0.30 ml/l) and HMO 0.75% @ 7.5ml/l after standard check Dimethoate (30EC @ 1ml/l) was found effective.

Keywords: Apple, Sucking pests, Seasonal incidence, Eco-friendly management

Bio-ecology and Eco-friendly management of Black Thrips, *Thrips Parvispinus* (Karny) on Chrysanthemum

Sake Manideep

Chrysanthemum (*Dendranthema grandiflora* L.) a member of the Asteraceae family (Compositae), holds a significant position as one of the most important flower crops in India, yielding 5.37 million metric tons from 110 thousand hectares, with a productivity rate of 48.6 metric tons per hectare. This is significantly higher than the national average for other agricultural crops. The invasive pest, *Thrips parvispinus* (Karny) (Thysanoptera: Terebrantia: Thripidae) is a polyphagous species that had been found to infest beans and eggplant, papaya, chili, pepper, potato, shallot, and strawberry. In addition, it inflicts injury to the ornamentals, *viz.* Anthurium, chrysanthemum, dahlia, Dipladenia, Gardenia and ficus. Roving surveys were carried out in the chrysanthemum growing regions of the Tamil Nadu (Salem, Dharmapuri and Krishnagiri districts) during the year 2022-2023 and found that black thrips *T. parvispinus* was the predominant insect species. The samples were collected from surveyed areas and identified as *T. parvispinus* through morphological taxonomic keys (7-segmented antennae with sense cones on the third and fourth segments, three pairs of ocellar setae, metanotum reticulate medially, with long median setae originating beneath the anterior edge and no campaniform sensilla, two pairs of long posteroangular setae and three pairs of posteromarginal setae on the pronotum, forewing with complete rows of setae on the first and second veins and clavus with five marginal setae, sternites II and VII without discal setae, and sternites III to VI with about 6 to 12 discal setae) and molecular analysis.

Field experiments were conducted in KN Pudur, Dharmapuri District, Tamil Nadu during the year 2022-2023 to test the effectiveness of different biorationals and chemical insecticides, in managing black thrips. Among the biorationals, application of pongamia soap @5g/lit reduced the thrips incidence significantly than other the treatments. The mean per reduction of thrips incidence in pongamia soap @ 5 g/lit application was 74.90%. The order of efficacy of other biorationals were, neem soap @ 5g/lit (72.25%) > azadirachtin @ 10000ppm (71.10%) >*Beauveria bassiana* (66.76%) > *Isaria fumosorosea* (64.93%) > *Lecanicillium lecanii* (63.72%) > *Metarhizium anisopilae* (62.46%). The Spinosad 45%SC, applied @ 0.2 ml per liter, emerged as the most effective, with 80.2% reduction in thrips population. The descending order of effectiveness of other chemical insecticides against black thrips in chrysanthemum were, spinetoram 11.7%SC (76.245%) > cyantraniliprole 10%OD (73.92%) > fipronil 5% SC (72.24%) > thiamethoxam 25% WG (70.79%) > dinotefuran 20% WG (69.80%) > and tolfenpyrad 15% EC (68.02%). Four IPM modules were evaluated in Dasarapalli, Krishnagiri district, for their effectiveness against the invasive black thrips, *T. parvispinus*, in chrysanthemum cultivation. Among the tested modules, Module I encompassing seedling root dip, mulching, use of blue sticky traps, and the application of Pongamia soap along with need based chemical insecticides was found to be the most effective with a mean thrips of 18.85 thrips per flower and an yield of 19.76 tonnes per

hectare. These findings highlight the potential of combining biorational and chemical solutions for a sustainable and environmentally friendly approach to *T. parvispinus* management in chrysanthemum.

Invasion of Fall Armyworm, *Spodoptera frugiperda* – A threat to maize growers in India

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Fall armyworm is an invasive pest which has now became a threat for maize growers in India. Pests which are not native in area where they cause problems are considered to be an invasive pest species because they invade and establish populations in new areas resulting in uncontrolled population growth and spread causing economic and environmental problems. This process of invading and establishment of pest population in non-native areas is known as invasion. Fall armyworm is an insect native to tropical and subtropical regions of the Americas where they primarily attacked maize crops during the autumn months. It was detected in Central and Western Africa, Nigeria, Sao Tome, Benin and Togo in early 2016. Then it spread to India *via* Karnataka state. The early emergence in crop life cycle, voracious feeding habit, large-scale aggressive behaviour, high fecundity, fast migration, wide host-range and irreparable nature of crop damage make fall armyworm as a key pest on maize. It is difficult to trace its arrival in to India. However, it is believed that the fall armyworm arrived in India from Africa through human aided transport, natural migration since they are capable to fly hundreds of kilometers in one night on prevailing winds and escaped regulatory systems or quarantine.

Keywords: Fall armyworm, invasive, maize

Developmental durations and Predatory potential of native green lacewings of Jammu region on different hosts

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Native green lacewings (Chrysopidae) are important biological control agents, yet their developmental biology and predatory efficiency remain understudied in the agroecosystems of Jammu. This study investigated the developmental parameters and prey consumption rates of indigenous lacewing populations on three key horticultural pests: okra jassid (*Amrasca biguttula biguttula*), brinjal mealybug (*Phenacoccus solenopsis*), and bean aphid (*Aphis craccivora*). These pests cause significant economic damage to Jammu's major vegetable crops, with yield losses estimated at 30-40%. Lacewing larvae exhibited host-dependent developmental variation, completing their larval stage fastest on aphids (10.4 ± 0.3 days) and slowest on mealybugs (14.8 ± 0.5 days). Predatory efficiency followed a similar pattern, with highest consumption rates recorded for aphids (477 ± 2.1 prey/larva), followed by jassids (302 ± 3.8) and mealybugs (354 ± 4.7) during their larval durartion. Statistical analysis revealed significant differences in both developmental duration ($p<0.05$) and prey consumption ($p<0.01$) across host species. These findings demonstrate that native lacewings exhibit optimal performance on aphids, suggesting their particular suitability for managing aphid infestations in Jammu's vegetable crops. The results provide critical baseline data for developing lacewing-based integrated pest management strategies in the region. The superior adaptation of indigenous lacewings to local conditions highlights their potential as sustainable alternatives to chemical pesticides and exotic biocontrol agents. Further research should focus on field validation and mass rearing protocols to facilitate practical implementation of these findings in regional agriculture.

Keywords: biological control, Chrysopidae, developmental biology, host specificity, integrated pest management, predatory efficiency

Harnessing local *Beauveria bassiana* Isolate for the Management of White grub in Apple Orchards of Kashmir

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White grubs (Coleoptera: Scarabaeidae), particularly *Holotrichia longipennis*, are major soil-dwelling pests causing significant damage to apple orchards in Kashmir. Conventional management relies heavily on chemical insecticides, posing risks to human health and the environment. This study aimed to explore eco-friendly alternatives through the evaluation of *Beauveria bassiana*, an entomopathogenic fungus, for white grub management in apple orchards. Surveys across Shopian and Baramulla districts revealed natural infections of *B. bassiana* in grub populations, with incidence ranging from 0–6.25%. The native isolate was morphologically identified and tested in laboratory bioassays. The highest larval mortality (67.45%) occurred at 1×10^{10} conidia/ml, outperforming the commercial strain. Field trials further confirmed the efficacy of the native isolate, with mortality ranging from 16.50–59.12% over 21 days, compared to 8.12–32.68% by the commercial isolate and 76.40% by Chlorpyrifos. The native isolate also exhibited lower LC_{50}, LC_{90}, and ST_{50} values, indicating higher virulence. These findings support the potential of the local *B. bassiana* isolate as an effective biocontrol agent and a sustainable alternative to chemical insecticides in integrated pest management of white grubs in apple orchards of Kashmir.

Keywords: Bioassay, *Beauveria bassiana*, *Holotrichia longipennis*, Management, White grub

Problematic Soil Arthropods in Jammu and Kashmir

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In Jammu and Kashmir soil arthropods species posses significant threat to crops including white grub, cutworms and wire worms. They cause damage by feeding on plant roots, stem and foliage impacting crop yield and overall Agricultural production. Key problematic groups include nematodes, mites and certain pests especially in apple orchards these can lead to reduced crop yields and damage to plants parts. plant parasitic nematodes such as *Tylenchorhynchus*, *Paratylenchus* and *Helicotylwnchus* can

infest plant roots causing damage and reducing nutrient uptake. *Tetranychus* species including the two spotted spider mite or a major pest of apple orchard causing browning, leaf drop and reducing photosynthesis. White grubs, termites cutworms and wireworms are common soil pests that can damage root and other plant parts majorly in potato, sugarcane and maize. Integrated pest management strategies are crucial for managing soil arthropod pests this include using a combination of cultural practices biological control agents and judicious use of pesticides village crop rotation and cover crop can help manage soil pest population, introducing natural enemies of best such a certain nematodes or predatory mites can be effective. Insecticides and other pesticides may be necessary in severe cases but should be used judiciously to minimise environmental impact. Practices that improve soil health such as adding organic matter and increasing plant diversity can also help reduce best population.

Keywords: Soil arthropods, nematodes, mites, termites, IPM

Role of sex-pheromone collected from *Spodoptera litura* for pest management strategies

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Spodoptera litura, the oriental armyworm, is a well-known agricultural pest that seriously damages crops all over the world. Knowing how chemicals communicate, especially sex pheromones, opens up exciting possibilities for integrated pest management (IPM). The purpose of this study is to determine how sex-pheromone glands extracted from *S. litura* can be used to create environmentally friendly pest control methods. In order to determine the primary elements in charge of mate attraction, pheromone glands from adult females were dissected, and the secretions obtained were examined using gas chromatography-mass spectrometry (GC-MS). For field testing, the discovered chemicals were synthesized and combined to create lures. The findings showed that these pheromone-based lures successfully drew male moths, which decreased the likelihood of mating and the population growth that followed. The results highlight the potential of using sex-pheromone glands to create species-specific, environmentally friendly pest management tools, which would reduce the need for chemical insecticides and support sustainable agriculture. Pheromone formulations and deployment techniques should be optimized in future studies to increase their effectiveness and suitability for use in various agro-ecosystems.

Keywords: Sex-pheromone, *Spodoptera litura*, IPM, GC-MS

Evaluating the Efficacy of certain Botanical Oils / Powders against Pulse beetle on Mungbean

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Pulses play a crucial role in global food production by providing a nutritious diet rich in proteins and essential amino acids. One of the major challenges in pulse storage is infestation by *Callosobruchus chinensis* also known as adzuki bean weevil, cowpea bruchid, Chinese bruchid which is highly destructive, causing both quantitative and qualitative losses. Mungbean seemed to be the most prevalent and appropriate host for *C. chinensis* in terms of egg deposition, as well as adult emergence causes 50.37 to 57.58% grain content loss in storage. To evaluates the efficacy of certain botanical oils / powders against pulse beetle on mungbeans, eight different treatments were taken as Papaya leaf powder @30g/100 seeds , Neem leaf powder @30g/100 seeds , Mentha leaf powder @ 30g/100 seeds, Lemongrass leaf powder @ 30g/100 seeds ,Clove oil @5ml/100 seeds, Ajwain oil @5ml/100 seeds, Mahua oil @5ml/100 seeds and Castor oil@ 5ml/100 seeds, with this Deltamethrin (2.8EC) @ 0.04ml /100 seeds and untreated control were taken as standard check. The result showed that maximum mean per cent seed damage and weight loss were noted in the untreated control at an interval of 30 and 60 days, whereas minimum seed damage and weight loss were in Deltamethrin, followed by clove oil. On the other hand, adult morality follows opposite trend, maximum was found in Deltamethrin and minimum in untreated control.

Keywords: Botanicals, *Callosobruchus chinensis*, Deltamethrin, Mung bean, Seed damage

Field screening of wheat germplasm against aphid complex

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The present investigations entitled “Field screening of wheat germplasm against aphid complex” were undertaken during *Rab*i 2021-22 and 2022-23 in Research Farm of Department of Entomology, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. Wheat germplasm selected for screening purpose comprised of thirteen genotypes and eleven varieties. The overall count for the lowest aphid population were found in genotypes MBW1417 P1 (5.1 aphids/shoot) MBW1488 P1 (5.3 aphids/shoot) and MBW1499-28 P4 (5.8 aphids/shoot) and

varieties HPW 368 (4.9 aphids/shoot) and HPW 373 (5.3 aphids/shoot). The varieties HPW 349 (15.2 aphids/shoot) and HPW 249 (16.4 aphids/shoot) were recorded with highest aphid population. Among the selected germplasms the genotypes MBW1417 P1, MBW1488 P1 and MBW1499-28 P4; varieties HPW 368 and HPW 373 appeared to be the resistant ones. While with highest mean aphid population varieties HPW 349 and HPW 249 were found to be the most susceptible. It is concluded from the study that the genotypes and varieties that were found to be resistant should be utilized in breeding and IPM programme.

Keywords: Screening, wheat, germplasm, genotypes, varieties, aphids

Theme-2

Agriculture

&

Ecosystem Conservation

Theme - 2

Eco-Integrated Plant Protection: Balancing Agricultural Productivity and Ecosystem Conservation

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Over the past two decades, the rapid expansion of agriculture has led to a significant increase in the use of plant protection products and nutrient inputs. Although these inputs have boosted crop yields, they have also adversely affected soil health and disrupted ecosystems. Growing scientific evidence and environmental concerns have sparked a broader realization of the need to curb the degradation of our natural resources. Consequently, sustainable agricultural practices such as integrated pest management (IPM), organic amendments, conservation tillage, and precision nutrient management are now widely advocated (Verghese and Rashmi, 2022). These approaches aim to balance high productivity with environmental stewardship, ensuring that farming methods sustain soil fertility, protect water quality, and preserve biodiversity for future generations.

The intersection of agriculture and ecosystem conservation is becoming increasingly critical as modern farming faces the dual challenges of climate change, biodiversity loss, and environmental degradation. These pressing issues require us to integrate ecological principles into everyday agricultural practices. By doing so, we not only work to preserve the rich tapestry of biodiversity that underpins ecosystem health but also maintain agricultural productivity and secure long-term food security (Rashmi *et al*., 2016).

Integrating ecological principles means adopting practices that reduce the environmental footprint of farming. Techniques such as conservation tillage minimize soil disturbance and help maintain organic matter, while cover cropping and crop diversification enhance soil fertility and create habitats for beneficial organisms like pollinators, predators, parasitoids and useful microflora. These methods contribute to natural pest regulation, improved yield, water retention, increased carbon sequestration, which are all essential for mitigating the impacts of climate change (Rashmi *et al*., 2020, Rashmi *et al*., 2024).

Moreover, sustainable agricultural practices reduce reliance on chemical inputs and promote organic amendments, encouraging a shift towards more resilient and self-sustaining agroecosystems. This approach not only supports robust, healthy ecosystems but also ensures that agricultural landscapes continue to provide essential ecoservices like pollination, positive food webs, nutrient cycling, and climate regulation.

Aligning farming practices with conservation goals, through strategies such as ecologically viable pest management, natural and commercial biological control agents, botanicals, and precision nutrient management. This holistic approach offers a pathway to achieving sustainable productivity, environmental stewardship, and improved resilience against environmental uncertainties, which includes pest and disease attacks and unexpected invasives (Rashmi *et al*., 2024, Verghese et al., 2023). Sustainable agriculture strives to reduce dependence on synthetic chemicals, restore soil fertility, and enhance ecosystem resilience by embracing practices that support vital ecosystem services (FAO, 2023) as mentioned above. Techniques such as conservation tillage, cover cropping, and crop diversification improve soil structure, water retention, natural pest control, and carbon sequestration laying the foundation for a resilient agricultural system that protects both our environment and our food supply (Rashmi *et al*., 2025). This is in line with the natural farming concepts mooted by the Ministry of Agriculture and Farmers Welfare.

Agroecology provides an ample scope for sustainable farming by combining traditional knowledge with modern science. Practices like intercropping, agroforestry, and crop-livestock integration increase resilience against pests, droughts, and market shocks (Altieri & Nicholls, 2022).

In this context, recent research by Rashvee International Phytosanitary Research and Services, Bengaluru has utilized traditional insights by integrating a homogeneous blend of eight plant volatiles in the form of herbal liquid soap to develop an innovative, ecofriendly adjuvant for pest management. This formulation serves a dual purpose: as an adjuvant for insecticides boosting their efficacy by 40% while preventing resistance and also as a standalone repellent and antifeedant against sucking pests such as thrips, whitefly, mealybugs, aphids etc., In combination with ecofriendly neem formulations, the spray disrupts pests' ability to chemically orient towards host plants, reducing application frequency and lowering plant protection costs. This innovative use of plant-based techniques not only mirrors agroecological principles but also provides a tangible pathway toward a sustainable agricultural model that is both economically viable and environmentally sound (Rashmi *et al*., 2025a, Rashmi *et al*., 2025b, David *et al*., 2025).

Climate change is manifesting in two significant ways. First, gradual environmental shifts such as steadily rising global temperatures, longer and hotter summers, reduced ice cover, rising sea levels, and the submergence of coastal areas and all these are driving species to adapt to new conditions. Second, sudden extreme weather events, including unpredictable cyclones, heavy rainfall, flash floods, and landslides, are eroding topsoil, devastating forest ecosystems, and lodging vulnerable cropping systems like banana plantations and cereals. Together, these gradual and abrupt changes call for a more resilient and adaptive approach to environmental management (Rashmi *et al*., 2020).

In response to these challenges, Rashvee IPRS, in collaboration with Biotechnology Industry Research Assistance Council (BIRAC), Department of Biotechnology (DBT), has developed an innovative insecticide-free solution for fruit fly management. We have engineered a **Climate Resilient, Fruit Fly**

Species Liquid Lure for fruits and vegetables. This bio-inspired product is designed to be inherently resilient, incorporating advanced anti-evaporant formulations that ensure stability and efficacy in high temperatures, heavy rainfall, and high wind conditions. A key feature is our uniquely engineered climate resilient cap, developed using cutting-edge "parachute" technology see figure 1. This cap, complete with a stilt mechanism to minimize air drag and a skirt rainhood to defend against heavy rainfall, ensures that the liquid lure remains active in the field for more than 60 days (Rashmi *et al*., 2025a, Rashmi *et al*., 2025b, David *et al*., 2025).

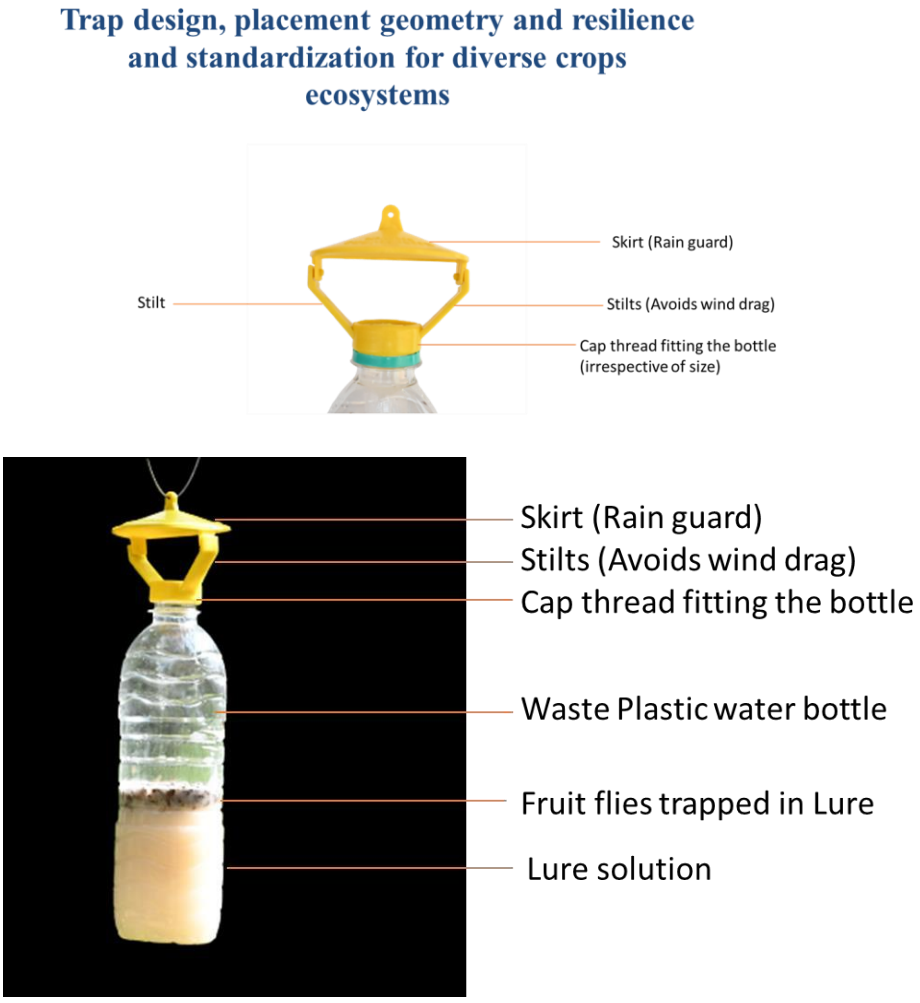

Fig 1. a) climate-resilient caps. (b) Rashvee fruit fly liquid lure

The trap's design also embraces sustainable waste management by repurposing disposable water bottles, making it both environmentally and user friendly. Extensive evaluations across diverse agricultural fields have yielded consistently positive feedback from farmers, who value the trap's performance and ease of use across varied cropping systems. By aligning our product development with the realities of climate change, we are not only enhancing fruit fly management but also contributing to sustainable agricultural practices that protect soil health and non-target organisms and promote safer

ecosystems, and support farmer livelihoods in an era of environmental uncertainty (Rashmi *et al*., 2025b).

Habitat management is another integral pillar of sustainable agriculture. Establishing flowering strips, beetle banks, and native vegetation corridors supports beneficial insects such as pollinators and natural enemies of pests thereby creating balanced ecosystems and enhancing crop resilience (Garratt *et al*., 2022). For instance, seed mixtures designed with multi-species flowering plants ensure continuous blooming and serve as vital refuges for insects and birds. Such habitat enhancements also synergize with innovative apiculture practices. In Kerala, for example, in January rubber trees burst into new foliage, releasing abundant sugary nectar that attracts bees especially *Apis cerana*. Apiculturists begin by strategically placing beehives in the Kasargod region in North Kerala and then sequentially relocate them southward through Kannur, Kottayam, and finally to the Trivandrum region. This well-orchestrated migratory apiculture process not only maximizes honey production yielding 25–30 kilograms of high-quality, pure rubber honey sold at Rs. 800 per kilogram. This approach also fosters a robust network of pollinators and beneficial insects, thereby reinforcing ecological balance and enhancing the sustainability of agricultural ecosystems (Verghese and Rashmi, 2025)

Bio-inputs including biofertilizers, compost, and biopesticides are increasingly used in natural and organic farming systems, boosting microbial activity while reducing the overall ecological footprint (Kumar *et al*., 2023). These inputs are aligned with broader ecosystem-based approaches that emphasize soil regeneration, water conservation, and reduced emissions. Incorporating bio-inputs alongside conservation practices and advanced pest management technologies represents a holistic strategy for maintaining soil health, promoting water quality, and reducing greenhouse gas emissions. In this context, bionematicides such as *Pochonia chlamydosporia* play a vital role in managing a wide range of plant-parasitic nematodes, including root-knot (*Meloidogyne* spp.), cyst (*Heterodera* spp.), and reniform (*Rotylenchulus reniformis*) nematodes. Additionally, entomopathogenic nematodes (EPNs), particularly species like *Heterorhabditis indica* and *Steinernema carpocapsae*, are highly effective in controlling soil-dwelling insect pests, including *Spodoptera frugiperda* (fall armyworm), thereby contributing significantly to sustainable pest management strategies (Verghese and Rashmi, 2022, Rashmi *et al*, 2023).

Agro-environmental schemes (AES) play a pivotal role in promoting such sustainable transitions. These policy instruments provide financial incentives to farmers for implementing environmentally friendly practices. For example, Switzerland's advanced AES program rewards farmers for enhancing biodiversity, managing nutrients effectively, and conserving critical habitats. Over 80% of Swiss farms participate in such programs integrating ecological compensation areas like hedgerows, wildflower strips, and rotational fallows—which have demonstrably improved insect diversity, soil health, and pollinator abundance (Herzog et al., 2023). Through its Plant Health Clinic, Rashvee is promoting the use of natural refuge strips to encourage the growth of native flora and fauna in agricultural landscapes,

thereby supporting long-term environmental conservation (Verghese and Rashmi, 2022, Rashmi *et al*, 2023).

Together, integrating conservation into agriculture through ecologically informed practices, innovative technologies, and supportive policy instruments is essential for reversing environmental degradation and building a resilient future. These combined efforts empower farmers to sustainably manage their resources, safeguard ecosystem services, and secure food and economic security for generations to come.

Farmers now have access to a wide range of products designed to enhance soil health and foster sustainable agricultural practices. For instance, biofertilizers formulated with beneficial bacteria such as *Rhizobium*, *Azotobacter*, and *Bacillus* species, along with mycorrhizal inoculants, promote efficient nutrient uptake and contribute to better soil structure. In addition, microbial consortia products combine multiple strains to optimize nutrient cycling and boost microbial diversity, while organic amendments like compost, vermicompost, and biochar are effective at increasing soil organic matter and overall fertility (Rashmi *et al*, 2023).

Shreenidhi Plant Health Clinic (PHC), Vijayapura Devanahalli, Bengaluru Rural plays a pivotal role in this ecosystem by supplying these innovative products and making them readily available on the shelf for farmers. By integrating these eco-friendly solutions into their practices, farmers can reduce their reliance on synthetic inputs, enhance soil health, and build resilient, sustainable agroecosystems and this also provides residue free produce (Verghese and Rashmi, 2022).

Building on these sustainable foundations, our work at the Shreenidhi is dedicated to supporting farmers in achieving soil sustainability, improved plant health, and a safer ecosystem. Operating daily from 8 AM to 8 PM, our PHC welcomes 50 to 60 farmers who visit for expert diagnosis of crop problems, quality-tested biocontrol inputs, and practical guidance on sustainable farming practices. We have significantly enhanced farmers' knowledge of diverse biocontrol strategies including the use of Entomopathogenic Fungi (EPF), Entomopathogenic Nematodes (EPN), pheromones, and *Trichoderma* for nematode control (Rashmi *et al*, 2023).

As a result, farmers are increasingly adopting a wide range of biocontrol products such as *Trichoderma*, Arka Microbial Consortia, *Bacillus* spp., *Pseudomonas, Metarhizium anisopliae, Beauveria bassiana, Verticillium lecanii, Bacillus thuringiensis*, Nuclear Polyhedrosis Viruses (NPV for Spodoptera and Helicoverpa), and entomopathogenic nematodes (EPNs). These initiatives not only help reduce reliance on synthetic chemicals and lower input costs but also secure long-term soil health, bolster biological diversity, and enhance overall ecosystem safety, thereby benefiting both human and environmental well-being (Verghese *et al*., 2021, Rashmi *et al*, 2023).

Amid mounting concerns about the so-called “insect apocalypse” driven by habitat destruction, pesticide overuse, and climate change the urgency to transform farming practices has never been greater. Insects are foundational to ecosystem functioning, providing essential services such as

pollination, decomposition, and natural pest regulation (Sánchez-Bayo & Wyckhuys, 2022). Recognizing these challenges, our strategies also incorporate ecosystem restoration in forestry. Initiatives such as native tree planting, invasive species control, and assisted natural regeneration not only support biodiversity and carbon storage but also reverse landscape degradation and build climate resilience (IUCN, 2023). We complement these efforts with education; by teaching children about trees as carbon sinks and the impacts of global warming, and integrating agricultural subjects with specialized forestry and arboreal culture courses, thereby we are nurturing an informed and proactive next generation.

Fig. 2 Nurturing next gen rural children

Digital innovation is reshaping agriculture by bridging the gap between farmers and expert knowledge. The integration of ICT tools and digital extension platforms have revolutionized decision-making by providing real-time weather forecasts, immediate pest alerts, and best practice recommendations (Patel & Singh, 2023). Taking these advancements further, Shreenidhi leverages ICT to create an efficient diagnostic network. Here, farmers' samples whether leaves, fruits, or soil are digitally relayed to specialist diagnosticians who analyze the data and quickly provide precise diagnoses and we provide tailored management advice and inputs. This real-time, data-driven exchange not only empowers farmers with actionable insights but also fosters a collaborative ecosystem where on-ground challenges are met with expert solutions, ultimately driving a more resilient agricultural landscape. Ecologically informed agriculture, bolstered by agroecological principles and digital innovation, represent the future of sustainable food production (Verghese et al., 2024).

To ensure that these innovations reach and benefit farmers directly, our Transfer of Technology (Extension) efforts span multiple channels. Through engaging YouTube messages, interactive WhatsApp networks, and direct field engagements via our Plant Health Clinics as well as personal contacts and major stakeholder meetings, we effectively disseminate genuine products and knowledge.

These extension initiatives not only improve crop health and reduce dependency on synthetic chemicals but also empower the farming community to adopt more environmentally responsible practices, laying the groundwork for a sustainable agricultural future.

This conference will be a real foundational eye opener in many ways to not only Jammu and Kashmer also to the temperate regions of Himachal Pradesh and Punjab as well as Indian agriculture at large the efforts put in by Prof. Gupta the chief organizers of this symposium and his team will pay way to greater sustainability in the years to come, we wish the deliberations all success.

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Abstracts

Field Evaluation of Newer Insecticides against *Spodoptera litura* and *Achaea janata* in Castor (*Ricinus communis* L.) and their Impact on Yield

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A field trial was conducted during *kharif* 2020–2022 at RARS, Palem to evaluate the efficacy of newer insecticides against *Spodoptera litura* (Fabricius) and semilooper, *Achaea janata* (Linnaeus), in castor (*Ricinus communis* L., cv. PCH-111). Treatments included Spinetoram 11.70% SC @ 1 ml/l, Thiacloprid 21.70% SC @ 1 ml/l, Cyantraniliprole 10.26% OD @ 1 ml/l, and Profenofos 50 EC @ 2 ml/l. Spinetoram was most effective, reducing *S. litura* and *A. janata* populations by 98% and 95% respectively, followed by Profenofos. The highest seed yield (1058 kg/ha) was recorded with Spinetoram, while Profenofos gave the highest cost-benefit ratio (1:9.1). All treatments significantly outperformed the control in pest suppression and yield. Spinetoram and Profenofos are promising tools for integrated pest management in castor.

Key words: *Achaea janata*, *Spodoptera litura*, *Ricinus communis*, Spinetoram and seed yield.

Growth, development and biomass productivity of forage crops in *Terminalia chebula* (Retz.) based agroforestry system in Jammu

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The present study was conducted during 2023–2024 at the experimental field of the Department of Silviculture and Agroforestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, to evaluate the growth, development, and biomass productivity of four forage crops—*Setaria sphacelata*, *Brachiaria brizantha*, *Stylosanthes hamata*, and *Setaria anceps*—under open and *Terminalia chebula* based agroforestry systems. Eight treatment combinations were tested to assess variations in plant height, number of leaves, leaf length, fresh and dry biomass, and dry matter content. The results revealed significantly higher performance of forage crops grown under open

conditions compared to intercropping. Among all forage species, *Setaria anceps* consistently outperformed others in terms of plant height (90.29 cm), leaf length (61.09 cm), fresh weight (13.41 Mg/ha), and dry weight (3.02 Mg/ha). Conversely, *Stylosanthes hamata* recorded the lowest values for these parameters, although it exhibited the highest (31.53%) dry matter percent. Forages grown in open treatment showed better growth, with an average plant height of 80.85 cm, fresh weight of 10.55 Mg/ha, and dry weight of 2.66 Mg/ha, compared to 70.66 cm, 8.88 Mg/ha, and 1.94 Mg/ha in intercropped treatment. Statistically significant interaction effects between treatments and forage types were observed, affirming the influence of species selection and planting conditions on forage productivity. The study concludes that among the evaluated forages, *Setaria anceps* is most suitable for integration into *Terminalia chebula* based agroforestry systems, with potential to optimize biomass yield and land-use efficiency under sub-tropical conditions of Jammu.

Keywords: Agroforestry, *Terminalia chebula*, Forage crops, Biomass productivity, *Setaria anceps*

Biodiversity of Odonata of Doodhpathri Tourist Spot of UT of Jammu and Kashmir

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The biodiversity of Odonata of Doodhpathri area of UT of Jammu & Kashmir is documented for the first time. During the present baseline field investigations carried out from April 2019 to December 2023, in the Doodhpathri area of district Budgam of Kashmir Himalayas, a total of 17 species of Odonates distributed under two suborders namely Anisoptera (Dragonflies: 9 genera and 13 species) and Zygoptera (Damselflies: 03 genera and 04 species) are reported. Family Libellulidae, suborder Anisoptera (Dragonflies) was the most dominant family. The area is rich in biodiversity of Odonates but also has many threats and challenges. The anthropogenic activities, grazing, climate change, tourism, new settlements, Land Use Land Change, poor capacity building and conservation interventions are impacting the distribution and diversity of the odonates in this eco-tourism hot spot. Many species are showing restricted distribution towards a particular habitat. The area needs to be studied further for its proper documentation, identification, conservation and management of odontata. This will fill the research gaps, generate long term data, and facilitate in designing proper conservation protocols for Odonates especially in the global climate change scenario.

Keywords: Odonata, Dragonflies, Damselflies, Doodhpathri, Kashmir Himalayas, Biodiversity, Distribution, Status

Impact of Natural Farming practices on crop production in district Poonch

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Use of chemical fertilizers, irrigation and high-yielding varieties intensively after the mid-1960s has surely helped the nation to overcome the threat of food scarcity. However, the intensification of agriculture through these tactics especially the use of chemical fertilizers have resulted in soil degradation, eutrophication of land and water bodies, greenhouse gas (GHG) emissions, biodiversity losses and other significant negative environmental effects. In order to combat these negative effects, Natural farming, which basically entails growing of microorganisms inside the soil, is regarded as a dependable strategy for long-term food security and environmental preservation. To evaluate the effect of Natural Farming practices on crop production in district Poonch, a field trail was conducted at Village Mangnar wherein homemade formulations like Jeevamrit @ 15% at 15 days interval for 60 days and Darekastra@ 8 litre per kanal twice at 30days interval after sowing where applied in Wheat, oats and Garlic crops. The results of our demonstration showed a B:C ratio of 3.22, 3.36 and 4.14 in case of wheat , oats and Garlic under Natural farming conditions in contrast to ratio of 3.09, 3.09 and 3.38 under conventional farming respectively. The results of our trial indicate that Natural Farming holds a promise to alleviate the cost of cultivation without affecting the production and productivity. However, long term field trials are needed to substantiate these initial observations prior to tagging Natural farming as an alternative to conventional farming for sustainable agriculture.

Keywords: Natural Farming, jeevamrit, conventional farming, sustainable agriculture

Nest architecture, feeding habits and ecosystem services of solitary wasps from of Northwestern Himalayas

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This study investigates the nesting biology and feeding habits of two solitary wasp species, *Chalybion bengalense* and *Sceliphron madraspatanum*, in the subtropical outer plains of Jammu region, northwestern Himalayas. Detailed analysis of nest architecture and biology revealed *C. bengalense's* distinctive behaviour of occupying *S. madraspatanum* nests, characterized by white lime coating on emergence holes. Nest architecture remained consistent across all study locations. Adult wasps of both species consumed nectar (8.5 µl) and honeydew (3.8 µl), extending their longevity to 32.0 and 24.5 days respectively, while their larvae exclusively fed on spiders playing a good role in predation services. This research presents the first comprehensive documentation of these species' complete life cycle stages, including egg metrics, hatching periods, larval development, cocoon formation, and pupal stages from this region. The total immature development period of *S. madraspatanum* and *C. bengalense* ranged between 29.1-34.8 days to 27-35.02 days. While, investigating the ecosystem services, mud daubers were found to be good indicators of ecosystem health considering availability of water, nectar, honeydew, prey, biomass, carbon dioxide emissions and urbanization. Considering their role in predation, stage specific predation was also investigated where the prey consumption by the larvae was found in the range of 14-25 and 8-18 spiders in *S. madraspatanum* and *C.bengalense* respectively. Whereas, while studying the role of mud daubers as pollinators, frequency of occurrence of wasp on *Cosmos sulphurous* was found to be maximum followed by *Zephyranthes carinata, Thevetia peruviana, Lagerstroemia speciosa and Calliandra.* Per cent increase from 16.6 - 63.3 in fruit set over control was reported when pollination by mud daubers was studied in *Zizyphus mauritiana.* These findings contribute to our understanding of solitary wasp behaviour and life history in the northwestern Himalayan region.

Keywords: *Chalybion*, *Sceliphron*, Nest architecture, Solitary wasps, predation

Chronic Exposure to Artificial Light at Night Impairs Learning and Memory in Cricket, *Gryllus assimilis*

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Circadian clock is ubiquitous in nature, it controls and coordinate physiology, behaviour and metabolism in organisms. These processes are entrained by the Earths'24-h light-dark cycle (LD). Such periodicity in LD cycle, enables organisms to anticipate and prepare itself for foraging and reproduction and enhance their fitness in their natural habitat. Because of rapid industrialization and urbanization, there is rapid increase in the artificial light at night (ALAN). Even though numerous research on the impact of ALAN on circadian clock haven been performed, however, its impact on learning and memory in cricket has been lees explored. We aimed to explore the effects of chronic ALAN on the circadian clock of wild cricket, *Gryllus assimilis*. Cricket has been proposed as a suitable model to investigate the impacts of light, in chronobiological investigations due of its high sensitivity to very low light levels. Cricket, *G. assimilis* were raised under 12:12-h LD cycle for two weeks. After stable entrainment crickets were divided into two groups, a. control (LD, 12:12-h) and b. chronic 8-h jet-lag. In control group LD cycle was kept same however in chronic jet-lag group, LD cycle was phase advance by 8-h after every third day for three consecutive phase advance cycle. Learning and memory was evaluated in cricket under both the lighting conditions. Crickets were fasted for 12-h and trained to explore olfactory cues (peppermint solution and after 3-sec drinking water, as a reward and, another lemon water and after 3-sec 20% saline water, aversive in nature). Student's T-test shows that chronic ALAN significantly impaired olfactory learning in cricket *Gryllus assimilis* compared to those under normal LD cycle. Our data show that ALAN disturb the circadian clock of cricket and leads to cognitive impairment which may lower their survival in their niche. In conclusion, proper designing of lighting protocol near the road side and natural habitat is mandatory to enhance species fitness.

Keywords: Circadian clock, *Gryllus assimilis*, ALAN, Circadian disruption, Learning and memory and chronic jet-lag

Patterns of Insect Richness and Abundance across Forest Landscapes of Northwestern Himalayas

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Insects play a crucial role in maintaining ecosystem stability and functioning. Understanding their diversity across altitudinal gradients is crucial for assessing ecosystem stability and informing conservation strategies. This study investigates the patterns of insect richness and abundance across the forest landscapes at three altitudinal gradients—Lower Shiwaliks (≤1100 m), Shiwaliks (≤1800 m) and Middle Himalayas (>2800 m)—in the northwestern Himalayas. A systematic survey was conducted from March 2022 to December 2023 using diverse sampling methods. Results revealed significant altitudinal variations in species distribution, with the Lower Shiwaliks exhibiting the highest species richness (30 species), followed by the Shiwaliks (23 species), and the Middle Himalayas (11 species). Taxonomic groups such as springtails (Protura), two-pronged bristle tails (Diplura) and mayflies (Ephemeroptera) were restricted to lower elevations, whereas grasshoppers (Orthoptera), robber flies (Diptera) and dragonflies (Odonata) were ubiquitous. Insect abundance patterns indicated that bees (74%) dominated the recorded insect population, followed by syrphid flies (28%), moths (13%), carrion flies (11%), butterflies (6%) and wasps (4%). The findings underscore the influence of altitudinal gradients on insect diversity, driven by climatic and habitat heterogeneity. The high representation of pollinators and decomposers highlights their ecological significance in forest ecosystems. These results emphasize the need for targeted conservation efforts to sustain insect-mediated ecosystem services in the Himalayan region.

Keywords: Insect diversity, altitudinal gradients, insect abundance, conservation

Comparative Analysis of Fruit Traits in Terminalia chebula Retz. (Harad) Selections across Different Temporal Harvesting Windows

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Variability in fruit traits and yield among different selections of *Terminalia chebula* Retz., a medicinally significant tree, substantially influences its commercial and therapeutic applications. This study evaluated the influence of genotypic selection during the different harvesting window on fruit traits and yield in the subtropical region of Jammu, India. The research was conducted at the experimental farm of the Division of Silviculture and Agroforestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, located at Chatha, Jammu, Jammu and Kashmir, during 2022. The results revealed significant genotypic variations across different harvest months ($p < 0.05$) in fruit length, fruit diameter, fresh/dry fruit weight and pulp content (fresh and dry). In September, the Plauri cultivar exhibited significantly greater fresh fruit weight, dry fruit weight, fresh pulp content, dry pulp content and fruit diameter compared to other selections. In contrast, the Jammu selection demonstrated significantly greater fruit length during this period. In October, Plauri maintained significant superiority in fruit weight and pulp content (both fresh and dry) and fruit length. Similarly to September, Jammu Selection exhibited significantly greater fruit length in October. However, in November, Jammu Selection recorded significantly greater fresh fruit weight, dry fruit weight, dry pulp content, and fruit length, whereas Plauri showed significantly greater fresh pulp content and Pragpur exhibited significantly largest fruit diameter. Strong positive correlations ($r \approx 0.88–0.95$) were observed among fruit weight, pulp content, and diameter, while fruit length showed weak/negative associations with yield traits. These findings demonstrate that genotype selection is crucial for optimizing *T. chebula* fruit traits and yield. Plauri is recommended for early harvests, while Jammu Selection offers superior late-season production, providing a strategic framework for cultivar selection and harvest scheduling.

Keywords: Cultivars, fruit traits, genotypic variation, harvest timing, *Terminalia chebula*

Soil Carbon Dynamics and Chemical Properties in Relation to Land Use Patterns in Kishtwar Valley, North India

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Soil organic carbon (SOC) is vital for soil health, agricultural productivity, and climate change mitigation. This study quantifies the SOC content, stocks and fractions across forest, apple orchard, vegetable farm, and fallow land in Kishtwar Valley, Jammu and Kashmir, India, to assess land-use impacts on carbon dynamics. During 2023-24, soils were sampled using a stratified random sampling design at 0–15, 15–30, and 30–60 cm depths. Samples were analysed for total organic carbon (TOC), active and passive carbon fractions, and bulk density to compute SOC stocks. Converting fallow land to other land uses significantly ($P<0.05$) increased TOC, with surface (0–15 cm) TOC rising from 11.0 g kg^{-1} in fallow land to 19.0 g kg^{-1} in forests, 18.9 g kg^{-1} in apple orchards, and 17.5 g kg^{-1} in vegetable farms. Subsurface (15–30 cm) TOC increased from 6.11 g kg^{-1} to 10.2 g kg^{-1}, 7.5 g kg^{-1}, and 7.2 g kg^{-1}, respectively. Forest soils exhibited the highest organic carbon stock (27.5 Mg C ha^{-1} at 0–15 cm), followed by apple orchards (25.5 Mg C ha^{-1}), vegetable farms, and fallow land. Carbon fractions and pools followed the pattern forest > apple > vegetable > fallow land across depths, with forests and apple orchards storing the most carbon. The vertical distribution of SOC also reflected land-use intensity and vegetation type, with perennials contributing more to deeper SOC storage. These findings highlight that forest and apple orchard systems enhance Soil carbon storage, offering insights for sustainable land-use practices to boost carbon sequestration in these agroecosystems. Such practices could be strategically employed to support regional climate action plans and soil restoration efforts in mountainous regions.

Keywords: Soil carbon pools; Organic carbon; Land use systems; Carbon sequestration

Butterfly Diversity and Conservation in Jammu & Kashmir: An Integrated Synthesis

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Jammu and Kashmir's diverse topography and floral composition contribute to a rich butterfly fauna, with surveys identifying 44-68 species across the union territory of Jammu and Kashmir. Surveys conducted between 2006–2021 report 44–68 butterfly species across J&K, representing 5–7 families and 27–38 genera. The family Nymphalidae consistently dominates species counts (e.g., 23 of 40 species in Gulmarg), followed by Pieridae and Lycaenidae. Papilionidae and Hesperiidae are relatively depauperate 126. Notably, the Blue Pansy (*Junonia orithya*), recently designated J&K's official butterfly, exemplifies the region's ecological significance and conservation focus.

Butterfly diversity exhibits strong altitudinal zonation. Studies along gradients (e.g., 2,700–3,200 m in Gulmarg) reveal peak species richness at lower elevations, declining with increasing elevation due to reduced floral diversity and harsher climates. Alpha diversity indices confirm this trend, with low-elevation sites supporting up to 21 species versus 4 species at higher sites. Habitat heterogeneity-including forests, orchards, grasslands, and agricultural areas-further modulates distribution, with dense vegetation and flowering plants correlating with higher abundance. Butterflies face escalating pressures from habitat alteration (deforestation, agricultural expansion), climate change, and anthropogenic development. These threats exacerbate population declines, particularly for endemic and elevation-sensitive species. Nymphalidae is the dominant family, and species richness typically decreases with increasing altitude. Butterflies in J&K face threats from habitat alteration, climate change, and development, necessitating conservation efforts such as protected area management, species-specific advocacy, and habitat restoration. Emphasis on preserving floral diversity and microhabitats, particularly in lower-elevation zones where biodiversity peaks. Long-term monitoring is essential to track climate impacts and anthropogenic stressors. Integrating community engagement with scientific research offers the most viable pathway to conserve J&K's lepidopteran biodiversity and its pivotal roles in pollination and ecosystem health. Further research and community engagement are crucial for effective long-term conservation of the region's lepidopteran biodiversity.

Keywords: Butterfly, Nymphalidae, diversity, floral diversity, ecological gradient, Conservation

Preliminary investigation of butterfly fauna of District Anantnag of UT of Jammu & Kashmir

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The butterfly fauna of district Anantnag of UT of Jammu & Kashmir is surveyed and recorded for the first time. During the present study conducted from January 2021 to December 2024, a total of 55 species of butterflies distributed under five families namely Hesperiidae (2 spp.), Lycaenidae (6 spp.), Nymphalidae (29 spp.), Papilionidae (6 spp.), and Pieridae (12 spp.), are reported from the region. The butterfly activity was found from February to November. The highest distribution was in the Summer season (June-August) followed by Autumn (September-November), Spring (March-May) with Winter season (December-February) having the lowest butterfly occurrence. The highest butterfly diversity was in family Nymphalidae while as lowest was in Hesperiidae. The butterfly activity was found from February to December. Among others, the major threats and challenges butterflies are facing in the region include grazing, use of pesticides, new development projects and settlements, Land Use Land Change, climate change, tourism, and feeble conservation interventions which if not addressed can cause species decline and local extinctions particularly in times of global climate change.

Key words: Butterflies, Budgam**,** Distribution, Status, Threats, Climate Change

Do Beneficial Insect Move from insectary plants to Crop Fields: Optimizing the Effective distance for floral strips for conservation biological control

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To address both the economic and environmental issues caused by agricultural pests, a holistic crop protection strategy is essential—one that reduces dependence on chemical pesticides. This integrated approach focuses on understanding and supporting natural pest enemies within farming systems through targeted habitat management and conservation biological control methods. Research supports setting aside at least 10% of farmland for non-crop vegetation to improve biodiversity and strengthen natural pest regulation. Diverse flowering plantings, for instance, can attract beneficial insects crucial for pest suppression. In a recent study, rubidium—chosen for its low toxicity and minimal environmental footprint—was used as a marker to trace the movement of beneficial insects from insectary plantings into adjacent crop fields. Syrphid flies and ichneumonid wasps were successfully tracked, with rubidium detection extending up to 60 feet from the insectary source, beyond which presence sharply declined. Sticky trap results confirmed a marked drop in parasitoid populations past the 60-foot range, suggesting this as the maximum effective distance for biological control. The data also revealed that beneficial insects were significantly more concentrated near insectary zones, reinforcing the value of strategically placed non-crop habitats for enhancing natural pest control.

Keywords: Conservation biological control, insectary plants, rubidium marking technique and beneficial insects

Management of Helicoverpa armigera (Lepidoptera: Noctuidae) infestation on chickpea crop (Cicer arietinum L) by integrated biopesticidal/ insecticidal sprays

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Chickpea is a globally cultivated dietary legume that provides substantial levels of protein, fat, soluble fiber, and other micronutrients. Chickpea is susceptible to damage by number of insect species globally,

with pod borer Helicoverpa armigera as the most prevalent insect pest and is regarded as "National pest" in India. Management of this pest using chemical insecticides have been traditionally used. However, resistance, residue effect, decline of natural predators need to be fostered upon. So, there is need to evaluate integration of biopesticides/insecticides sprays for the management of H. armigera population below economic threshold levels and to conserve the natural enemies. Field trials were thus conducted for two years during two consecutive years against *H. armigera* on chickpea. Results indicated that treatment (*B. thuringiensis* DOR Bt-1: Chlorantraniliprole 18.5% SC) recorded lower per cent pod damage and higher grain yield ,followed by treatment (*B. thuringiensis* DOR Bt-1 : *B. thuringiensis* DOR Bt-1). This was followed by treatment (B.bassiana Pcs-4; chlorantraniliprole 18.5% SC) and (*B. bassiana* Pcs-4: B. thuringiensis DOR Bt-1) in reducing larval infestations, decreasing pod damage. However, insecticidal treatment with both sprays of chlorantraniliprole 18.5% SC recorded least pod damage but affected natural enemies population. So, we concluded from the present study that integrated sprays of *B. thuringiensis* DOR Bt-1 followed by second spray of chlorantraniliprole 18.5% SC and both sprays of *B. thuringiensis* DOR Bt-1 at interval of ten days had potential for the management of H. armigera in chickpea.

Status of natural enemies of Eucalyptus gall wasp *Leptocybe invasa* in North Western India

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Eucalyptus is native to Australia and is grown throughout the world in tropical and subtropical areas as non-native plantation species. *Leptocybe invasa* Fisher & La Salle (Hymenoptera: Eulophidae) is an invasive pest, that causes significant damage to Eucalyptus all over the world. In this study, survey was conducted in three agroclimatic zones of Punjab viz., Submountainous zone, Central zone and South western zone from August 2020-July 2022 to investigate the incidence and distribution of *L. invasa* and its natural enemies. Branches of Eucalyptus damaged by *L. invasa* were collected from nurseries, road side and field plantations and brought to the laboratory for recording of emerging insects. Adults of *Megastigmus viggianii* and *Quadrastichus mendeli* emerged throughout the year from parasitized galls of *L. invasa*. The number of adults of M. viggianii and Q. mendeli were significantly higher during September under different agroclimatic zones of Punjab. Decrease in mean number of adults was observed after November and the number of emerged adults was lowest during January. With the rise in temperature, the number of adults started to increase in March and reached its peak in the month of April. Per cent parasitization of *L. invasa* by *M. viggianii* and *Q. mendeli* was in the range of 9-19 and 17-31 per cent, respectively. The parasitism of *L. invasa* larvae and pupae by *M. viggianii* and *Q. mendeli* exhibits their potential as biocontrol agents in the integrated management of Eucalyptus gall wasp.

Bumble Bee Biodiversity Unveiled: A Study on the Genus *Bombus* from the Indian Himalayas

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Bumble bees (*Bombus spp*.) are highly efficient pollinators of both wild and cultivated plants, playing a crucial role in sustaining ecosystems and enhancing agricultural productivity. Their unique ability to perform buzz pollination and forage in cooler temperatures and low-light conditions makes them invaluable for various plant species. However, their populations are experiencing a global decline due to factors such as habitat fragmentation, climate change, pesticide exposure, and the loss of floral resources. Given their ecological importance, it is essential to understand the factors influencing bumble bee diversity and abundance to aid conservation efforts. One of the most significant factors affecting bumble bee populations is the availability of flowering plants. This study presents a comprehensive survey of bumble bee (*Bombus*) diversity and abundance in the Bhaderwah region of Jammu, India. Over the sampling period, six species were identified: *Bombus tunicatus*, *B. haemorrhoidalis*, *B. albopleuralis*, *B. trifasciatus*, *B. simillimus*, and *B. eurythorax*. Species composition and relative abundance varied across sampling sites and time, with *B. tunicatus* emerging as the dominant species.It exhibited a widespread distribution and heightened foraging activity, especially during mid-elevation summers (June–August), aligning with peak flowering of key host plants such as *Digitalis purpurea* and *Cirsium falconeri*. *B. haemorrhoidalis* and *B.albopleuralis* were associated primarily with *Cirsium falconeri*, also occasionally visiting *Digitalis*. In contrast, *B. trifasciatus* and *B. simillimus* showed strong preferences for *Strobilanthes* and *Impatiens balsamina*, thriving in cooler, moist, shaded microhabitats. The least abundant species, *B. eurythorax*, was confined to higher-altitude forest edges, foraging mainly on *Impatiens balsamina*. Overall bumble bee abundance peaked in mid-summer, coinciding with maximal floral density and diversity, and declined toward autumn. Strong positive correlations were found between floral resource availability and bee abundance. Spatial distribution patterns differed significantly among species, influenced by elevation gradients, microhabitat characteristics and floral composition. These findings emphasize the ecological prominence of *B. tunicatus* and reveal species-specific floral associations, offering essential insights into pollinator ecology and conservation in the Indian Himalayas.

Keywords: *Bombus tunicatus*, *Digitalis purpurea*, Diversity, Indian Himalayas and Ecological importance.

Techniques in Pesticide Residue Analysis

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Pesticide residue analysis is a critical field in agricultural and environmental sciences, focusing on detecting and quantifying trace amounts of pesticides in various matrices. This abstract explores the latest techniques and methodologies employed in pesticide residue analysis, emphasizing their applications in agriculture and entomology. Modern analytical approaches, such as liquid chromatography-tandem mass spectrometry (LC-MS/MS) and gas chromatography-mass spectrometry (GC-MS), have revolutionized the detection and quantification of pesticide residues, offering high sensitivity and selectivity. These techniques are complemented by advanced sample preparation methods, including QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) extraction, which has become a standard in multi-residue analysis. The integration of novel materials, such as molecularly imprinted polymers and nanomaterials, has further enhanced the efficiency and specificity of extraction processes. Recent advancements in high-resolution mass spectrometry have enabled the identification of unknown pesticide metabolites and transformation products, providing a more comprehensive understanding of pesticide fate in the environment. Additionally, the application of chemometrics and machine learning algorithms has improved data interpretation and predictive capabilities in residue analysis. This abstract also discusses the challenges faced in pesticide residue analysis, including matrix effects, the need for multi-residue methods capable of detecting hundreds of compounds simultaneously, and the increasing complexity of pesticide formulations. The importance of these analytical techniques in monitoring pesticide residues in crops, assessing environmental contamination, and studying pesticide resistance in insects is highlighted. The continuous evolution of pesticide residue analysis techniques plays a crucial role in ensuring food safety, environmental protection, and the development of sustainable pest management strategies in agriculture and entomology.

Keywords: LC-MS/MS, GC-MS, QuEChERS, pesticide residue, nanomaterials.

Foraging Activity of Insect Pollinators on Maize (*zea mays* l.) in Trans-Yamuna region of Prayagraj

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The foraging behavior of insect pollinators visiting maize *(Zea mays* L.) was systematically studied during the Kharif season of 2023 at the Central Research Farm, Naini Agricultural Institute, SHUATS, Prayagraj, located in the Trans-Yamuna region. Observations were recorded at hourly intervals (06:00–18:00 hrs.) across six dates during the crop's blooming period. a total of nine insect species were identified, with marked differences in their diurnal foraging patterns and flower handling times. Peak activity was recorded between 08:00–10:00 hrs. for key pollinators such as *Apis dorsata*, *A. mellifera*, *A. cerana indica*, and *A. florea*, while species like *Polistes wattii*, *Danaus chrysippus*, and *Papilio demoleus* showed greater activity between 14:00–17:00 hrs. Among these, *A. dorsata* exhibited the highest visitation rate (8.03 ± 3.57 at 09:00 hrs.), followed by *A. mellifera* and *A. cerana indica*. Foraging activity declined sharply after 11:00 hrs., with the lowest activity observed post 18:00 hrs. in terms of floral interaction duration, *A. cerana indica* spent the most time per flower (mean: 10.81 s), with a peak of 21.3 ± 5.12 s on 30 September 2023. This was followed by *A. dorsata* (9.70 s) and *A. mellifera* (7.23 s). In contrast, non-*Apis* pollinators such as *D. chrysippus* (0.49 s) and *P. demoleus* (0.16 s) showed minimal flower visit durations. These findings highlight species-specific foraging rhythms and the supplementary role of insect pollinators—particularly honey bees in enhancing pollen dispersal in maize, a predominantly wind-pollinated crop. Identifying peak activity hours of efficient pollinators is critical for promoting pollinator-friendly agronomic practices, such as minimizing pesticide application during high-activity periods, thereby supporting sustainable maize production and biodiversity conservation.

Keywords: *Apis* species, diurnal activity, foraging behavior, maize, pollination ecology, diversity

Theme-3

Technology Driven
&
Climate Smart
Agrotechnologies

Theme- 3

Technology Driven and Climate Smart Agro Technologies

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As agriculture faces increasing challenges from climate change, biotic stress, and resource degradation, the integration of technology-driven and climate-smart agro-technologies has become essential to ensure food security, environmental sustainability, and economic viability.

Artificial Intelligence (AI) and Precision Agriculture are transforming modern farming by enabling data-driven decisions. AI-powered models use remote sensing, drones, and machine learning to optimize irrigation, fertilizer application, and pest prediction. These tools reduce input costs and environmental impact while maximizing productivity (Jha *et al*., 2023). Precision tools such as GPS-guided tractors and variable rate technology enhance field-level management with accuracy and efficiency.

Innovations in crop technologies—including genetic improvement, speed breeding, and CRISPR-based gene editing—are helping develop high-yielding, climate-resilient, and pest-resistant crops. These innovations are vital to adapt to unpredictable weather, prolonged droughts, and emerging pest pressures (Sharma *et al*., 2022).

Nanotechnology is emerging as a powerful tool in agriculture and pest control. Nano-fertilizers and nano-pesticides offer controlled release, targeted delivery, and improved nutrient absorption, reducing leaching and environmental pollution. Nanosensors enable real-time soil and crop health monitoring, making farming more precise and responsive (Singh & Roy, 2023).

Climate change mitigation and adaptation strategies are central to climate-smart agriculture. Practices such as carbon sequestration through conservation tillage, agroforestry, and low-emission livestock systems contribute to reducing agriculture's greenhouse gas footprint. Climate-smart practices also improve productivity and resilience in the face of extreme weather events (FAO, 2023).

Developing climate-resilient crops—especially those tolerant to biotic stress such as pests, pathogens, and weeds—is crucial. Drought-, heat-, and salinity-tolerant crop varieties ensure stable production despite erratic climatic patterns. Integrated pest and disease management further strengthens resilience (Zhang *et al*., 2022).

Smart pest surveillance and monitoring systems using IoT, AI, and satellite imaging offer early warning and real-time tracking of pest outbreaks. These technologies reduce crop losses, minimize pesticide overuse, and support sustainable crop protection (Mehta & Verma, 2024).

Protected agriculture, including greenhouse technologies, vertical farming, and hydroponics, offers climate-resilient food production systems. These systems shield crops from environmental extremes, allow year-round production, and conserve water and land. With automated controls for temperature, humidity, and nutrient supply, they are ideal for urban and peri-urban agriculture (Kumar *et al*., 2023).

In conclusion, climate-smart and technology-integrated agriculture is the future of global food production. By adopting AI, nanotech, protected cultivation, and resilient crop varieties, farmers can address climate change, improve productivity, and conserve natural resources. Policy frameworks, public-private partnerships, and digital extension tools are essential to ensure equitable access and large-scale adoption.

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Theme- 3

Ecological engineering as tools of organic insect-pests management in vegetables

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Abstract

In general, agro-ecosystems are unfavorable environments for natural enemies due to high levels of disturbance. There is need to integrate new approach is to interface ecosystems with technology to create new, hybrid systems. Ecological engineering, a form of conservation biological control, is an ecologically based approach aimed at favoring natural enemies and enhancing biological control in agricultural systems. The goal of ecological engineering is to create a suitable ecological infrastructure within the agricultural landscape to provide resources such as food for adult natural enemies, alternative prey or hosts, and shelter for survival in adverse conditions. These resources must be integrated into the landscape in a way that is spatially and temporally favorable to natural enemies and practical for producers to implement. The literature on Ecological Engineering is reviewed with attention to practices for favoring predators, parasitoids and pollinators' implementation of ecological engineering or habitat management, and the contributions of modeling and ecological theory to this developing area of conservation biological control. The potential of integrate the goals of ecological engineering for the conservation of natural enemies, enhanced biodiversity and natural agricultural pest management with organic amendments. Many of the proximate factors identified as limiting the effectiveness of natural enemies in vegetable ecosystem can be viewed as direct results of the disturbance regimes imposed on these systems. In particular, the ubiquity of pesticides use in crop production systems has posed a limitation to the successful implementation of biological control. A focus of many past conservation efforts has been to seek more selective pesticides, or to time the use of pesticides to minimize their negative impacts on natural enemies. Recently, increasing attention has been paid to conservation practices that seek to alter the quality of the natural enemies habitat for biodiversity conservation and sustainable pest management.

Introduction

Ecological Engineering (EE) for pest management is a new paradigm to enhance the natural enemies of pests in an agro ecosystem and is being considered an important strategy for promoting Bio intensive Integrated Pest Management (BIPM). This approach relies on use of cultural techniques to bring about habitat manipulation and enhance biological control. Concept: Ecological Engineering emerged as a paradigm for considering pest management approaches that are based on cultural practices and informed

by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops. Objectives: The primary objective in Ecological engineering is to make environment of the Agro-ecosystem suitable for the better survival of natural enemies of pests. Habitat manipulation aims to provide natural enemies of pests with nectar, pollen, physical refuge, alternate prey, alternate hosts and living sites. This can be through plantation of appropriate companion plants like floral trap crops and repellent crops, through which the population of pollinators, predators and parasitoids can be enhanced to manage the herbivorous insect pests. Ecological Engineering (EE) strategies focus on pest management both below ground and above ground. The main emphasis is to improve the soil health below ground by developing soils rich in organic matter and microbial activity and above ground plant health by habitat manipulation to increase the biodiversity of beneficial natural enemies.

The goal of ecological engineering is to generate cost effective alternatives to conventional solutions. It can be considered a subset of conservation biological control methods that alters habitats to improve availability of the resources required by natural enemies for optimal performance. Habitat management may occur at the within-crop, within-farm, or landscape levels. Underlying these practices is the understanding that agricultural landscapes often do not provide resources for natural enemies at the optimal time or place. The need for habitat management is directly linked to the biology of specific pests and natural enemies, and the qualities of the environment in which they occur. As a result of frequent and intense disturbance regimes, many agricultural systems are recognized as particularly difficult environments for natural enemies.

It could be argued that all pest management approaches are forms of ecological engineering, irrespective of whether they act on the physical environment (e.g., via tillage), chemical environment (e.g., via pesticide use) or biotic environment (e.g., via the use of novel crop varieties). It is, however, the use of cultural techniques to effect habitat manipulation and enhance biological control that most readily fit the philosophy of ecological engineering. These cultural techniques typically:

1. Involve relatively low inputs of energy or materials.
2. rely on natural processes (e.g., natural enemies or the response of herbivores to vegetational diversity)
3. have developed to be consistent with ecological principles
4. are refined by applied ecological experimentation
5. Contribute to knowledge of theoretical and applied ecology.

Ecological Engineering and Conservation Biological Control

It can be considered a subset of conservation biological control methods that alters habitats to improve availability of the resources required by natural enemies for optimal performance. Habitat management may occur at the within-crop, within-farm, or landscape levels. Underlying these practices is the understanding that agricultural landscapes often do not provide resources for natural enemies at the

optimal time or place. The need for habitat management is directly linked to the biology of specific pests and natural enemies, and the qualities of the environment in which they occur (Parvaiz and Khan, 2022). As a result of frequent and intense disturbance regimes, many agricultural systems are recognized as particularly difficult environments for natural enemies. This is especially true for annual monocultural cropping systems where the rates of establishment of imported natural enemies and their success in controlling the target pest are lower than in more stable cropping systems. Many of the proximate factors identified as limiting the effectiveness of natural enemies in agricultural systems (pesticides, lack of adult food, lack of alternative hosts) can be viewed as direct results of the disturbance regimes imposed on these systems. In particular, the ubiquity of pesticide use in crop production systems has posed a limitation to the successful implementation of biological control. A focus of many past conservation efforts has been to seek more selective pesticides, or to time the use of pesticides to minimize their negative impacts on natural enemies. Recently, increasing attention has been paid to conservation practices that seek to alter the quality of the natural enemies' habitat.

Contrasting genetic engineering (GE) and ecological engineering (EE)

Genetically engineered (GE) crops, otherwise known as transgenic or genetically modified (GM) crops, are becoming an increasingly dominant feature of agricultural landscapes. Worldwide, the areas planted to transgenic crops have increased dramatically in recent years, from 3 million hectares in 1996 to 58.7 million hectares in 2002. Globally the main GE crop species are soybean occupying 36.5 million ha and maize at 12.4 million ha, followed by cotton and canola. Other GM crops available are potato, sugar beet, tobacco and tomato. In the USA, Argentina and Canada, over half of the area planted to major crops such as soybean, corn and canola is occupied by transgenic varieties. Herbicide tolerant (HT) crops and those expressing insecticidal toxins from the bacterium *Bacillus thuringiensis* (Bt) have been consistently the dominant traits in GE crops, though a range of quality traits has been the subject of much research and these are likely to be used commercially in the near future. As a consequence, ecological engineering approaches merit greater research attention. Not only are these often effective and sustainable, the approaches that use are unlikely to meet resistance from the general public (Table 1).

Table 1. Comparison of genetic engineering with ecological engineering in agriculture System.

Characteristic	**Genetic engineering**	**Ecological engineering**
Units engineered	Organisms	Ecosystems
Tools for engineering	Genes	Species
Biotic diversity	Potentially threatened	Maintained/enhanced
Principles	Genetics/ molecular biology	Ecology
Maintenance and development costs	High	Moderate

Public acceptability	Low	High
Level of current use in agriculture	Widespread in some 'developed' countries	Limited uptake in developed countries, though reflected in many traditional agricultural systems

Sources: Gurr et al., 2004

Mechanisms of Ecological Engineering

1. Enhanced the Specific Diversity

Biodiversity in agro-ecosystems may favour reduced pest pressure and enhanced activity of natural enemies. However, several authors have noted that to selectively enhance natural enemies, the important elements of diversity should be identified and provided rather than encouraging diversity per se. Indeed, it has been shown that simply increasing diversity can exacerbate certain pest problems. Identifying the key elements of diversity may be a difficult process, but the process can be guided by an understanding of the resources needed by natural enemies. Potential mechanisms include improving the availability of alternative foods such as nectar, pollen, and honeydew; providing shelter or a moderated microclimate in which natural enemies may overwinter or seek refuge from factors such as environmental extremes or pesticides; and providing habitat in which alternative hosts or prey are present. In addition, the temporal availability of such resources may be manipulated to encourage early season activity of natural enemies. Finally, the spatial arrangement of such resources to enhance natural enemy activity within the crop must be considered.

2. Substitute Food Sources

Most of the Ecological engineering techniques attempts with alternative food sources have involved hymenopteran parasitoids, Diptera may benefit as well. Quantifying the impact of different nectar sources on parasitoid survival and fecundity has yielded important information on which plant species to retain or introduce into an agroecosystem. Studies have examined a range of wildflowers as nectar sources and identified significant differences in the accessibility of nectaries as a result of floral architecture (Khan et al., 2020a). They found that floral architecture influenced the selection of nectar plants, with *E. puttleri* feeding effectively only upon flowers with exposed nectaries, while *P. foveolatus* could also utilize flowers with partially concealed nectaries. Provision of nectar resources may provide increased benefits to herbivores as well as parasitoids, but careful selection of plants can reduce this possibility. Substantial work has been conducted on the enhancement of aphidophagous syrphids by provision of flowering plants. where syrphid numbers increased, and aphid populations declined. Scientists screened a range of flowers to determine which were suitable for Colorado potato beetle (*Leptinotarsa decemlineata* Say) predators. They found that that dill (*Anethum graveolens* L.) and coriander (*Coriandrum sativum* L.) had flowers compatible with the head morphology of *Coleomegilla maculata* (Degeer) and *Chrysoperla carnea* Stephens.

3. Shelter and Microclimate

The natural enemies' populations may persist from year to year in perennial crops. However, in some perennial crops such as alfalfa (*Medicago sativa* L.), the normal practice of harvesting entire fields causes disruption to the resident arthropod fauna (Khan et al., 2020b). Among the earliest examples of EE were attempts to provide a refuge for natural enemies of alfalfa pests displaced by cutting. This practice has also been explored in more recent work where strip harvesting was associated with lower pest densities and lower aphid-to-predator ratios, except in spring. Altered harvesting patterns also offer refuge to the brown lacewing *Micromus tasmaniae* (Walker) and a range of coccinellid and hemipteran predators. In these approaches, the provision of a moderated microclimate of uncut alfalfa is likely to be important. Overwintering of natural enemies has also been investigated in a number of temperate perennial systems. Shelter has been provided by augmenting leaf debris on the orchard floor with peppermint (Mentha x piperita L.), wrapping the bases of apple (Malus domestica Borth.) trees in vegetable debris held in place with plastic, placing similar debris around the base of smaller trees, or providing on-tree refugia of burlap and aluminum in peach, *Punus persica* (L.).

Non-crop vegetation may be favored by natural enemies as oviposition sites. It has been observed that *Coleomegilla maculata* (Coleoptera: Coccinellidae) lays more eggs on a native weed, *Acalypha ostryaefolia* Ridell than the sweet corn (*Zea mays* L.) crop, even though the plant supported few prey. Larvae then disperse from the weed and climb maize plants. Maize plots bordered by *A. ostryaefolia* contained significantly more *C. maculata* than did plots without a border. Other examples of ground covers or intercrops influencing natural enemy density, activity or impact include carabids in maize, parasitoids in cabbage (*Brassica oleracea capitata* L.), mite predators in citrus, and various natural enemies in pecan (*Carya illinoensis* Koch) and cotton. Although microclimate factors are likely to be involved, in at least some cases the availability of alternative foods in the form of floral resources and/or prey or hosts in the non-crop vegetation may have contributed to the observed effects. It is important to note that other studies indicate inconsistent or limited benefits of ground covers or intercrops on natural enemies or even negative effects.

4. Substitute Prey or Hosts

Provide the sufficient alternative prey, populations of generalist predators may establish within a crop before the arrival and seasonal increase of pests. The homopteran pests of apple the distribution of predators was determined by the presence of alternative prey on weeds or in surrounding vegetation. Management of crop residues or organic matter may also be effective in enhancing natural enemy populations. A classic demonstration in rice, *Oryza sativa* L., involved increasing the amount of organic matter in test plots leading to increases in detritivores, plankton-feeders, and generalist predators. In habitat management approach, cutting the bean plants when aphid infestation was detected within the hops was planned as a means of encouraging dispersal of natural enemies to the crop.

5. Multiple Mechanisms

Ecological Engineering may benefit natural enemies by the simultaneous operation of more than one mechanism. Work with *Eriborus terebrans* (Gravenhorst), the primary parasitoid of *Ostrinia nubilalis* (Hu¨bner) in maize in Michigan showed that females were most frequently captured in maize fields close to wooded field edges and that parasitism of *O. nubilalis* was higher in these areas. The wasps were also shown to be more active on hotter days, which could result in their leaving crop habitats to find shelter in adjacent wooded areas. It was suggested that wooded edges benefited *E. terebrans* by providing both a source of adult food (nectar and honeydew) and access to a moderated microclimate. Intentionally established ‘‘insectary hedgerows’’ containing a diversity of shrubs and herbaceous plants to provide continuous sources of pollen, nectar, and shelter have been studied. Marking studies showed that natural enemies utilize these habitats and disperse into adjacent crops. Up to 47% of the marked *Hyposoter* wasps and 23% of lady beetles were found up to 75 m into the crop. Because of the potential for natural enemies to be simultaneously favored by more than one mechanism, the small number of studies that have explicitly sought to elucidate which mechanism is most important are noteworthy. Irvin et al used ground covers of either buckwheat (Fagopyrum esculentum Moench) or faba bean to increase the impact of natural enemies of leafrollers (Tortricidae) in apple orchards. Sticky trap catches of the leafroller parasite *Dolichogenidea tasmanica* Cameron were significantly greater in plots of flowering buckwheat than in plots of buckwheat where flower buds were removed. This showed that floral rewards, rather than either availability of shelter or presence of alternative hosts on the buckwheat foliage was responsible for enhancement of parasitoid activity. In a second study, buckwheat had the greatest effect on *Anacharis* sp., a parasitoid of the brown lacewing (*Micromus tasmaniae* Walker), itself an important natural enemy. In these trials, sticky traps in the buckwheat plots caught more parasitoids that those in the control except in the period prior to buckwheat flowering. This indicated that feeding upon flowers, rather than the presence of aphids on the buckwheat upon which host lacewings were feeding, influenced parasitoid catches. Vacuum sampling the buckwheat confirmed the very low densities of lacewings and *Anacharis* suggesting they were not using plants for shelter.

Implementing of Ecological Engineering

Here we address five key issues in the implementation of habitat management: (a) the selection of the most appropriate plant species; (b) the predator/parasitoid behavioral mechanisms which are influenced by the manipulation; (c) the spatial scale over which the habitat enhancement operates, with implications for the area, shape and spacing of resources and refugia for predators and parasitoids; (d) the negative aspects associated with adding new plants to an agroecosystem, such as the use of the plant resources by the pest being targeted; (e) the degree of uptake by the agricultural/horticultural community of the proposed habitat changes.

EE for Pest Management: Above Ground in vegetable crops

1. Focus is on making the habitat less suitable for pests and more attractive to natural enemies.
2. Raising flowering plants along the border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
3. Inter-cropping, border-cropping and mix cropping of the flowering plants provide nectar/ pollen as food for various bio-control agents. Trap crops and repelling crops for pests are also grown as intercrop along with the main crop.
4. Not uprooting weed plants which are growing naturally like White clover, Mint etc. as they act as nectar source for natural enemies.
5. Not applying chemical pesticides, when the Prey (P): Defender (D) ratio is favorable.

The compensation ability of the plant should also be considered before applying chemical pesticides.

Different types of Plants used in Ecological Engineering: These can be classified into 5 categories.

1. **Attractant Plants - Attract the Natural Enemies of pests**

   Plants which attract Natural Enemies of Pests: These include Mustard, sunflower, buckwheat, carrot, marigold, French bean, maize/corn, cowpea, spearmint. The actual selection of flowering plants could be based on availability, agro-climatic conditions and soil types. Due to enhancement of biodiversity by the flowering plants, the number of parasitoids and predators (natural enemies) also increase due to availability of nectar, pollen, fruits, insects, etc. The major predators are a wide variety of spiders, ladybird beetles, long horned grasshoppers, *Chrysoperla*, earwigs, etc. Management of aphid in Cole crops through ecological engineering During a demonstration of ecological engineering in Cole crops conducted by the Directorate of Plant Protection, Quarantine & Storage, Cole crops were bordered by Sunflower, Mustard, Marigold and Coriander crops. The Sunflower was the tallest crop to attract the *Helicoverpa* pest; it was surrounded by two rows of mustard to attract *Chrysoperla* and Lady Bird Beetle. Coriander crop attracts different natural enemies of main crop pests. Marigold was the preferable crop for egg laying of *Helicoverpa*. It was observed that the cabbage and cauliflower crops found affected with aphid and the aphid population on Cole crops was found parasitized by *Aphidius*, a potential parasite of aphid. This parasite was able to manage the aphid population on Cole crops

2. **Trap plants - Trap the crop pests**

   A trap crop is a crop that is planted to lure insect pests away from the main crop. • Basil and marigold as a border crop (main crop- Garlic) controls Thrips • Castor plant as a border crop in Cotton and chilli field, controls Tobacco caterpillar • Legume as inter / alternate crops in sugarcane enhances the population of fungal and bacterial BCA for the management of nematodes & other soil borne diseases. • Inter crop rows of *Tridax procumbens* in paddy crop enhances the natural parasite and predator populations.

3. Repellent plants - Repel the crop pests

Repellant Plants which repel harmful insect-pests: Grown either as border crop or main crop, these repel the pests away from the crop mainly due to the release of volatile repellent plant chemicals such as Coriander and dill. • Basil repels flies, mosquito, tomato borer • Garlic repels beetles, aphids, weevils, spider mites, carrot fly • Radish deter cucumber beetle • Mint repel cabbage moth • Marigold repels beetles, cucumber beetles, nematodes

4. **Barrier/Border plants - Prevent the entry of pests**

Barrier/ Border plants which attract insect-pests and reduce pest population on main crop: These protect the main crop against small soft bodied flying insects which migrate from one field to other field such as whiteflies, hoppers, aphids, mealybugs, thrips etc. Eg. Maize, Sorghum, Bajra, Redgram etc. as barrier crops.

5. **Cover crops- conserve/provide shelter the natural enemies of crop pests**

The population of predator depend on the aphids, so maintain cover crop or alternate host of aphids or alternate prey to maintain the population. Buckwheat is good examples of cover crop.

EE for Pest Management: Below Ground in vegetable crops

This focuses on improvement of soil health • Keeping soils covered round the year with living vegetation and/or crop residue. • Adding organic matter in the form of farm yard manure (FYM), Vermicompost, crop residue which enhance below ground biodiversity. • Reducing tillage intensity so that hibernating natural enemies can be saved. • Applying balanced dose of nutrients using biofertilizers. • Applying mycorrhiza and plant growth promoting rhizobacteria (PGPR) • Applying Trichoderma spp. and Pseudomonas fluorescens as seed/seedling/planting material, nursery treatment and soil application. These practices strengthen the ability of crops to withstand pests and also help improve soil fertility and crop productivity. Thus, Biodiversity is crucial to crop defenses: the more diverse the plants, animals and soil-borne organisms in a farming system, the more diverse are the pest fighting beneficial organisms on the farm. Integrating AESA (Agro-Eco System Analysis) based IPM and Principles of Ecological Engineering There is a need to integrate AESA based IPM and principles of ecological engineering for pest management to help farmers maintain biodiversity and keep pests under control while at the same time maintain the eco-system.

CONCLUSION

The science of Ecological Engineering is still in its infancy. Publications on the topic date from the first half of the century, but close to 80% of the literature reviewed herein was published after 1990. While this is in part attributable to our intention to focus on recent literature, within the current decade a marked trend toward increasing activity is evident. The international community of scientists engaged in this field appear well poised to meet the challenge of making agricultural pest management more effective, and production systems more sustainable, as well as being increasingly compatible with nature conservation.

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Abstracts

Mitigation of dry spell effect on Wheat crop production through KCl spray

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Rainfall is an important factor for successful crop production in district Poonch as more than 90% of the cultivated land depends on timely and adequate rainfall. However, due the climate change, the region is facing frequent dry spells more so during critical crop growth stages in both Rabi and Kharif seasons, posing serious challenges to agricultural productivity, particularly in the wheat crop. The occurrence of persistent moisture deficit has significantly impacted crop yields and farmer livelihoods, underlining the urgent need for adaptive strategies to combat drought stress. Under NICRA project, a foliar spray of 1% potassium chloride (KCl) was applied on wheat crops in the village Mangnar, district Poonch. The intervention was aimed at enhancing Water Use Efficiency (WUE) and boosting crop resilience under water-stressed conditions. Our result demonstrated that foliar application of KCl substantially mitigated the effects of drought, leading to a significant 29.59% increase in wheat yield with a B:C ratio of 1.96 compared to untreated plots. This successful field-level demonstration highlights the potential of potassium-based foliar nutrition as a cost-effective and practical strategy to enhance drought tolerance and sustain crop productivity in rainfed agro-ecosystems like Poonch.

Keywords: Dry spells, Moisture deficit, Rainfed, Water Use Efficiency

Empowering Agriculture through Extension Outreach and Technological Innovation: Pathways to Sustainable Development

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Agriculture is seeing as an era of revolutionary change being driven by technology and the growing need for sustainable avenues. In this context, extension outreach plays a very crucial role between research institutions and farmer populations to ensure that advanced solutions find their way at the grassroots level. This study unfolds the ways in which the interface between agricultural extension and technological innovation can enhance productivity, improve livelihoods and promote climate-resilient

agriculture. As digital agriculture has been evolving, digital technologies such as mobile advisory services, artificial intelligence-based decision support systems, precision farming, remote sensing and ICT platforms are redefining traditional extension practice. These technologies, when combined with participatory approaches such as Farmer Field Schools and patterns of experiential learning, encourage enhanced adoption rates and local relevance. This study also highlights the importance of capacity development, participatory policy frameworks and multi-stakeholder partnerships to strengthen the effectiveness of extension systems. Special importance is given to the use of Agri-startups and youth engagement in scaling up innovations. By connecting research outputs with real farmer needs through forward-looking extension mechanisms, agricultural development can be made inclusive, responsive and sustainable. The linkage of extension outreach and technology innovation not only empowers farmers with relevant information and tools in a timely manner but also sets the path for a knowledge-based, resilient agriculture system. This integrated approach is the solution to addressing food security, environmental sustainability and rural prosperity in the future.

Keywords: Agricultural Extension, Technological Innovation, Sustainable Agriculture, Precision Farming, Farmer Empowerment

Observation on Insect Pest of Gerbera (*Gerbera jamesonii*) in Protected Cultivation

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Gerbera (*Gerbera jamesonii*), is one of the potential and popular ornamental plant belonging to the family Asteraceae and aid value to the rural youths and unemployed in development of entrepreneurship and and income generation to promote the floriculture industry. It has gained global recognition for its vibrant and diverse-coloured blooms and long vase life. However, its cultivation is severely affected by several insect pests that reduce the quality and aesthetic value of flowers. A large magnitude of insect pests was recorded in protected cultivation of gerbera such as aphids, whiteflies, white mites, and thrips. Although the pests are minutes in size but they causes economic losses. These insect pests not only cause direct damage by feeding on plant tissues but also act as vectors for various plant viruses, further complicating their management issues and in turn reduced the yields of flowers. damage the flowers and foliage by rasping and feeding on cell contents, resulting in silvering, deformation, and blemishes on petals, making the flowers unmarketable. Besides, they cause speckling, leaf bronzing, and premature leaf drop and half opened blossom which drastically reduced the flower value in market. Effective pest management is the only way out to overcome the sucking insect pests and their huge losses in protected cultivation of Gerbera. IPM includes, regular monitoring, promotion of biological

control agents (e.g., ladybird beetles, green lace wing, predatory mites) and selective use of pesticides in maintaining pest populations below economic thresholds. Further, Cultural practices such as proper spacing, sanitation, and weed control also contribute to effective pest management. Understanding pest biology and timely intervention are critical to ensuring healthy gerbera production and minimizing economic losses in protected cultivation of Gerbera..

Keywords: *Gerbera jamesonii*, aphids, whitefly, mites, thrips, ornamental plants, IPM, Biocontrol agents

Field Efficacy of Biorationals and Chemical Insecticides in Management of Fruit Damage in Okra

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An investigation on “Field efficacy of biorationals and chemical insecticides in management of fruit damage in Okra” was conducted with seven treatments including Metarhizium anisopliae, Verticillium lecanii, NSKE 5%, Azadirachtin 1500 ppm, Emamectin benzoate 5% SC, Chlorantraniliprole 18.5% SC, Imidacloprid 17.8 % SL and Untreated control. All the biorationals and chemical insecticides tested significantly reduced the fruit infestation by shoot and fruit borer (OSFB) compared to untreated control. The lowest fruit damage of 8.66% was recorded in Chlorantraniliprole 18.5% SC followed by Emamectin benzoate 5% SC 13.46%, Imidacloprid 17.8 % SL 14.97%, NSKE 5% 15.81 %, Azadirachtin 1500 ppm 16.64%, Metarhizium anisopliae 1x108 CFU/gm 17.59 % and least effective treatment was Verticillium lecanii 1x108 CFU/gm 18.19 %, respectively. However, when cost benefit ratio was worked out, the highest yield (154.28q/ha) with C:B ratio of 1:7.21 was recorded in T6 Chlorantraniliprole 18.5% SC and found to be best superior treatment followed by T5 Emamectin benzoate 5% SG recorded 135.15 q/ha yield with 1:6.95 C: B ratio followed by T7 Imidacloprid 17.8 SL recorded (129.51 q/ha and 1:6.67), T3 NSKE 5% (97.69 q/ha and 1:4.83), T4 Azadiractin 1500 ppm (91.71 q/ha and 1:4.58), T1 Metarhizium anisopliae 1x108 CFU/gm (75.64 q/ha and 1:3.89), T2 Verticillium lecanii 1x108 CFU/gm (64.87 q/ha and 1:3.34) and recorded lowest yield 50.14 q/ha and C:B ratio 1:2.68 in T8 control.

Keywords: Biorational, Insecticide, Earias vittella, okra, fruit damage

Screening of Local Horsegram (*Macrotyloma uniflorum* L.) Germplasm collected from Jammu Region for Morpho-Physiological and Seed Traits

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The study was conducted during the *kharif* 2023 at the farm of Krishi Vigyan Kendra, Samba, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu. Twenty-five local horsegram germplasm lines including three checks Pratap Kulthi-1, Pratap Kulthi-2 and Arja Kulthi-21 were evaluated under RCBD and CRD with three replications. Analysis of variance among the germplasm for all the traits under study indicated sufficient variation among germplasm lines. The HG-21 germplasm showed the maximum seed yield per plant i.e. 5.98 g, highest harvest index i.e. 45.63% and maximum chlorophyll content at 60 days after sowing i.e. 42.23 SPAD value among all the germplasm including the checks followed by HG-15 germplasm. The laboratory investigation indicated germplasm HG-15 and HG-21 had high vigour index i.e. 2028.7 and 1955.0, high seedling length i.e. 24.04 cm and 23.64 cm and high germination percentage i.e. 88% and 85% respectively. These results suggest that the promising germplasm HG-21 and HG-15 collected from Ramkot village Kathua and Sartangal village Bhaderwah respectively showed high morpho-physiological and seed traits that can be further utilized for the horsegram improvement programme.

Keywords: Germplasm, Horsegram, Local, Morpho-physiological, Seed, Traits

Theme-4

Bioresources, Food safety and Livelihood

Theme- 4

Paradigm of Pesticide–Pollinator Interactions in Indian Agriculture

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Introduction

In the epoch of ecological uncertainty and agricultural intensification, the delicate balance between pesticide uses and pollinator conservation has emerged as a critical frontier in Indian agriculture. The paradigm of pesticide–pollinator interactions is no longer a peripheral concern but a central narrative in the discourse of sustainable farming and biodiversity protection. India, with its diverse agro-ecological zones, rich entomofauna, and largely reliance on synthetic inputs, faces an urgent need to collate / re-evaluate these interactions in a manner that is both scientifically robust and policy-responsive. This perspective write-up aims to briefly underscore the current state, emerging threats, research gaps, and actionable pathways for reconciling pesticide use with pollinator safety, thereby sustaining India's agrarian resilience.

Pollinators - the Pillars of Agricultural Sustainability

Pollinators (bees, butterflies, moths, beetles, flies, and birds) play a cardinal role in enhancing productivity, improving crop quality, and sustaining ecological functions. It is estimated that nearly 75 per cent of global food crops benefit from animal-mediated pollination. In India, cross-pollinated crops such as mustard, cotton, sunflower, cucurbits, fruits, and several legumes significantly depend largely on native and managed Apoid pollinators, like hive as well as wild honey bees (*Apis* spp.), stingless bees (Meliponines), *Bombus* spp., and a large number of sub-social bee spp.

India hosts over 750 species of bees alone, a large number of which are indigenous, solitary, and poorly understood in terms of their ecology and pesticide susceptibility. The ecological services offered by these native pollinators often go unnoticed due to the lack of schematic monitoring and documentation. With an economic valuation of pollination services in India estimated in billions of rupees annually, the decline of pollinators diversity and abundance would pose a direct threat to national food security, rural livelihoods, and ecological resilience.

On the contrary, the growing dependence on agrochemicals (particularly insecticides, fungicides, and herbicides), would continue to imperil pollinator health, behaviour, and population dynamics. Additionally, changes in land-use patterns, monocultures, and fragmentation further compound the risks.

Pesticide Exposure: Pathways and Patterns

Pesticides affect pollinators through multiple exposure routes, *viz.* direct spray, contaminated nectar and pollen, dust from treated seeds, guttation fluids, contaminated water, and residual contact on plant surfaces. Sub-lethal exposure, to neonicotinoids, organophosphates, pyrethroids, and newer systemic molecules, has been scientifically linked to impaired foraging, disorientation, navigation loss, decreased learning ability, weakened immunity, queen bee mortality, and reduced colony strength.

Neonicotinoids, particularly imidacloprid and thiamethoxam, have been detected in pollen and nectar for extended periods post-application. The ability of these compounds to persist and translocate within plant systems makes them especially harmful to non-target beneficial insects, including pollinators. Multiple field studies have highlighted pesticide residues in bee bread, bees wax, larvae, and even marketable honey.

Furthermore, tank mixing of insecticides and fungicides, is a prevalent agronomic practice across Indian cropping systems and occasionally herbicides also form part. These combinations, may in the particular situation be safer to plants, often lead to synergistic toxicity, dramatically increasing the risk to bees (herbicides impacting bee's internal micro-fauna/ flora). Such mixes may impair the detoxifying enzymes in pollinators, rendering them more vulnerable to otherwise low-toxicity compounds.

Regulatory Landscape and Research Gaps

India's regulatory framework for pesticides operates primarily under the Insecticide Act (1968), administered by the Central Insecticides Board and Registration Committee (CIB&RC). However, the framework predominantly focuses on mammalian toxicity, environmental persistence, and efficacy on target pests, with insufficient emphasis on pollinator safety. While assessing the field level bio-efficacy for registration, besides recording data on the target pest, data on natural enemies (mainly for spiders) in the treated fields is often recorded. However, field-level toxicity assessments of the pesticides on pollinators are neither mandated by regulation nor routinely documented. This oversight is critical, as the productivity of cross-pollinated crops is heavily dependent on the diversity and abundance of pollinators. In fact, even in pest-free conditions, such crops may fail to deliver optimal or even marginal yields in pollinator-deficient environments.

Moreover, the laboratory toxicity assessments that are mandated during pesticide registration are largely limited to honey bee (*Apis mellifera*), which, while useful, do not adequately represent India's vast and unique diversity of native pollinators. The other native honey bees, social bees (Meliponini, Bombini) and sub-social bees, including large carpenter bees (*Xylocopa* spp.), leaf-cutter bees (*Megachile* spp.) and stingless bees (*Tetragonula* spp.) are known to have different foraging behaviours, life cycles, and

sensitivities to chemical exposures. So there is increasing scientific interest in expanding testing to the native species under pollinator safety frameworks. Furthermore, even when laboratory-based toxicity assessments indicate high or moderate toxicity to *Apis mellifera*, corresponding usage warnings or cautionary statements are often lacking. In particular, there is a notable lack of regulatory measures such as label-claim restrictions to safeguard pollinators, especially concerning applications on bee-floral crops during their blooming periods. This lack of regulatory safeguard poses a significant risk to managed and wild bee populations alike. The prolonged pendency of such regulatory decisions, stretching over more than a decade, despite now well-established evidence of field-level insecticide toxicity of one group of insecticides to honey bees on key bee-attractive crops across the states for the last four years, cannot be viewed in isolation from the substantial pollinator/ honey bee losses that have since occurred.

For all the pesticides that are recommended on bee flora, particularly for use during the crops' blooming, there is an acute need for:

- Regional pesticide residue data on bee products and hive matrices
- Comprehensive field level toxicity assessment against the pollinators
- Comprehensive sub-lethal and chronic toxicity studies
- Pollinator-specific Environmental Risk Assessments (ERA)
- Inclusion of local pollinator bioassays in regulatory protocols

At the extension level, awareness about pollinator-safe pesticide practices among farmers is dismal. Several State Agricultural Universities (SAUs) continue to recommend highly toxic insecticides on bee-attractive crops even during their blooming phases—often replicating CIB&RC recommendations without due contextualization. This practice persists despite the fact that many of these states fall within regions of intensive beekeeping activity. It is imperative that both the Agricultural Universities and the respective State Departments of Agriculture/ Horticulture remain vigilant and take proactive measures to critically review and revise such recommendations within their jurisdiction. There is minimal inclusion of pollinator and bio-diversity protection modules in university curricula, Krishi Vigyan Kendra (KVK) trainings, state agricultural extension programmes, or in state Package of Practices for Crops, in spite of *World Bee Day* and *International Day for Biological Diversity* being celebrated in great fan-fare.

Towards a New Paradigm: Integrating Science, Policy, and Practice

For ensuring the coexistence of crop protection and pollination services, India must urgently adopt an integrated, science-driven, pollinator-conscious pesticide management paradigm. This shift demands coordinated actions at multiple levels:

1. **Policy Reforms and Risk Assessment Innovations**

- Field-level toxicity and impact assessments on pollinators, covering both adult and immature stages, should be mandatorily integrated into the bio-efficacy evaluation phase of pesticide

registration. These studies must comprehensively address parameters such as acute and chronic toxicity, repellency, effects on colony growth and development, and impacts on the yield and quality of hive products. Inclusion of such data should be considered a prerequisite for regulatory approval.

- Include long-term, sub-lethal, and behavioural studies in pesticide evaluation.
- Update risk assessment frameworks to account for cumulative and synergistic effects of pesticide mixtures.
- Mandate inclusion of multiple indicator pollinator species for ecotoxicology tests.

2. **Scientific Surveillance and Pollinator Monitoring**

- Establish a National Pollinator Monitoring Network (NPMN) for baseline data on population trends, diversity, and chemical exposures. However, available state- and region-specific data should also be systematically compiled and analyzed to support this objective.
- Promote participatory science models involving beekeepers, universities/ institutes, and extension functionaries for local data capture.

3. **Agroecological Transition and Sustainable Pest Management**

- Promote Integrated Pest and Pollinator Management (IPPM) combining ecological pest suppression with pollinator-friendly practices.
- Enhance adoption of biological control agents, pheromone traps, and habitat diversification strategies.

4. **Labeling, Communication, and Enforcement**

- Introduce pollinator-risk pictograms on pesticide packaging.
- Prevent application of bee-toxic pesticides during blooming phase of bee floral crops.
- Strengthen surveillance system and promote adherence through well-defined and proportionate accountability measures.

5. **Farmer Education and Multi-stakeholder Partnerships**

- Develop structured training modules in regional languages to enhance farmers' awareness and practical understanding of pollinator-friendly agricultural practices and conservation strategies.
- Establish collaborative platforms involving ICAR institutions, State Agricultural Universities (SAUs), NGOs, Farmer Producer Organizations (FPOs), and the apiculture industry to ensure coordinated efforts, knowledge exchange, and field-level implementation of pollinator-supportive interventions.

Conclusion

The pesticide–pollinator interaction paradigm in Indian agriculture stands at a defining crossroads. The cost of inaction — dwindling crop yields, loss of pollination-dependent biodiversity, and declining honey bee industries — would be far too high for a nation already grappling with climate stress, soil degradation, and rural distress.

What is required is a transformative leap, one that blends ecological prudence with scientific rigor and regulatory foresight. The future of Indian agriculture lies in our ability to harmonize crop protection with pollinator protection. This calls for proactive investment in research, restructuring of regulatory protocols, and re-imagination of farming systems that are not only productive but also pollinator-safe. As custodians of entomological knowledge and stewards of biodiversity, the insect science and apicultural communities have a pivotal role to play in advancing this paradigm. Incremental measures are no longer adequate. An holistic and integrated paradigm of pesticide–pollinator coexistence must now guide our research priorities, regulatory frameworks, and agricultural development trajectory.

Theme-4

Kissan Khidmat Ghar – A Strategic boom to the Innovative Extension

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Introduction

In the post independence era, Indian agricultural extension system has been struggling with regard to strategic planning, The extension system faces the challenges of serving a very large clientele with structural complexity and functional diversity. There is a very wide gap vis-a-vis extension workers to farmer ratio (1:1100) with contact intensity of one hour/ farmer/ year. Critical analysis of the existing system recognizers defects in realistic base level information and lack of continued real time impact assessment at the backend; discrete operation of schemes, poor coordination and cohesiveness among the extension players, low level of public confidence and lack of real time connectivity at the execution level, as the major impediments in realizing the bio-economic potential of agriculture and allied sector. UT of Jammu & Kashmir is bestowed with highly fertile lands and abundant water resources. However geo-physical and climatic variability leads to diverse agro climatic Zones, warranting a robust and versatile extension system. A robust technology enabled agricultural informatics, AI based analysis and reporting system with real time farmer-extension agents interface shall constitute the basis of strategic planning for a proactive agriculture extension system. The extension policy propounded is essentially a cluster approach, with real time regional analysis of the climate and agro-ecology information for promoting the niche agriculture under given agro climatic conditions; and synergizing the interventions under various agriculture development schemes tailored to various agro climatic zones. This shall facilitate holistic development and sustainable bioeconomy. This however warrants restructuring and

strengthening of agricultural extension. The key features of the proposal include a bottom-top approach with establishment of Panchayat level “Kissan Khidmat Ghar", revitalizing the "Block- level Extension Advisory Committee”, promoting KVKs as the hub of convergence of services at District level and establishment of Business orientation centres at SKUAST-K & J with reinforced coordination for planning and execution of AES. Cyber extension including RS-GIS driven agro-advisories and ICT based virtual contacts and communication systems facilitating an enabling environment fostering real-time problem redresses. Other important interventions include capacity building of professionals, skill development of youth for promoting entrepreneurship and generating employment, awareness programmes promoting secondary agriculture and Public Private Partnership and remodelled students rural exploration programme for outreach intensification. Research in extension warrants special consideration for identifying Technology and Service Gaps, Technology adoption and Impact Assessment. Looking into the technological gaps the project was initiated with following Vison, Mission and objectives

Vision: To foster smart technology driven seamless innovative, implementable and inclusive agri-extension services for empowering farmers educated youth to realize the sustainably progressive bioeconomy.

Mission: A dynamic Agri.-extension system using IoT enabled real time big data for farm centric planning and re-orientation of resources to foster sustainable and profitable agriculture with significant increase in the share of agricultural GDP.

Objectives:

1. Holistic planning and execution of Production to Profitable agriculture with Ares. Commodity Specific Extension Approach based on agri. knowledge system (JK As stack platform).
2. Convergence of functional extension resources and approaches for Participatory planning and decentralized decision making to promote remunerative agriculture.
3. To provide seamless agricultural extension services with perfect outreach a dynamic contact across the value chain and real time resource person-clients interaction.
4. Capacity building in agricultural extension and skill development for entrepreneurship development and employment generation.

Project components:

I. Establishment of “Kissan Khidmat Ghar" at Panchayat level for seamless agricultural extension services

In order to extend quality services to farmers' doorsteps, it is proposed to extend Andhra Model of “Rythu Bharosa Kendras" to UT of J&K by establishing the "Kissan Khidmat Ghar" at panchayat level. This shall establish a sustainable and seamless agricultural extension outreach to the farmers by serving as a ground level convergence point for synergizing the extension efforts of multitude of stake

holders and provide self – employment to 2000 youth in first phase. So far as 200 KKG has been established. These KKG provide one-stop centre serving the agriculture and allied sectors, acting as an information and knowledge hub equipped with modern ICT tools, including kiosks for direct farmer access to a wide range of services such as input supply, technology updates, and market information. This centre aims to foster effective and economical value chain management through a public-private partnership model. It will be staffed by village-level workers from various departments associated with agriculture and allied sectors, supported by contractual personnel. The centre will be led by the senior-most Agricultural Assistant or an equivalent official possessing at least a diploma in agriculture or a related field, who will serve as the in-charge of the Krishi Kiosk and Guidance (KKG) Centre. To promote self-employment, each KKG will engage one technical facilitator who will provide end-to-end services to farmers for a nominal fee. A robust Management Information System (MIS) will be implemented to ensure transparency and accountability in service delivery, as well as efficient sharing of both discrete and consolidated data with the parent departments and local administration. Furthermore, the centre will maintain strong linkages with Krishi Vigyan Kendras (KVKs), line departments, and agricultural universities, working in close coordination with Panchayati Raj institutions to foster a collaborative public-private-panchayat partnership.

Key Functions of KKG

- Execution of direct services in agriculture and allied sector as per mandate of respective Departments viz. health services (soil, plant, animal, etc.) including monitoring, surveillance, clinical diagnosis, laboratory testing and treatment/ prophylaxis; Artificial insemination in cattle; Consultancy services, etc.
- Input booking/ delivery and market intelligence services
- Capacity building and skill development with technical backstopping for Departments, KVKs and Agricultural Universities.
- Facilitating custom hiring services.
- Shall facilitate generation of baseline information for policy planning and review of

Operational schemes at block and higher levels.

II. KVK as Central hub of Convergence at District

For holistic development of agriculture in the Union Territory of Jammu and Kashmir, For implementation of these projects/schemes, There is a pressing need for Krishi Vigyan Kendras (KVKs) to have all essential supporting facilities consolidated under one roof to ensure seamless service delivery and holistic development of the agricultural sector. These facilities should include dedicated centres for information dissemination, advanced agricultural technologies, processing units, certification and testing—especially for niche products like honey—along with adequate storage infrastructure. In addition, provisions for branding, value addition, and marketing of finished products must be integrated to empower farmers and enhance their market competitiveness. To ensure sustainability, the KVK

should also serve as a hub for continuous capacity building and handholding support for Farmer Producer Organizations (FPOs), particularly after project-based interventions are phased out. Bringing all these elements together within the KVK framework will enable it to function as a comprehensive, one-stop solution centre for farmers and stakeholders in the agriculture and allied sectors. For strengthening the research and extension in the region it is necessary to strengthen the KVKs and their infrastructure. So in order to accomplish that, 29 civil works have been under process.

The key features of KVK as a district level facilitation centre are:

- To act as facilitation centre for complimentary and supplementary support to various projects implemented through different Departments/ agencies. The common/central demonstration units, facility centres, etc. that cannot be extended to individual KKG shall be developed in KVKs.
- To act as resource centre for end-to-end solutions. The facilities for all the products in terms of certification, packing, branding and marketing shall be created in KVK'.This shall provide for collectivization and hence a better market control.
- To act as centre for capacity building for different agri. & allied enterprises, all type of capacity building programmes including skill trainings, vocational trainings awareness programmes required for effective implementation of the developmental programmes will be conducted at the KVK's.
- To test and validate high value low volume crops in non-traditional areas, High value, low volume crops like saffron, lavender, kala zeera, pecanut, chestnut etc., which are grown under niche areas will be tested validated and demonstrated in non-traditional areas by providing seed/planting material and training interventions.
- To develop potential based agro-tourism models in KVKs. Krishi Vigyan Kendras are well located to attract tourists. The infrastructure in these KVKs will be further strengthened to develop model of agro-tourism to provide demonstrations to farmers and build their confidence. The provisions will be made for construction of guest houses, tourist vehicles etc. so as to provide comfortable stay to tourists. Schools from all over the state and outside the states will be the targeted clientele for this intervention.
- To facilitate impact assessment of developmental schemes under different sectors in a cohesive and coordinated manner.

III. Cyber Extension/Multimedia

Cyber Extension refers to the use of information and communication technology (ICT), especially digital tools like the internet, multimedia content, and mobile applications, to enhance the dissemination of knowledge, particularly in fields like agriculture, education, and rural development. It represents a shift from traditional, face-to-face methods of communication to modern, technology-driven approaches.

In the context of rural development and social sciences, cyber extension allows researchers, educators, and government agencies to reach wider audiences with timely and relevant information. For example,

farmers can access weather updates, market prices, best farming practices, and government schemes through mobile apps or online platforms. Multimedia elements—such as videos, animations, and interactive modules—make complex information easier to understand, especially for populations with low literacy levels. These tools enhance learning, encourage community participation, and empower individuals with the knowledge they need to make informed decisions.

Overall, cyber extension and multimedia improve the effectiveness, speed, and reach of communication strategies in social science research and outreach, making them powerful tools for social change and sustainable development.

The project is helpling in strengthening cyber extension through:

- Establishment of Community radio station in SKUAST Jammu namely "Radio Kissan SKUAST Jammu". Established Radio Kissan SKUAST Jammu has been established on 20 Nov, 2024 with aerial range up to 10 km radius along with that mobile app has been launched which offers worldwide connectivity of CRS.
- One more Community radio station yet to be established in KVK Samba.
- Technological centre at SKUAST Jammu yet to be established for augmenting documentation and production of high quality agri-extension/technology Vedios/documentaries.

IV. Students Rural Exploration Programme

A novel and innovative approach for continued exposure of the graduates, post graduates and doctoral students to in-situ Real Challenges in agriculture and allied sectors shall provide a unique opportunity for students to immerse themselves in the social and economics realities of rural areas. The programme aims to bridge the gap between theoretical knowledge and practical experience, fostering a deeper understanding of rural life and its challenges in general and agriculture in particular.

Objectives

- Students Rural Internship
- Minimizing expert deficit at grassroot
- Extended outreach for services at doorstep
- Generation of primary agricultural data at farmers' level
- Promoting real-life learning process among students for capacity building in creative and critical thinking
- Inculcating ethical and social values for better public relations
- Promoting leadership qualities and team work culture in addressing real-life problems.
- Promoting a dynamic system for continued assessment of potential resources, ITKs, Technology interventions vis-à-vis SWOT analysis for furthering the development.
- Optimal use of human resources for widening the SKUAST-Jammu outreach to the farming community.

- Total number of students to be covered under students rural exploration programme are 1327, for graduate students are 953, for post graduation 217 and Ph.D. 157.
- Total number of Block to be covered in Jammu Region 148, Panchayats 2105 and villages 4615.

Goals

- Reaching out to farmers at panchayat level and extended coordination with extension agencies
- To create baseline data related to farming of whole Jammu region
- To aware students about the farming situation of whole Jammu region

V. Research in Extension

Research in this project component, as we collecting data from all districts of Jammu region. It will collect the data regarding the farming, extent of reach of government intervention and about the other information related to agriculture/farming. It will help govt. in policy making. The following research projects are under progress.

1. Impact of Agriculture input use on productivity of major cereal crops of the Jammu region.
2. Impact evaluation of different Government interventions in agriculture sector.
3. Determinants of income diversification in family farm households for livelihood security in J&K.
4. Yield gap analysis of field crops in Jammu region of J&K.

VI. Capacity Building and skill development

Capacity building of farmers is essential to improve their knowledge, skills, and access to resources, ultimately leading to more sustainable, productive, and profitable farming. Here's why it's needed:

1. Adoption of Modern Techniques

Modern agriculture involves advanced techniques like precision farming, integrated pest management, and climate-resilient practices. Many farmers, especially in developing areas, are unaware of or untrained in these.

2. Climate Change Adaptation

Farmers need to adapt to changing weather patterns, droughts, floods, and other climate-related risks. Capacity building helps them implement resilient practices to protect crops and livelihoods.

3. Sustainable Resource Use

With growing pressure on land, water, and biodiversity, training helps farmers use resources efficiently and sustainably, reducing environmental degradation.

4. Improved Market Access

Capacity building can teach farmers how to grade, package, and market their products better, enabling them to access local and global markets and get fair prices.

5. Increased Income and Livelihood Security

When farmers apply better practices, yields and quality improve. This translates into higher income and better food security for their families.

6. Empowerment and Decision-Making

Educated and skilled farmers can make informed decisions about crops, inputs, finances, and investments, reducing dependency on middlemen or external actors.

7. Digital Literacy

With growing use of mobile apps and digital tools for weather forecasts, market prices, and online training, farmers need capacity building to use these effectively.

8. Capacity Building

- To develop the skill and knowledge of farmers, 41 trainings has been organised at different institution of SKUAST Jammu and also 6 trainings programme for capacity building of officials from agriculture experts.
- 40 interview programme has been recorded and telecasted through Doordarshan studio Janipur, Jammu under the Programme name “Sadhi Dharti Sadhe Lok”. Special features of these programme was that these were recorded in regional (Dogri) and Hindi language. Experts from different field of agriculture were invited in these interview.

Strategy of work:-

- Step I Call for Mission Mode Projects
- Step II Screening & Evaluation

- Step III Facilitation / Execution
- Step IV Report / Impact

Conclusion:-

The HADP project was initiated in 2022. This project converges all the department and research institutions related to Agriculture and allied activities on single platform which will ultimately help the farmers in easiest possible way and create the sense of collective responsibility. This project covers all the aspects of farming as mentioned in different components and whole work has been streamlined through online process. So that empowered farmers can adopt climate resilient practices and move towards Sustainable and advance farming.

Abstracts

Bees' assemblage pattern during various seasons in Punjab: A North-western state of India

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Bees are important pollinators necessary for any agricultural landscape. Their assemblage was measured in terms of diversity and abundance during five different seasons in Punjab primarily an agricultural state of India. Random sampling was done at various locations by swaying a hand insect net for thirty times over the blooms. Among 7482 collected and identified bees' specimens, *Apis mellifera* was the most abundant (12.58%) followed by *Apis dorsata* (12.24%), *Apis cerana* (11.61%) and *Apis florea* (9.18%). The highly diverse seasons with respect to number of bee species and their number was summer (23 species, 1994 individuals) followed by spring (18 species, 1998 individuals) and monsoon (18 species, 2132 individuals). The least diversity was recorded during winters (4 species, 70 individuals). Megachilid bees started appearing late in the summer season and remained active till autumn season except *Osmia sp.* which appeared only during spring season. Monsoon and summer seasons were highly similar to each other as represented by Bray-Curtis and Jaccard's indices. The studies showed that *A. mellifera* was the most abundant besides non-Apis bees appeared in different seasons. Nonetheless, further studies are required to investigate possible linkages between various agricultural landscapes with bee pollinators' community.

Keywords: Bees, Pollinator, Assemblage, Abundance, Regions

Kissan Khidmat Ghar – A Strategic boom to the Innovative Extension

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In the post-independence era, Indian agricultural extension system has been struggling with regard to strategic planning, The extension system faces the challenges of serving a very large clientele with structural complexity and functional diversity. There is a very wide gap vis-a-vis extension workers to farmer ratio (1:1100) with contact intensity of one hour/ farmer/ year. Critical analysis of the existing system recognizers defects in realistic base level information and lack of continued real time impact assessment at the backend; discrete operation of schemes, poor coordination and cohesiveness among the extension players, low level of public confidence and lack of real time connectivity at the execution

level, as the major impediments in realizing the bio-economic potential of agriculture and allied sector. UT of Jammu & Kashmir is bestowed with highly fertile lands and abundant water resources. However geo-physical and climatic variability leads to diverse agro climatic Zones, warranting a robust and versatile extension system. This however warrants restructuring and strengthening of agricultural extension. The key features of the proposal include a bottom-top approach with establishment of Panchayat level “Kissan Khidmat Ghar", revitalizing the "Block- level Extension Advisory Committee”, promoting KVKs as the hub of convergence of services at District level and establishment of Business orientation centres at SKUAST-K & J with reinforced coordination for planning and execution of AES.

Key words: Extension system, Kissan Khidmat Ghar, Extension workers, Agro climatic Zones.

Taye: A Low-Cost Fodder Storage Tradition from Doda District, Jammu and Kashmir

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The Taye, a vernacular term in the Bhaderwahi language of Jammu and Kashmir's Doda district, represents a unique and enduring indigenous structure for storing dry fodder. This low-cost and remarkably durable design passed down through generations utilizes readily available local materials for effective fodder preservation. The construction techniques though slightly modified over time demonstrate the ingenuity of traditional knowledge. However, the transfer of this knowledge to future generations faces challenges. This paper aims to comprehensively document the Taye's construction methodology ensuring its preservation as an invaluable component of livestock rearing in the region. Furthermore, this study analysed the costs associated with both traditional and modern Taye construction methods providing valuable insights into the economic aspects of preserving this indigenous practice. The documented knowledge can serve as a foundation for further improvements and adaptations, potentially extending the Taye's utility to wider contexts. By highlighting the Taye's significance, economic viability and adaptability, this work encourages the continuation of this sustainable and culturally rich tradition.

Key words: Dry fodder, Taye, Indigenous, Traditional knowledge

Species composition, elevational distribution and morphometric analysis of bumblebees in Jammu region, J&K (U/T)

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Bumblebees (*Bombus spp.)* are essential pollinators in alpine and temperate ecosystems, playing a key role in sustaining biodiversity and agricultural systems. The study examined the altitudinal distribution, species richness and diversity of bumblebees across the Jammu region of the Indian Himalayas, ranging from 300 to 2500 meters above mean sea level (amsl). Field surveys were conducted during the years 2021–2022 across different altitudes of Jammu region and collected 223 bumblebee specimens, including five species: *Bombus haemorrhoidalis*, *B. albopleuralis*, *B. tunicatus*, *B. simillimus*, and *B. eurythorax*—the latter being a new record for the Jammu region. Species diversity was found to be highest at 1200–1800 m amsl (Shannon index: 1.453; Simpson index: 0.735), while species richness peaked in 1800–2500 m range (Margalef index: 0.893). The lowest diversity was found at lower elevations (0–600 m), indicating that altitude affects bumblebee distribution. Morphometric analysis revealed significant differences among species, with *B. eurythorax* having the largest body size and *B. albopleuralis* the smallest. Further, the variations in proboscis length, wing size, and hamuli count also showed the species adaptations to various floral resources. Additionally, 25 plant species from 15 families were identified as foraging sources, with *Digitalis purpurea*, *Trifolium pratense*, *Cirsium arvense* and *Impatiens glandulifera* being key nectar and pollen sources.

Keywords: Bumblebees, ecosystem, biodiversity, species, richness.

Physicochemical Characterization and ATR-FTIR Spectroscopy of Royal Jelly (A*pis mellifera* L.)

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Royal jelly is a sole diet of the queen and three days old larvae of honey bee, *Apis mellifera*, which impact on the queen's body size, longevity, development time and reproductive output in comparison to workers. Royal jelly has a complex chemical constitution and a wide range of pharmacological

properties. The aim of this study is to investigate the quality of royal jelly. Twenty fresh royal jelly (RJ) samples were analyzed for moisture, pH, free acidity, electrical conductivity (EC) and protein content. The result of physicochemical properties was varied from 61.70 % to 76.80 % for moisture; 3.14 to 3.83 for pH; 39.4 to 45.0 mL for free acidity, 0.1 N NaOH/100 g, 571.60 to 745.80 µS/cm for electrical conductivity and 6.73% to 13.27% for protein content. The attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) was used to determine the 10-HDA content of RJ. Absorption peak observed from 1100-1000 cm^{-1} -COH stretching vibration of alcohol to 3302 $^{cm-1}$ of OH stretching vibration of lipid water were found in RJ. Therefore, ATR-FTIR spectra can be used as a reliable tool for 10-HDA quantitation. The study findings will aid in the establishment of a database of Indian royal jelly physicochemical properties, which will in turn aid in establishing national standards for royal jelly quality.

Key words: Royal Jelly, Physicochemical, ATR-FTIR, 10-HAD, Spectroscopy and Stretching vibration etc.

From Flooded Fields to Forward Thinking: Direct Seeded Rice Learning Curves in Sri Fatehgarh Sahib, Punjab

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Rice is a staple for over half the global population, but its traditional cultivation in Punjab has led to critical groundwater depletion, where levels are declining by 0.49 meters annually. Direct-Seeded Rice (DSR) presents a viable water-saving alternative, reducing irrigation needs by 25–30% while offering ecological benefits. Under Project PRANA (Promoting Regenerative and No-burn Agriculture) of The Nature Conservancy, the NGO Manav Vikas Sansthan (MVS) promoted DSR in six districts: Ludhiana, Moga, Sri Fatehgarh Sahib, Jalandhar, Patiala and Malerkotla with this study focusing on farmer adoption patterns and challenges in Sri Fatehgarh Sahib. MVS has facilitated the adoption of DSR across 5353.90 acres in six districts. Notably, in Sri Fatehgarh Sahib, MVS helped farmers increase DSR adoption from 171 to 437.5 acres under the project area in 2023-24. Based on surveys with 65 farmers and one focused group with 21 participants, results showed rising awareness (88%) and adoption, with short duration PR 126 as the most preferred variety. Key constraints included weather uncertainty, high weed and rodent pressure, expensive laser levelling, limited advisory support, and input costs. While farmers valued soil improvements, decreased disease incidence (especially Bakanae disease) and post-harvest wheat gains, many recommended increasing DSR subsidies and expanding training on nutrient, weed and rodent management. To scale DSR adoption, the study recommends enhancing on-ground demonstrations, improving access to equipment, and tailoring policy support to

local needs. Sri Fatehgarh Sahib holds promise as a model district for sustainable rice intensification in North India.

Lac Insect associated natural enemies in arid western plains of India

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A two years survey conducted on bio-diversity of lac insect, *Kerria lacca* (Kerr) and associated faunain arid western plain agro ecological region of India. The survey record of lac insects and its host plants revealed a total 21 host plants *i.e*., *Acacia auriculiformis*, *A. lebbeck*, *A. reticulate*, *A. senegal*, *Butea monosperma*, *Calliandra calothyrsus*, *Dalbergia sissoo*, *Delonix regia*, *Ficus religiosa*, *F. benghalensis*, *F. palmata*, *F. racemosa*, *F. benjamina*, *F. tsiela*, *Peltophorum ferrugineum*, *Pithecellobium dulce*, *Polyalthia longifolia*, *Prosopis cineraria*, *P. juliflora*, *Samanea saman*, and *Ziziphus mauritiana* during 2022 and 2023 under 14 genera from families *i.e*., Annonaceae, Caesalpiniaceae, Fabaceae, Mimosaceae, Moraceae and Rhamnaceae. Of these, family Mimosaceae comprised of highest number of species under different genera and least by family Rhamnaceae and Caesalpiniaceae. During both the years *F. religiosa* was the most abundant host. The associated fauna comprised 11 species of predators, primary parasitoids and hyperparasitoids under 8 families of 3 orders. Of these, 8 species belonged to Hymenopetra, 2 to Lepidoptera and 1 to Neuroptera. The predators were *Eublemma amabilis*, *Pseudohypatopa pulverea* and *Chrysopa zastrowi*; primary parasitoids were *Tachardiaephagus tachardiae*, *Aprostocetus purpureus*, *Tyndarichus clavicornis*, *Erencyrtus dewitzii* and Hyperparasitoids were *Apanteles fakhrulhajiae*, *Eupelmus tachardiae*, *Bracon greeni*and *Brachymeria tachardiae*. Maximum number of genera and species were recorded from family Encyrtidae, followed by Braconidae, Eupelmidae, Chalcididae, Noctuidae, Blastobasidae, Chrysopidae and Eulophidae in descending order.

Keywords: Lac insect, predators, primary parasitoids and hyperparasitoids

Exploring the Effect of Herbal Supplements on the Economic Indicators of Silkworm, Bombyx mori L.

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The mulberry silkworm, Bombyx mori L., is the most widely used species in commercial silk production due to its superior fiber quality and high economic value. However, its productivity and commercial traits are significantly influenced by environmental factors, diseases and nutritional status. Among the major diseases affecting B. mori, viral infections such as grasserie caused by Bombyx mori nucleopolyhedrovirus (BmNPV) pose a serious threat, often resulting in substantial economic losses. The study was conducted at the Silkworm Research Laboratory, Division of Sericulture, SKUAST-Jammu, during the spring and autumn season. The objective was to assess the effectiveness of certain locally available botanicals viz., Psoralea corylifolia L., Vitex negundo L., Tinospora cordifolia (Thumb.) and Adhatoda vasica Nees in managing grasserie disease in the silkworm hybrid FC1×FC2, along with conventional bed disinfectants like slaked lime and Vijetha green. After the second moult, the silkworms were exposed to BmNPV (1×10^3) and subsequently treated three times using botanical applications in both aqueous and powdered forms, in addition to the disinfectants. Among the treatments, silkworms administered with 2% aqueous extract of Vitex negundo demonstrated superior performance, with the highest values in single cocoon weight (1.50 and 1.29g), shell weight (0.29 and 0.23 g), shell ratio (19.55 and 15.77%) and average filament length (809 and 762 m) in spring and autumn season respectively. These were accompanied by the lowest denier readings (2.40 and 2.50d) as compared to the control group (T9) which was exposed to BmNPV without treatment. Additionally, treatments involving 2% Psoralea corylifolia and a combination of P. corylifolia with slaked lime (1:1) also yielded encouraging results. Overall, the findings indicate that 2% aqueous extract of Vitex negundo, followed by Psoralea corylifolia and its blend with lime may serve as effective options for enhancing economic indicators of silkworms inoculated with BmNPV.

Keywords: Silkworm, Bombyx mori nuclearpolyhedrosis virus, Management, Botanicals.

Cross infectivity of Spilosoma obliquae Nucleopolyhedrosis Virus towards Bombyx mori L.

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SoNPV which is highly virulent against its host under field conditions in mulberry has a greater potential as a microbial insecticide against *S. obliqua*, but, its safe application in the mulberry field can be assured only after ensuring its host specificity towards *Bombyx mori*. To check the cross infectivity, naturally SoNPV exhibiting larvae of *Spilosoma obliqua* were collected from the field to extract SoNPV, and this SoNPV given to the laboratory reared, disease free *Spilosoma obliqua* larvae and obtained pure culture of SoNPV used to give inoculum to the silkworm larvae. OBs of SoNPV extracted from *Spilosoma obliqua* with different concentrations were given to the 1st, 2nd, 3rd, 4th, 5th and 6th group by leaf disc method and 7th group used as controlled group of silkworms. The average highest mortality was recorded in 6th group that is 10 larvae by the end of the fifth instar. Weight of ten larvae from each group was measured at the end of every instar and observation shows that the larval weight declines from first group (34.8g) to 6th group (21.6g) as the number of OBs increased. The longest total larval period was observed in 1.0×107 OBs/ml with 26 days and 15 hours (26.15 ± 0.05) which is 2 days 22 hours more than control group larvae 23.17 ± 0.02. More no. of larvae from 6th group with high OBs concentration dies during spinning and also unable to pupate. 6th group has the lowest cocoon weight (0.63 ± 0.01) and shell ratio 12.69%. Moths of 6th group go for oviposition for 41 hours and live about 31 hours extra after oviposition. The fecundity is recorded lowest that is 172.33 ± 1.46 eggs laid by the 6th group's female moth.

Exploring the feasibility of mass multiplication of *Trichogramma embryophagum* on eggs of *Philosamia ricini*

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Trichogramma embryophagum, a crucial biological control agent, requires host eggs that are not only easily accessible but also remain suitable under a range of storage and operating conditions in order to be mass-reared efficiently. This study compares the suitability of eggs from the Eri silkworm Philosamia ricini and the rice moth Corcyra cephalonica at nine distinct age intervals (1-day-old to 16-day-old eggs) for T. embryophagum development and performance under controlled laboratory conditions (27±5°Cand 70±5%) for mass multiplication. The parasitism, adult emergence, female emergence (per cent), and adult longevity (days) were among the important biological parameters evaluated. The findings showed that C. cephalonica eggs that were one-day-old supported the highest initial parasitism and emergence, their suitability drastically decreased as they grew older. Conversely, P. ricini eggs maintained 70.00±1.64per cent parasitism and 65.77±1.30 per cent emergence even at 16-day-old eggs, which were significantly higher than the 06.60±2.97per cent and 1.81±1.81per cent in C. cephalonica eggs, respectively. In addition, parasitoids reared on P. ricini exhibited consistently higher female proportions and extended adult longevity across all age groups. Moreover, evaluations of host searching ability showed that females originating from P. ricini eggs parasitized 92.4 percent of P. ricini eggs and 88.5 percent of C. cephalonica eggs in subsequent exposures; these differences were reflected in emergence and female progeny, with females of P. ricini origin producing 90.2 per cent adult emergence and 67.5 per cent female progeny, as opposed to 86.3 percent and 53.4 per cent, respectively, from C. cephalonica. This demonstrated that females developing on P. ricini eggs maintain greater biological vigour, host discrimination ability, and reproductive potential in the following generation. Using P. ricini eggs will also increase mass-rearing efficiency, decrease reliance on C. cephalonica, and make it easier to combine sericulture with biological control programs. In addition to encouraging environmentally friendly pest control methods and enabling sustainable, year-round Trichogramma production, this will improve rural livelihoods by implementing environmentally conscious pest management practices.

Keywords: host suitability, biocontrol, mass multiplication.

Temporal variation in Foraging Behaviour: Role of Biotic and Abiotic factors on the Circadian Clock of *Apis mellifera*

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Almost all the organisms possess a biological clock, which is regulated primarily by Earth's 24-h light-dark cycle. It enables organisms to predict daily variations in their natural environment and adjust their activities accordingly. In honeybees (*Apis mellifera*), the circadian clock controls activities like foraging, navigation, communication, and sleep-wake cycles. Any disturbances to honeybees' circadian clocks may impact the agricultural ecosystems, as they are key pollinators. A bee's capacity to locate, navigate, and identify flowering plants is influenced by several biotic and abiotic factors, of which the length and intensity of daylight, temperature, and humidity play crucial roles in affecting honey production. However, the role of such factors on the circadian clock is scarce. Thus, we aimed to investigate the temporal variations of light (intensity and duration), temperature, humidity, and different plant species on the foraging behaviors of honeybees on honey production from March to April. We observed maximum foraging on Kasuri methi, followed by white daisy and mustard plants. One-way ANOVA showed temporal variation in the bee's visit to the Kasuri methi plant, with a peak (acrophase) at 2:00 p.m., when the light intensity was around 60,000 lux, the temperature was between 25 and 32°C, and the relative humidity was between 40 and 50%. Our results suggest that honeybees favor foraging in warm, illuminated, and dry environments. Hence, appropriate use of biotic and abiotic factors in synchronizing the circadian clock of *A. mellifera* may result in a high yield of honey production. Together, biological clocks play a crucial role in maximizing ecological interactions and offer insights into how honeybees' foraging and timekeeping habits may impact the ecosystem as a whole.

Keywords: Circadian clock, *Apis mellifera*, biotic, abiotic factor, Kasuri methi, foraging

Cocoon to Clinic: Insect Derived Silk for Biomedical Applications

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Soil to Silk or Field to Lab, silk is the final product of sericulture industry which is popularly known as 'Queen of Textile'. Silk is mainly associated with the domesticated silkworm *Bombyx mori* L., is gaining renewed attention all over the world for its biomedical applications in medical field. Importantly silk biomaterial supports cell adhesion, cell proliferation and differentiation and its low immunogenicity reduces the risk of adverse immune responses compared to other synthetic polymers used as biomaterial for clinical applications. Silk is promising biomaterial owing to its biocompatibility, biodegradability, mechanical strength and versatile structural adaptability. Beyond *B. mori*, a wide range of organisms like —including spiders and other wild species of silkworms—produce silk with different structures and functions, offering novel potential for its biomedical applications. Silk cocoons are primarily composed of proteins, with fibroin (70–81%) and sericin (18-28%) being the key constituents. The silk protein has been applied for enzyme immobilization, antithromboplastic materials, dialysis membranes, soft contact lenses, wound dressing, drug delivery system, polymeric nanoparticles and tissue engineering.The study mainly focused on exploring recent advances in characterization, processing and biomedical utilization of insect-derived silk. We examine its applications in tissue engineering, wound healing, drug delivery systems and regenerative medicine, In order to differentiate the potential of how some specific silk types meet distinct biomedical needs. Study also focused on the molecular structure, mechanical behavior and its histocompatibility with the human body that make insect silk a high demand for the biomedical field.

Keywords: Silk, Biomedical, , Nanoparticles, Tissue engineering

Role of Decision-making ability and Organizational climate of extension agents for Agricultural Extension Effectiveness

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The success of agricultural development initiatives largely depends on the effectiveness of extension systems, where the decision-making ability of extension agents and the organizational climate of agricultural institutions play a crucial role. Decision-making ability enables agents to analyze field situations, provide timely and accurate advisories, and promote appropriate agricultural practices. Simultaneously, a positive organizational climate—marked by supportive leadership, effective communication, adequate resources, and a collaborative work culture which enhances the motivation and efficiency of extension personnel. The synergy between individual capability and institutional environment fosters innovation, accelerates technology adoption and strengthens farmer engagement. Decision-making ability refers to the agent's capacity to evaluate alternatives, and implement appropriate solutions that enhance farm productivity and rural development. Organizational climate encompasses the internal work environment, including leadership style, communication flow, resource availability, job satisfaction and institutional support. A positive organizational climate fosters confidence, motivation, and autonomy, enabling extension agents to make timely and impactful decisions. Conversely, a poor organizational setting can impede performance and restrict innovation. The need for strengthening organizational support systems and enhancing individual competencies through training, participatory management and performance-based frameworks. Enhancing both decision-making capacity and organizational climate is vital for improving the quality and responsiveness of agricultural extension services. Therefore, capacity-building programs, participatory management practices, and performance-oriented organizational reforms are essential to strengthen both individual and institutional capabilities within the agricultural extension framework.

Keywords: Organizational climate, Extension services, Technology adoption, Extension agents, Decision-making ability.

Preservation of Kinnow mandarin using lac-based coating: A study on post-harvest quality and shelf life under ambient and cold storage conditions

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Lac is natural, renewable, non-toxic, bio-degradable, and eco-friendly resin secreted by a tiny scale insect, Kerria lacca (Kerr), which belongs to the family Kerriidae and order Hemiptera. This natural resin has numerous applications across diverse industries, including food, leather, pharmaceutical, electronics, paints, and cosmetics etc. One such lac-based product is an eco-friendly fruit coating formulation, with lac resin as the primary ingredient. Commercially, surface coating of fruits like kinnow and apples is carried out to improve visual appearance, reduce moisture loss and shrivelling, minimize post-harvest decay, and extend shelf life. The present study was conducted over three years (2022 to 2024) to evaluate the effect of lac-based fruit coating on post-harvest quality parameters and shelf life, in comparison with other commercially available formulations (Citrashine, Citrasol, and Fomesa), under both ambient and cold storage conditions. Kinnow fruits were coated using a foam pad and stored in corrugated fiberboard (CFB) boxes under ambient conditions for up to 20 days and under cold storage (4–6°C) for a period of three months. Untreated fruits were kept as controls for comparison. Fruits were analyzed for physiological (weight loss, juice content, and spoilage) and physicochemical (total soluble solids, titratable acidity, and ascorbic acid) parameters. The values of physiological weight loss, total soluble solids (TSS), and spoilage percentage increased with longer storage intervals. Conversely, juice content, acidity, and ascorbic acid content decreased over time. Physiological weight loss and spoilage percentages were found to be lower in all coated fruits compared to the untreated controls. Coating Kinnow mandarin fruits with the lac-based formulation prior to storage was found to be as effective as other commercial formulations under both ambient and cold storage conditions. Based on various physiological and physicochemical parameters, as well as organoleptic evaluations, Kinnow mandarin fruits coated with the lac-based formulation retained their post-harvest quality for up to 15 days under ambient conditions and up to 60 days under cold storage. This coating may

help extend the marketing period, offering better economic returns compared to uncoated (control) fruits. The findings clearly demonstrate that lac-based fruit coating is a viable and eco-friendly option for improving Kinnow quality, extending shelf life, and reducing post-harvest losses thereby making the fruits more marketable.

Keywords: Fruit coating, lac, shelf life, post-harvest quality, storage

Extended Exposure to Artificial Light at Night Impacts Growth, Survival and Silk Production in *Bombyx mori*

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Sericulture, a centuries-old agro-based industry centered on the domesticated silkworm *Bombyx mori*, plays a crucial role in rural economies and sustainable textile production. This study investigates the impact of altered photoperiods on the physiological development, cocoon characteristics, and survival rates of *B. mori* under controlled laboratory conditions. Three distinct light regimes—12 hours light: 12 hours dark (12L:12D; LD), constant darkness (24 hours darkness; DD) and 18 hours light: 6 hours dark (18L:6D; 18:6 LD) were applied to separate silkworm cohorts throughout their larval development. Parameters including larval body weight, cocoon weight, shell weight, shell ratio, oxidative stress and survival rates were systematically recorded and analysed. Results showed no statistical significance in larval or cocoon weight between groups LD and 18:6 LD h ($p > 0.05$) were noticed, in contrast these results showed significant difference between the group DD vs 18:6 LD conditions ($p < 0.05$). There were reduced larval growth and silk output under LD compared to DD however it did not differ statistically. Notably, a significantly higher mortality rate and a statistically significant reduction in shell weight were observed in the 18:6 L:D group ($p < 0.05$), indicating photoperiod-induced physiological stress. This is corroborated by altered antioxidants like SOD, catalase, GSH and MDA (oxidative stress parameters) under LD vs18:6 LD lighting conditions. These findings underline the influence of photoperiod on circadian clock of silkworm on development; and advocate for proper use of lighting conditions for increasing silk production. This study highlights the importance of chronobiological factors in optimizing silk production, and suggests future research involving molecular analyses to further elucidate the mechanisms underpinning photoperiodic sensitivity in *B. mori*.

Keywords: Photoperiod, Circadian clock, Oxidative stress, artificial light at night and *Bombyx mori*

Exploring the Potential of Eri Silkworm (*Samia ricini* D.) on Wild Castor in Jammu Region

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The Eri silkworm (Samia ricini D.) known for its unique ahimsa or non-violent silk production, primarily feeds on the castor plant. The present study investigates the biochemical composition of wild castor leaves and evaluates their suitability for eri silkworm rearing in the region. Leaves were collected from seven different locations, to assess variability in nutritional content. Nutritive analysis revealed significant differences in protein, carbohydrate and chlorophyll content among the samples, indicating that leaf quality varies across locations. The rearing performance of eri silkworm was evaluated based on parameters effective rate of rearing (96.5±0.20), cocoon weight (3.35±0.07) and shell weight (0.55±0.07) correlating with the biochemical profiles of the leaves. The result indicates that castor leaves from location 4 and 7 support optimal silkworm growth and silk production suggesting the feasibility of utilizing wild castor as sustainable feed source for eri silkworm in the region.

Keywords: Eri silkworm, biochemical, wild castor, silk production

Exploring the biology and natural enemies of leaf roller, *Diaphania pulverulentalis* (Hampson) in mulberry ecosystem

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The incidence of various insect pests affects both quality as well as the quantity of mulberry leaves which in turn has a direct bearing on the quality of silk produced by the mulberry silkworm. In the plethora of different insect pests affecting mulberry leaves, mulberry leaf roller, *Diaphania pulverulentalis* (Hampson) is a serious one. In line with this, the present study was conducted in the laboratory of Division of Sericulture as well as in mulberry field, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha during year

2021-2022, for evaluating both lifecycle and natural enemies of this pest. Larvae were collected from mulberry fields and were reared under ambient conditions. The results showed that pests undergo complete metamorphosis with total development period of 28.65 days. The duration of different stages viz., egg, larva, pre-pupa, pupa, adult male and female was found 4.2, 10.06, 2.48, 9.06, 6.02 and 8.08 days, respectively. Average fecundity was found 367.33 ± 9.71 with sex ratio of 1:1.2. A total of ten predators and four parasitoids were found to attack *D. pulverulentalis*. Six species of predators were from order Araneae (*Cheiracanthium* sp., *Neoscona* sp., *Telamonia* sp., *Philodromus* sp., *Oxyopes* sp. *and Tetragnatha* sp.), two species from Coleoptera (*Illeis* sp. and *Cheilomenes sexmaculata*), one *Calosoma* sp. from family Carabidae and one *Mantis* sp. Four hymenopteran parasitoids including three braconids (*Schoenlandella diaphaniae* Marsh, *Habrobracon hebetor* Say and *Phanerotoma* sp.) and one *Elasmus* sp. belonging to family Eulophidae were also found parasitizing the larvae. The results of present investigation give an insight into the biology and natural enemies of *D. pulverulentalis*, which could prove beneficial in formulation of integrated management practices.

Keywords: *Diaphania pulverulentalis*, biology, natural enemies.

Influence of Plant Height on Morpho-Physiological, and Biochemical parameters of Som (*Persea bombycina* Kost.): Implications for Muga Silkworm Rearing & Cocoon Traits

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Muga, the golden silk, is the world's costliest natural fiber, produced by the sericigenous insect *Antheraea assamensis* Helfer (Saturniidae: Lepidoptera). Among the host plants, Som (*Persea bombycina* Kost.) and Soalu (*Litsea polyantha* Roxb.) serve as primary food sources, while Dighloti (*Litsea salicifolia*), Mejankari (*Litsea cubeba*), and others act as secondary and tertiary

hosts. Due to its superior nutritional profile, Som is the most preferred host, significantly influencing larval growth, grainage efficiency, and cocoon quality in Muga silkworms. Although seasonal variability in Muga crop performance is well-documented, limited research has been conducted on the impact of plantation structure; particularly plant height, on host plant quality and subsequent silkworm productivity. The present investigation aimed to evaluate the influence of five distinct height categories of Som plantations: Short Plant (T1, 6–10 ft), Medium Tree (T2, 20–25 ft), High Tree (T3, 25–30 ft), Wild/Un-pruned Tree (T4, >30 ft), and the recommended Control (Small Tree, 10-15ft) on morpho-physiological, biochemical, and economic traits. Results revealed that T2 (Medium Tree) showed significantly superior outcomes across most parameters. T2 showed significantly higher values for studied morpho-physiological parameters, where leaf area was recorded as 52.4 cm^2, fresh leaf weight 580g, dry leaf weight 158g, moisture percentage 72.76%, moisture retention capacity 70.2% and stomatal frequency as 242 per mm^2. Female and male larval weights in T2 were highest at 16.21 g and 14.01 g, respectively, compared to the lowest values in T4 (7.24 g and 5.12 g). Fecundity peaked at 168 eggs/khorika in T2 and declined to 69 eggs/khorika in T4. Biochemical parameters in T2 leaves were also optimal, with crude protein at 20.5%, total lipid 5.3%, crude fiber 13.8%, and total ash 6.1%. Cocoon quality traits followed a similar trend: cocoon weight (3.42 g), shell weight (0.48 g), shell ratio (14.03%), and effective rate of rearing (ERR%) (74.6%) were highest in T2, highlighting its superiority over taller, unpruned plantation types. The study conclusively demonstrates that maintaining Som plantations at a height of 20–25 feet significantly enhance leaf biochemical composition, supports better larval growth, and leads to improved cocoon yield and grainage performance in *Antheraea assamensis*. These findings underscore the importance of plantation architecture in host plant management and provide a practical, cost-effective recommendation for maximizing productivity in sustainable Muga sericulture. Integrating this strategy with existing practices could revolutionize silkworm host plant cultivation and ensure higher economic returns for rearers in the Muga-producing regions of India.

Keywords: muga, som, height, morpho-physiological, biochemical and cocoon traits.

Exploring the Dynamics of Agricultural Input Usage and Forecasting Trends among Indian Farmers

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Agricultural inputs play a crucial role in enhancing agricultural productivity and ensuring food security. Adhering to scientific principles, the effective utilization of these inputs fosters agricultural advancement and enables farmers to meet the growing global demand for food. This research focuses on examining the intricate dynamics of agricultural input utilization within the context of India's economy, where agriculture plays a vital role, engaging over 58% of the population. The study delves into forecasting trends, through regression models, analysed using IBM SPSS 25, drawing insights from historical data and contemporary farming practices. It aims to unravel the interconnections between input usage, crop productivity, and sustainability. Utilizing predictive models, the research offers valuable insights to policymakers and stakeholders for making well-informed decisions. Notably, the findings indicate promising growth trajectories in the consumption of certified cereal-quality seeds, NPK fertilizers, and technical-grade pesticides. Projections suggest a continued upward trend in these areas, thus contributing significantly to India's agricultural sustainability goals through 2029-2030.

Keywords: cereals, seeds, fertilizers, consumption, JEL Codes: C53, E27, E28

Weed Flora as an Alternate Forage Resource for Sustainable Apiculture

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Weeds, often regarded as undesirable in agricultural systems, play a vital ecological role in sustaining pollinators, especially honey bees (*Apis mellifera*). Several weed species such as *Parthenium hysterophorus*, *Trifolium repens*, *Digitalis purpurea*, *Tridax procumbens*, *Lantana camara*, *Cassia tora*, and *Ageratum conyzoides* exhibit extended flowering periods and high nectar availability, making them reliable forage sources when cultivated crops are not in bloom. These resources are crucial for maintaining colony health, promoting brood development and supporting pollinator biodiversity. In intensive farming systems, mass-flowering crops such as rapeseed and sunflower offer only short peaks of floral resources. Weeds help bridge these forage gaps, ensuring continuity in nectar and pollen availability. However, agricultural intensification, particularly the excessive use of herbicides, has led to a significant decline in weed flora and pollinator populations, thereby threatening ecosystem services like pollination. The strategic management of weed diversity especially in field margins, fallow lands and uncultivated patches can enhance pollination services, support honey production and contribute to agroecosystem resilience. Raising awareness about the importance of weeds in beekeeping can help develop sustainable agro-ecosystems and improve pollination services in both natural and cultivated landscapes.

Keywords: Honey bees, flowers, weeds, pollinators, forage, herbicides

Physicochemical Properties and Mineral Content profiling of Propolis Using Atomic Absorption Spectroscopy

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The current study explores the physicochemical characteristics, mineral composition, and antioxidant activity of bee propolis sourced from seven regions across Jammu & Kashmir (Ramban, Reasi, Udhampur, Samba, Doda, Srinagar, and Jammu). The parameters *viz.* moisture, ash content, wax, resin, pH, soluble, insoluble matter and six trace elements (zinc, iron, manganese, copper, cadmium, and lead) were studied. The antioxidant capacity was evaluated using total phenolic content (TPC), total flavonoid content (TFC), DPPH radical scavenging, and ferric reducing antioxidant power (FRAP). The results revealed noticeable variations among the samples from varied locations. The lowest moisture content was found in Srinagar (1.85%), while Ramban had the lowest ash content (2.75%). The resin levels

were the highest in Srinagar (52.16%), whereas Samba showed the highest wax content (33.53%). All samples exhibited mildly acidic pH values ranging from 4.23 to 5.03. Among all regions, Srinagar exhibited the strongest antioxidant potential with the highest TPC (234.25 mg GAE/g), TFC (82.73 mg QE/g), DPPH activity (83.23µg/ml) and FRAP value (260.78 µM Fe^{2+}eq./g). A positive correlation was observed between resin content, phenolic concentration, and antioxidant activity. In terms of mineral concentrations, Zinc was the most abundant, particularly in Ramban (0.2975 mg/kg), followed by iron and manganese. Toxic elements such as cadmium and lead were detected at low concentrations and remained within the safety limits set by the Food Safety and Standards Authority of India (FSSAI). The overall distribution pattern across all locations followed the order: Zinc > Iron > Manganese > Copper > Cadmium > Lead. These findings suggest that the superior chemical composition and antioxidant activity of propolis from Srinagar and Ramban holds promising potential for use nutraceutical and pharmaceutical applications, potentially attributed to the distinct regional floral diversity.

Keywords: Propolis, Antioxidant activity, Total phenolic content (TPC), Total flavonoid content (TFC), Mineral composition, AAS.

Economics of *Apis cerana* beekeeping in the Jammu region

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The present study aimed to document the Economics of *Apis cerana* beekeeping in the Jammu region. A survey was conducted in Doda and Ramban district during 2024 to access the financial support provided by the *Apis cerana* beekeeping. A total of 120 beekeepers were interviewed through questionnaire survey, study revealed that average landholding of beekeeper was 0.38 ha and it was found that 13% of the beekeepers were exclusively dependent on farm income. The majority of the beekeepers possessed log hive followed by wall hive and honey production in log hive and wall hive was 8.38 kg and 6.85 kg/hive/season, respectively. The 63 % of beekeepers harvested honey once a year while only 17% practiced honey processing. It was found that none of the honey had received AGMARK certification, nor any brand name given to the honey. The average honey produced by each beekeeper was 28.23±1.21kg and average amount of honey sold by beekeeper was 18.46±1.44 kg. Beekeepers sold honey at a higher price (Rs.907 kg^{-1}). Most beekeepers sell honey directly to consumers

without any intermediaries in the supply chain. Except honey other bee products are not gathered by the beekeepers.

Keywords: *Apis cerana*, Beekeepers, economics, honey production.

Latent effects of organic products on biological aspects of hadda beetle, *Henosepilachna vigintioctopunctata* (Fabricius)

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The efficacy of certain organic products was investigated against hadda beetle, *Henosepilachna vigintioctopunctata* on various biological parameters. Observations revealed that maximum ovicidal activity was shown by Neem Baan (95.55% at 5% concentration) followed by Dashparni (81.67% at 40% concentration). Least ovicidal activity was shown by fermented butter milk (46.66% at 40% concentration). From the laboratory studies, it was found that different organic products tested at 10 per cent concentration impaired the normal development and prolonged the total life cycle. Dashparni was found to delay the total life cycle (29.33 days) followed by Panchgavya (28.66 days) and Darekastra (27.66 days). Minimal delay in the total life cycle was observed in fermented butter milk (23.33 days). Whereas, Neem Baan at 0.31 per cent concentration significantly prolonged the total life cycle up to 33.33 days as compared to control (23.00 days). Similar trend of effectiveness was observed in larval growth index.

Keywords: Biological traits, *Henosepilachna vigintioctopunctata*, larval growth index, ovicidal activity, total life cycle, Dashparni, Azadirachtin

Comparitive profiling of Unifloral Honey from Jammu Region

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The present investigation entitled "Comparitive profiling of Unifloral Honey from Jammu Region" was conducted in the Division of Entomology, Faculty of Agriculture, collaborated with Institute of Biotechology, division of plant pathology, SKUAST- Jammu during the year 2023-25. In the present study thirty Unifloral Honey samples representing Jammu Region were evaluated for their physicochemical characteristics specified by FSSAI (Food Safety and Standards Authority of India) 2024. They vary with respect to bee species, floral source, climate, geography etc. The demand for

honey is increasing year by year. Therefore, beekeepers focus towards the production of good quality honey. The tested honey samples ranged in their physico-chemical properties viz., Moisture content (16.1-20%), Ash Content (0.01-0.22%), seven colour variation (water white – dark amber), pH (3.19-4.47), TSS% (71.35-86.07%), TS (73.29-85.1) , Refractive index(1.445-1.530), F:G ratio (1.02-1.52%), EC (0.1-0.72 mS/cm), Specific gravity (0.98-1.36) and HMF (12.1-23.43 mg/kg). The quality parameter for honey indicated that the vegetation and honey flow sources are natural and wild in origin. No specific trend in chemical characteristics was observed with respect to altitude. Thus, honey from Jammu region was well within the limit of FSSAI, safe for consumption and suitable for Indian market and export purpose.

Keywords: Physicochemical, Honey, Floral Sources

Physico-chemical properties of beeswax from *Apis mellifera* and *Apis dorsata*

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This study investigates the physico-chemical properties of beeswax derived from two species of honeybees, *Apis mellifera* and *Apis dorsata*, sourced from three districts in the Jammu region: Jammu, Kathua, and Samba. The results indicate that *A. mellifera* exhibits a higher average melting point (63.28°C) compared to *A. dorsata* (59.70°C), suggesting differences in thermal properties that may influence their suitability for various uses. Additionally, *A.mellifera* presents a lower average density (0.9545 g/cm³) than *A. dorsata* (0.9554 g/cm³), indicating that *A. dorsata* may possess a denser wax structure. Notably, the acid value of A. dorsata (20.68) surpasses that of *A. mellifera* (20.09), implying a higher free fatty acid content in *A. dorsata*. These findings contribute valuable insights into the comparative analysis of beeswax properties from different bee species, offering implications for both researchers and industries reliant on beeswax for diverse applications.

Keywords: beeswax, acid value, melting point, saponification value.

Optimization of Sericin from *Bombyx mori* Cocoons for wound healing hydrogel

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Sericin, a natural hydrophilic protein derived from silk cocoon waste, has gained significant attention for its diverse biological and industrial applications owing to its antioxidant, moisturizing and biocompatible properties. This study investigates the effect of varying extraction temperatures on the yield and structural characteristics of sericin, aiming to optimize recovery conditions while preserving its functional integrity. In this study, *Bombyx mori* silk cocoons were subjected to aqueous extraction at different temperatures (60°C, 80°C, 100°C and 120°C) and the extracted sericin was analyzed for changes in yield, solubility and structural attributes. Temperature played a critical role in influencing both the quantity and quality of sericin extracted. The extracted sericin samples were characterized and it was observed that the higher temperature enhanced protein solubility and extraction efficiency and also induced alterations in molecular structure, possibly due to partial hydrolysis and denaturation. The structural characterization revealed differences in molecular weight distribution, absorption profiles and heavy metal analysis, suggesting that the thermal conditions modulate sericin's peptide chain configuration and stability. These variations could have implications on the material's suitability for downstream applications in cosmetics, biomedicine, and sustainable textiles. The findings highlight the importance of optimizing extraction temperature to maintain the maximum yield with minimal structural degradation, thus preserving bioactive properties. This work underscores the importance of thermal control during sericin recovery and contributes to the sustainable valorization of silk industry byproducts.

Key words: Sericin, Thermal Extraction, Protein Characterization, Biomaterials, Green Processing

A Systematic Literature Review on Blockchain Technology in Sustainable Agriculture Practices

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The study aims to systematically analyze the existing literature on the usage of blockchain technology in agriculture sector to enhance sustainability. Studies from the past 18 years were identified and collected from the Scopus database. The data was analysed using VOS viewer software. The SPAR-4-SLR Protocol and TCCM framework guided the overall search process. The present research proved to be a significant milestone in understanding the importance of blockchain technology in sustainable agricultural practices. The publication trends revealed that the field is growing significantly in the years and India is also a major contributor to this sector of research. The TCCM framework further provided an insight into the key areas where research can be conducted. Despite the increasing research, the content analysis revealed the need for extensive research in entrepreneurship. The review provides deep insight into the topic and offers a unified picture of the subject field. The present study is significant to understand the theoretical and empirical evidence of research related to blockchain technology and sustainable agricultural practices. The society at large will get the benefit from the present research to understand the sustainable aspects of agricultural technology using blockchain.

Keywords: Blockchain, theoretical structure, TCCM framework, future research agenda

Hygienic behaviour in *Apis mellifera* Linnaeus during Resource Deficient Period in Monsoon and Winter Seasons

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The studies were carried out at Campus Apiary, Entomological Research Farm, Department of Entomology, PAU during monsoon and winter seasons. *A. mellifera* colonies were segregated into hygienic, intermediary hygienic, and non-hygienic colonies, in each category seven colonies were selected. Hygienic behavior was assessed using the pin-killed brood method at fortnight intervals. A colony was considered hygienic if it removed a mean of 80 per cent or more of the dead brood 24 h after pricking. The effect of feeding on hygienic behaviour during monsoon season was studied in 6 bee frames colonies belonging to different hygienic behaviour categories (Category I, II and III). One set of 21 colonies (seven colonies under each hygienic behaviour category) were provisioned with PAU pollen

substitute while another set was devoid of it. In addition, all the colonies were uniformly provisioned with supplementary feed at regular intervals. The interaction between hygienic behaviour categories and seasons showed that in monsoon season the mean per cent of pin killed brood cells emptied was 83.83±0.74 in hygienic colonies, 72.34±0.49 in intermediary hygienic and to 55.46±1.49 in non-hygienic colonies while in the winter season was 82.15±0.40, 71.35±0.17 and 52.43±1.11, respectively. In non-hygienic colonies the workers performed only uncapping and were highest in winter season. The per cent brood cells emptied decreased over the seasons but it had no affect on the hygienic behaviour in the colonies of different categories. Similarly the interaction between hygienic behaviour categories and feeding showed that the hygienic behaviour of the colonies provisioned with PAU pollen substitute increased non- significantly compared to colonies devoid of it. The hygienic colonies provisioned with PAU pollen substitute recorded 83.37±1.30 hygienic behaviour compared to hygienic colonies (82.49±0.76 per cent) devoid of it.

Keywords: *Apis mellifera*, hygienic behaviour, colony strength, monsoon season, winter season

Temporal and varietal factors influencing the graft success in Ramphal (*Annona reticulata*)

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The present study was conducted to determine the impact of scion cultivar and grafting time on custard apple in an arid region of Karnataka, India, during 2020-21. The experiment was laid out in a Completely Randomized Design with factorial concept and three replications. Balanagar and Arka Sahan cultivars of custard apple, together with four disparate grafting dates viz., 15th January, 30th January, 15th February and 28th February, were employed as treatments and the entire analysis was set down in two factorial randomized complete block design (RCBD). Forty-five grafted plants were defined per treatment for the investigation and each treatment were replicated thrice. The results of the present study revealed that both the time of grafting and scion varieties had a significant influence on different parameters studied. Among the time of grafting and scion varieties, softwood grafting in the month 15th of February using Arka Shan as scion (D_3V_2) emerged as the most suitable yielding the highest graft success (95.55 %), and early bud sprouting (9.2 days), scion diameter (7.60, 8.06 and 8.43 mm), rootstock diameter (5.89, 6.35, 6.74 mm), sprout length (2.28, 15.77, 26.30 cm) at 30, 60 and 90 DAG, number of leaves (31.16 and 33.66), leaf area (29.64 and 33.67 cm^2) at 60 and 90 DAG. While (D_1V_1) softwood grafting on 15th January with Balanagar as scion exhibited the lowest graft success

rates (68.85 %) and slower growth. These findings underscore the importance of optimizing appropriate time of grafting and scion varieties to optimize custard apple propagation under varying climatic conditions, aiming to enhance productivity and quality in commercial cultivation practices.

Keywords: *Annona reticulata*, softwood grafting, graft survivability, custard apple, graft success

Theme-5

Bioinspiration
&
Bitechnology for
Next Generation Agriculture

Theme 5

Molecular Techniques in Agricultural Entomology: An Update

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Biotechnology has considerable potential to contribute to sustainable biological elements of integrated pest management (IPM), though biotechnology development to date has been directed at more conventional models for pest control technologies. Biotechnology for insect pest management has to some extent been an early byproduct of the acquisition of biotechnological know-how, which will have more substantial implications for agriculture than simply improved IPM. Recombinant DNA technology has significantly augmented the conventional crop protection by providing dramatic progress in manipulating genes from diverse and exotic sources, and inserting them into microorganisms and crop plants to confer resistance to insect pests and diseases, increased effectiveness of biocontrol agents; improved understanding of gene action and metabolic pathways. Paratransgenesis which involves genetic manipulation of symbiont organisms is successful in management of vector transmitted diseases. While structural genomics focuses on analyzing the complete genetic sequence of an organism, functional genomics aims to uncover how this genetic information is utilized within the organism. The RNA interference and CRISPR cas9 techniques are being used for study the function of various genes in insects. The success of integrated pest management also depends on the accurate identification of target pest species—an objective increasingly achievable through advances in molecular biology. In addition, molecular techniques are useful for understanding the molecular mechanisms of insecticide and Bt resistance, transgenic insects, insect-plant interactions, genetic diversity of insects, etc. In this paper, a few molecular techniques which are being utilized extensively in entomology are discussed briefly.

Molecular Taxonomy

Scientific description and taxonomic characterization of various species is important both for their taxonomic identification as well as cataloguing biological diversity. DNA-based identification systems exploiting diversity among specific DNA sequences (molecular signatures or genetic ‘barcodes’) have also been applied to higher organisms. ‘Mitochondrial cytochrome c oxidase I’ gene (COX-1 or COI) region has attracted most attention for single gene based molecular identification of animals including insects. DNA barcoding has been used extensively to identify various insect pests upto species level. This technique is helpful in genotyping of particular insect pests like *Bemisia tabaci*, *Spodoptera frugiperda*, *Helicoverpa armigera*, etc. particular upto cryptic species/ haplotypes/ genetic groups. For

examples worldwide 46 genetic groups of *B. tabaci* has been identified. Use of DNA barcoding is helpful in monitoring spread of invasive insect pests, correct identification of insect pest before adopting Integrated Pest Management strategies and it offer robust alternatives to traditional taxonomy for biodiversity assessment. The genetic diversity of insect over a geographical region can be studied though sequencing of conserved gene.

Transgenic Plants

During last thirty years, the major biochemical principals governing such resistance and involved genes have been identified for their directed use through biotechnological approaches, but most emphasis has been given to primary protein products of specific genes as they are the functional units that directly mediate resistance. For affording host plant resistance, genes of primary interest are those whose protein product could be detrimental to the normal growth and development of the target insect pest/ pest group based upon the mechanism of insecticidal action of the gene product. So far strategy have remained on use of open reading frames (ORFs) of target genes as they occur in both prokaryotes and eukaryotes.

Protease inhibitors, lectins, amylase inhibitors, and chitinase genes are associated with the natural defenses developed by plants to counter insect attacks. Some toxin genes are also derived from spiders and scorpions for protection against insects. Various cry toxins from *Bacillus thuringiensis* were used and commercialized in terms of transgenic plants against insect pests. Plant derived genes such as lectins, protease inhibitors, and alpha-amylase inhibitors; chitinase and some proteins like arcelins, plant defensins have been successfully utilized to impart resistance to insects.

Future of GM crops however relies upon search for new genes from diverse sources and many of these when evaluated have shown significant potential for exploitation in crop protection. Thus, future trends and prospects for biotechnological applications to mediate crop protection against insects include strategies employing stacked genes, modified Bt- toxins, spider/ scorpion venom peptides, vegetative insecticidal proteins, lectins, endogenous resistance mechanisms as well as novel approaches.

Omics

With advancement of sequencing technologies, sequencing the genome, transcriptome, proteome, etc. from any organisms is easy, less time consuming and inexpensive. More than 817 insect genomes, many projects of transcriptome are available in international database. The researchers can use these data to understand the insect plant interactions, molecular and biochemical pathways in insect physiology. The sequences of genes identified in the genomes, functional annotation, and other information are curated into databases that are available online and freely available. FlyBase, VectorBase, ButterflyBase, AphidBase, BeeBase, DBM-DB, SilkDB, BeetleBase, etc. are example of some specific database.

RNA interference

RNA interference (RNAi) is a biological process which occurs in the cytoplasm of cells and affects the expression level of specific genes in a selective process by degrading the mRNA of target genes through a post transcriptional gene silencing process (PTGS). It is a powerful technique to study function of gene in insect in which the dsRNA corresponding to target gene was delivered to insects. The dsRNA is processed into short 21 to 25 bp fragments known as short interfering RNA (siRNA) by an enzyme known as Dicer, a form of RNase III enzyme. These siRNAs has a guide and passenger strand that attach with the RISC (RNA-induced silencing complex) protein. The guide strand eliminates the passenger strand from the complex, while the passenger strand directs the RISC complex to interact with complementary mRNA. The argonaute protein, which is found in RISC, is essential for mRNA recognition and degradation. The PAZ domain keeps the guide strand, which is used as a template to capture the intended mRNA, while the PIWI domain cleaves the captured mRNA into two fragments and ends the translation and silence the gene.

The use of RNA interference (RNAi) has grown significantly in a number of insect orders, including Thysanoptera, Diptera, Lepidoptera, Coleoptera, Hymenoptera, Hemiptera, etc in last 25 years. Number of genes has been screened in various insect pests which are important for some important biological function in insects. The ecdysis, reproduction, diuresis, feeding, host recognition, behaviour, digestion, etc have been studied in insect through RNAi. In *Blatella germanica*, RNAi of vitellogenin (*Vg*) gene inhibited vitellogenin production in the fat body and impaired oocyte growth, whereas RNAi of *Vg* receptor produced a similar phenotype, with the permanently immature oocytes. In *B. germanica*, RNAi has shown that the protein TOR (target of rapamycin) is crucial for the transformation of nutritional signals into production of JH, which is essential for vitellogenesis and reproduction in this species. Silencing of ecdysis triggering hormone receptor in *Bemisia tabaci* resulted in significantly higher mortality. Host probing behaviour is affected by silencing of apyrase *AgApy* in the salivary glands of the malaria mosquito *Anopheles gambiae*. silencing of juvenile hormone esterase gene *jhe* in whitefly adults caused reduced fecundity and egg hatchability in *Bemisia tabaci*. Reduced oviposition and arrested embryogenesis is found in *Rhodnius prolixus* after feeding dsRNA for the *Rhodnius* heme-binding protein (RHBP, egg protein) and for catalase (CAT).

In 2007 plant mediated RNAi has been established in maize against western corn rootworm. The reduction of corn root damage by western corn rootworm was reported in transgenic maize plants producing *vacuolarH+ ATPase* dsRNA (Baum *et al*, 2007). During same time, Mao and his co-workers developed plants expressing dsRNA specific to *CYP6AE14*. The levels of *CYP6AE14* in the midgut of cotton bollworm, *Helicoverpa armigera* decreased and larval growth was retarded. Plant-mediated RNA interference against *Nilaparvata lugens*, *Myzus persicae*, *H. armigera*, *Myzus persicae*, *B. tabaci* also successful in reducing the expression of targeted gene.

The first commercial RNAi product targeting an insect pest is a transgenic corn crop, developed by Monsanto (currently Bayer CropScience) is SmartStax Pro, which expresses a hairpin dsRNA targeting the *snf7* gene in the Western corn rootworm, *Diabrotica virgifera virgifera*. The first registered and commercialized foliar-applied dsRNA product, Calantha™, active ingredient ledprona, controls the Colorado potato beetle (*Leptinotarsa decemlineata*), a devastating pest of potato. It was registered in the USA in 2023.

Genome Editing

The Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and CRISPR-associated (Cas) system is a versatile and widely used gene-editing technology, commonly utilized to investigate gene function across a broad range of insect species. The CRISPR/Cas system facilitates the binding of the Cas9 protein to a specific target region in the genome, typically located near a protospacer adjacent motif (PAM) sequence (NGG). Upon binding, Cas9 unwinds the DNA duplex, allowing the single-guide RNA (sgRNA) to align with the complementary target sequence. Once properly aligned, Cas9 introduces a double-stranded break in the DNA. The cell then attempts to repair this break through one of two mechanisms: non-homologous end joining (NHEJ) or homology-directed repair (HDR). These repair processes can result in the insertion, deletion, or modification of nucleotides, potentially leading to genetic alterations in the organism.

CRISPR/Cas9 has recently been employed in functional studies of genes across various insect species to explore its potential as a powerful tool for pest control. One notable example is the use of the *white* gene as a phenotypic marker in multiple insect orders. Mutations in this gene lead to a distinctive white eye color, providing a clear and easily identifiable trait that facilitates genome editing experiments. This has been established in *B. tabaci*, *S. frugiperda*, mosquitoes and many more insects. Additionally, CRISPR/Cas9 has been applied to knock out the *doublesex (dsx)* gene, which plays a critical role in reproduction and sexual differentiation in many insects. The genome editing using CRISPR cas9 will be obtained in insects if the guide RNA and cas9 is injected in freshly laid eggs (pre-blastoderm).

Injecting eggs is a limiting factor for CRISPR cas9 efficiency, therefore the scientists has come up with ReMOT, DIPA, SYNCAS CRISPR techniques. ReMOTis based upon the physiological process of vitellogenesis where the yolk protein precursors bind to the cognate receptors on ovary and get internalized and accumulated as nutrient source for developing embryos. The vitellogenic *Aedes aegypti* females were injected with ligand P2C-Cas9/sgRNA RNP where sgRNA was designed to target *Kynurenine monooxygenase* (*kmo*) gene and the editing efficiency of 0.3 mutants per injected mosquito was achieved. Another new method was introduced for direct parental delivery of Cas9 RNP *i.e.* DIPA-CRISPR. It has opened up the opportunities for gene editing in diversity of insect's species of agricultural importance. This technique acts as an alternative to highly technical and sophisticated experimental set up requiring microinjection technique which is to be completed in specific time period

after oviposition. SYNCAS based CRISPR/Cas9 has recently been introduced for gene editing in arthropods which are difficult to transform using microinjection (egg stage) because of less transformation efficiency and physiological factors like arrhenotokus species and vivparity. The newly introduced SYNCAS based gene editing protocol has made it possible to edit haplodiploid species which are *T. urticae* and *F. occidentalis* and also can potentially be used for other economically important insects. CRISPR-Cas9 can be used to create and implement gene drives for sustainable and effective insect pest control.

Paratransgenesis

Paratransgenesis is the process of genetically transforming an organism's symbionts to confer specific function (s) that decrease vector competence to pathogens. In this approach, symbiotic gut bacteria are carefully isolated from disease-carrying vectors and genetically engineered in vitro to produce compounds that block pathogen transmission. These modified bacteria are then reintroduced into the vector, where they express the engineered molecules and reducing the vector's ability to spread disease. It has been used effectively for the management of Pierce's disease (PD) of grapevines. This disease is caused by the bacterium *Xylella fastidiosa* which is transmitted through glassy-winged sharpshooter. In case of termites, the protozaon are genetically engineered which are important for digestion of cellulose in gut. Therefore digestion is adversely affected and the termites can be managed using this technology.

Conclusions

Molecular biology tool can be effectively used for detection and identification of insects, improve the efficacy of biocontrol agents, and discover new insecticide molecules, for effective pest management programs, gene drive, new transgenic plants, etc. However, rapid and cost effective development, and adoption of biotechnology-derived products will depend on understanding of the interaction of genes within their genomic environment. There is need to address biosafety and regulatory systems for proper management of GMOs must be in place to enable the full exploitation of biotechnology.

Abstracts

Molecular diagnostic techniques for accurate and fast identification of bee disease

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Honey bee health is critical to global food security due to their essential role in pollination. However, bee populations are increasingly threatened by various pathogens, including viruses, bacteria, fungi and parasites. Timely and accurate diagnosis of these diseases is vital for effective management and prevention. Traditional diagnostic methods, though widely used, are often time-consuming, labor-intensive and may lack sensitivity. In contrast, molecular diagnostic techniques offer rapid, sensitive and specific identification of pathogens, even at early stages of infection. Key molecular tools such as Polymerase Chain Reaction (PCR), Real-Time PCR (qPCR), Loop-Mediated Isothermal Amplification (LAMP) and Next-Generation Sequencing (NGS) are revolutionizing the detection of honey bee diseases. These techniques enable the identification of major pathogens such as *Nosema spp.*, *Paenibacillus larvae*, *Ascosphaera apis* and a wide range of bee viruses with high accuracy. Additionally, portable platforms and point-of-care diagnostics are making field-level detection increasingly feasible. The integration of molecular diagnostics into routine beekeeping practices can significantly enhance disease surveillance, support early intervention and ultimately contribute to the sustainability of apiculture.

Keywords: Disease, Honey bee, Molecular techniques, DNA

Method development and validation of Chlorpyriphos in HPLC

Bhumika Sharma, R.S.Bandral, Marvi Khajuria

An HPLC method was developed and validated for the quantitative determination of chlorpyriphos insecticide. The chromatographic separation was achieved using a RP-C18 endcapped column with a mobile phase consisting of acetonitrile and water in the ratio of 80:20 v/v. The method was optimized for various parameters including column temperature, flow rate and detection wavelength. Validation studies were conducted according to ICH guidelines, assessing linearity, precision, LOD, and LOQ. The method demonstrated excellent linearity ($r^2 > 0.999$) over a concentration range of 0.4-50ppm. The sensitivity of the method was determined by establishing the limit of detection (LOD) and limit of quantification (LOQ). The LOD, representing the lowest detectable concentration, was found to be 0.2ppm, while the LOQ, indicating the lowest concentration that can be reliably quantified, was 0.72ppm. These low limits demonstrate the method's high sensitivity, making it suitable for trace analysis of chlorpyriphos in various matrices. Precision was evaluated in terms of both intra-day (repeatability) and inter-day (intermediate precision) variability. The relative standard deviation (RSD) for both precision parameters was less than 2%, well within the acceptable limits for analytical methods. This high precision ensures consistent and reliable results across multiple analyses and different days.

This validated HPLC method offers a rapid, sensitive, and reliable approach for the routine analysis of chlorpyriphos in various environmental and agricultural samples.

Keywords : HPLC, RP-C18 column,linearity, precision, LOD and LOQ.

Evaluation of Insecticidal Activity of Selected Himalayan Medicinal Plants and Molecular Docking of Bioactive Compounds from *Artemisia absinthium*

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The Kashmir range of the North-Western Himalayas harbors a rich diversity of medicinal plants with insecticidal, antifeedant, or insect-repellent properties. In this study, we evaluated the insecticidal activity of five medicinal plants namely *Artemisia absinthium*, *Acorus calamus*, *Digitalis purpurea*, *Plectranthus rugosus* and *Achillea millefolium* against *Corcyra cephalonica*, *Sitophilus oryzae* and *Helicoverpa armigera*. Among them, *A. absinthium* extract exhibited the highest *in vitro* insecticidal activity against the test insects. Consequently, the extract of *A. absinthium* was subjected to high-resolution liquid chromatography–mass spectrometry (HR-LCMS) analysis. The identified small molecules were flexibly docked into the active site of acetylcholinesterase from *H. armigera*, using the known inhibitor Malaoxon as a reference. Four compounds namely kaempferol, diosmetin, 1,7-bis(4-hydroxyphenyl)heptan-3-one, and NP-021018 demonstrated higher binding affinity than Malaoxon. Notably, kaempferol exhibited the strongest binding interaction with acetylcholinesterase, suggesting that the insecticidal activity of *A. absinthium* extract may be primarily attributed to this compound.

Keywords: Medicinal plants, *Artemisia absinthium*, Molecular docking, Kaempferol

Distribution and allelic expression of hybrid necrosis genes in bread wheat (*Triticum aestivum* L.)

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The investigation was undertaken during *Rabi*, 2022-23 and 2023-24 in which a total of 33 lines and two testers (C 306 and HD 2380) along with two checks were grown in a randomized complete block design, to investigate the distribution and allelic expression of two hybrid necrosis genes Ne_1 and Ne_2. Results revealed that out of 33 lines used, 19 lines were carriers of the necrotic genes. Among the 19 necrotic gene carriers lines, 12 lines *viz.*, DH 1, DH 53, DH 57, DH 58, DH 87, DH 139, L9, L18, L42, L47, WRDH3 and WRDH 8 were carriers for Ne_2 gene while 7 lines *viz.*, DH 158, L6, L10, L25, L32, L33 and L34 were carriers for Ne_1 gene. F_1s between lines DH 102, DH 103, L 7, L 26, L 16, L 35, L 36, L 37, L38, L 43, L45, L 61, TWDH 5 and TWDH 7 with both the testers i.e. C 306 and HD 2380 showed normal growth and development with no necrotic symptoms, were graded as non-carriers. Predominance of Ne_2 gene among the lines used in the study was observed. For Ne_1 gene, all the carrier lines (100 %) had Ne_1^s allele indicating strong necrotic strength. However, with respect to Ne_2 gene, allele for moderately strong strength (Ne_2^{ms}) was of predominant occurrence with presence in 50 percent of lines.

Keywords: Wheat, Ne_1 , Ne_2, hybrid necrosis and testers

Quantification of metabolic reserves and their insulin mediated reduction during natural diapause in *Zygogramma bicolorata* (Coleoptera: Chrysomelidae)

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The goal of the current investigation was to assess the level of metabolic reserves, *viz.* proteins, carbohydrates and lipids in diapausing and non-diapausing adults of *Zygogramma bicolorata* Pallister so as to reflect a relationship between metabolic reserves and diapause in *Z. bicolorata*. The results of our laboratory experiment revealed that diapausing adults had significantly higher levels of metabolic

reserves than non-diapausing ones. Furthermore, significantly higher amount (µg/beetle) of proteins, carbohydrates and lipids were found in females (482.10±7.13, 497.85±19.21 & 556.06±14.19) than males (261.04±9.13, 354.80±10.12 & 416.22±15.18), respectively in *Z. bicolorata*. The metabolic reserves and natural diapause of *Z. bicolorata* reflected a significant positive correlation with a high coefficient of determination. In the second step, we investigated whether the natural diapause in the adults of *Z. bicolorata* can be altered or minimized to some extent by reducing the level of metabolic reserves. For this purpose, each diapausing adult received an intra- haemocoelic injection of 5 µL of human insulin 30/70, on abdomen's ventral side with a Hamilton microsyringe. We found that injection of vertebrate insulin significantly moderated the natural diapause due to a significant drop in the above three metabolic reserves in *Z. bicolorata*. It was concluded that manoeuvring of natural diapause using insulin can improve the efficacy of *Z. bicolorata* towards the management of *Parthenium hysterophorus*.

Keywords: Diapause, Metabolic reserves, Insulin, *Zygogramma bicolorata*, Parthenium

Estimation of cyantraniliprole and lufenuron residues on chilli by LCMS/MS

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Chilli (*Capsicum annuum* L) is an important cash crop in India and is grown for its pungent fruits, which are used both green and ripe to impart pungency to the food. Several pesticides are recommended for the control of insect pests in chilli. Cyantraniliprole and lufenuron mixture has been found to be effective against insect pest of chilli. So, the study was planned to estimate the persistence of cyantraniliprole and lufenuron residues in chilli fruits. The field experiment on chilli crop consisted three treatments including one control and two concentrations of Cyantraniliprole 20% + Lufenuron 20% w/v SC @ 150 mL ha^{-1} (X dose) and 187.5 mL ha^{-1} (1.25X dose). Green chilli samples were collected at 0, 1, 3, 5, 7, 15 and 20 days from each plot. Red chilli samples were collected at the time of harvest. The samples were extracted using QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) method followed by estimation of residues on LCMS-MS. The limit of detection and limit of quantification were 0.003 and 0.01 mg kg^{-1}, respectively for both pesticides. Average initial deposits of cyantraniliprole on green chilli were found to be 0.42 and 0.73 mg kg^{-1} following the last application of Cyantraniliprole 20% + Lufenuron 20% w/v SC @ 150 and 187.5 mL ha^{-1}. Average initial deposits of lufenuron on green chilli were found to be 0.16 and 0.28 mg kg^{-1} at X and 1.25 X dose, respectively. At recommended dose, cyantraniliprole and lufenuron residues on green chilli were found to be below the limit of quantification (0.01 mg kg^{-1}) at 10 and 20 day, respectively. Red chilli samples collected at

harvest from both treatments did not reveal the presence of cyantraniliprole and lufenuron residues. The half-life of cyantraniliprole and lufenuron residue was found to be 3.96 and 9.24 for X dose and 3.54 and 6.72 days for 1.25X dose, respectively.

Keywords: Cyantraniliprole, Lufenuron, LCMS-MS, Chilli, QuEChERS, half-life

Residual behaviour and dissipation kinetics of beta-cyfluthrin and imidacloprid and its metabolite in potato by LCMS-MS

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Potato (*Solanum tuberosum*) is important vegetable crops widely cultivated and consumed for its high nutritional value and economic relevance, particularly in developing countries. *Solomon*, a combination of beta-cyfluthrin and imidacloprid, plays a crucial role in protecting potato crops from a wide range of insect pests, including aphids, whiteflies, and beetles, thereby ensuring better yield and crop quality. However, due to its chemical nature and mode of application, there is a possibility of residue retention in the tubers. Therefore, a supervised field trial was conducted to study the residual behaviour of beta-cyfluthrin and imidacloprid on potato leaves, tubers and soil. QuEChERS methodology was employed for efficient extraction and clean-up of samples, while quantification of beta-cyfluthrin and imidacloprid residues was carried out using LC-MS/MS. Residual behaviour was studied after three foliar application of Solomon (Beta-cyfluthrin 90 G/L + Imidacloprid 210 G/LOD) @ 75 (X dose) and 93.75 g a.i. ha^{-1} (1.25 X dose) in potato at an interval of 7 days. The mean initial residues of beta-cyfluthrin in potato leaves was recorded to be 8.24 and 12.44 mg kg^{-1} at X and 1.25 X dose, respectively. Similarly, the average initial residues of imidacloprid in potato leaves at X and 1.25 X dose were 0.44 and 0.67 g a.i. ha^{-1}. The residues declined gradually and reached below the quantification level on 21^{th} day for beta-cyfluthrin and 10^{th} day for imidacloprid after the last application at both the doses. The mean residues of beta-cyfluthrin and imidacloprid in tubers and soil collected at harvest were found to below quantification limit (0.01 mg kg^{-1}). There were no residues detected of metabolite 6-CNA in samples of potato leaves, tubers and soil. The kinetic model of the residues depicted that dissipation of both beta-cyfluthrin and imidacloprid residues in potato leaves adhered to second order kinetics. The observed half-life of beta-cyfluthrin was 1.50 and 1.28 days at X and 1.25 X dose, respectively. Whereas for imidacloprid it was 0.34 and 0.42 days.

Keywords: beta-cyfluthrin, imidacloprid, LCMS-MS, QuEChERS, Kinetics, Half-life

Impact of neonicotinoids exposure on honey bee (*Apis mellifera*) larval development and adult emergence: a comparative toxicity studies of six neonicotinoids

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The reported high mortality rates of managed honey bee (*Apis mellifera* Linn.) colonies have been attributed to diverse stressors including neonicotinoids. Honey bee larvae can be exposed to neonicotinoids through drift as well as through contaminated nectar and pollen. Due to the difficulties of rearing larvae *in vitro*, research focusing on adult bee exposure to neonicotinoids is more common than that on larval exposure to neonicotinoids. In the present study, honey bee larval and adult mortality were assessed owing to larval exposure to six neonicotinoids viz. Imidacloprid, thiamethoxam, clothianidin, dinotefuran, thiacloprid and acetamiprid. The results revealed that the larvae directly and their development to adult was affected after exposure to each tested insecticide as on exposure, as they progressed towards adult stage and emergence LC_{50} and LD_{50} were calculated for bee larvae at 72 h following a single diet admixture exposure on 4th day of their age. In untreated control, larval mortality was less than 15 per cent at 72 h while the adult emergence was 74 per cent. The toxicity of the test neonicotinoid insecticides on honey bee development (from larvae to adult emergence) was in the order of thiamethoxam>clothianidin>imidacloprid>dinotefuran>thiacloprid>acetamiprid. LD_{50} for thiamethoxam was worked to be 0.036 µg/ larvae followed by clothianidin (0.078 µg/ larvae). Among the tested six neonicotinoids, least toxicity (LD_{50}) values were found to be for acetamiprid (0.570 µg/ larvae) and thiacloprid (0.509 µg/ larvae). The adult honey bee emergence in the neonicotinoid treated larvae was reduced and was observed in the range of 5.39 to17.45 per cent with least emergence in the larvae fed orally with thiamethoxam (5.39 %) and clothianidin (7.49 %). The percentage of adult emergence was only 17.45 per cent in acetamiprid. Thus, exposure of bee colony directly through insecticidal drift or indirectly through contamination of pollen, nectar food can adversely impact colony.

Key words: *Apis mellifera* Linn., neonicotinoids, laboratory testing, LC_{50}, LD_{50}

Evaluation of foliar spray naked dsRNA for the sustainable management of the Thrips palmi

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Thrips palmi (Thysanoptera: Thripidae), a highly polyphagous pest and vector of Orthotospoviruses, causes significant losses in horticultural crops. Due to its rapid development of insecticide resistance, sustainable control strategies are urgently needed. RNA interference (RNAi)-based approaches, such as spray-induced gene silencing (SIGS), offer a promising non-chemical alternative. In this study, we targeted the V-ATPase-B gene, essential for cellular pH regulation, to suppress *T. palmi* populations through foliar-applied dsRNA. Initial validation via oral delivery of dsV-ATPase-B in artificial diets confirmed effective gene silencing, reducing V-ATPase-B expression by 5.40-fold compared to dsGFP controls. This suppression led to significant mortality (57.03%) and impaired reproductive fitness (67.73% reduction in offspring). To assess field applicability, naked dsV-ATPase-B was sprayed on cucumber plants (3–4 leaf stage) under controlled and semi-field conditions. At concentrations of 3.0 µg/mL and 5.0 µg/mL, the treatment reduced *T. palmi* populations by 30.00% and 43.33%, respectively, while downregulating V-ATPase-B expression by up to 4.24-fold. Furthermore, dsRNA-treated plants exhibited a 31.24% decrease in offspring production, confirming transgenerational effects. Two consecutive sprays (5.0 µg/mL) provided sustained protection for up to 10 days against newly introduced thrips, demonstrating the persistence of dsRNA on plant surfaces. These findings highlight SIGS as a viable, eco-friendly strategy for *T. palmi* management, reducing dependence on conventional insecticides.

Keywords: foliar spray naked dsRNA, sustainable management, Thrips palmi

Development and validation of of melon fruit fly, Zeugodacus cucurbiate specific primers for quick diagnostics

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Melon fruit fly, Zeugodacus cucurbitae is a major pest of cucurbits, widely distributed in Southeastern Asia, the Mediterranean region, parts of Australia, Africa, and the Hawaiian Islands. The maggot stage is the primary source of damage, feeding internally on the fruit and causing significant economic losses

in cucurbit production. The discrimination of Z. cucurbitae from other species of fruit flies especially at immature stages is often difficult due to lack of taxonomic characters. DNA barcoding has proved to be more reliable alternative in some cases, but its high cost and time-consuming nature make it inaccessible for many laboratories. To address this limitation, the present study aimed to develop PCR-based species-specific primers for Z. cucurbitae, coupled with a rapid DNA extraction technique. This streamlined protocol has the potential to significantly reduce processing time and can be highly beneficial for plant protection and quarantine centers. We have developed species specific primer that identifies the species (Zeugodacus cucurbiate) accurately without any cross amplification with other species of fruit flies. Further, the primers have sensitivity to detect target species DNA down to 1 pg/µl. The specific primers also validated on different developmental stages and geographic population of Z.cucurbiatae and it has shown 100% accuracy. The cross-specificity was further validated by real time PCR by comparing the critical threshold (Ct) values and by analyzing melting curve. The developed protocol significantly play an important role in detection and management of melon fruit fly, Z.cucurbitae.

Keywords: Quarantine pest, Rapid DNA extraction, species-specific primers, real-time PCR, quick detection technique.

Phytochemical profiling of *Eriobotrya japonica* leaf extract and evaluation of their insecticidal activity: An Insilco analysis

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Spodoptera litura, a notorious agricultural pest, poses a significant threat to global crop yields due to its high adaptability and resistance to conventional insecticides. This study investigates the insecticidal potential of the organic leaf extract of *Eriobotrya japonica* and its interaction with essential proteins in S. litura. Bioassay results revealed insecticidal activity of the extract; however, the observed LC_{50} value was relatively high, indicating moderate efficacy. To explore this, GC-MS analysis was performed on the crude extract, identifying approximately 70 phytochemical, including squalene, sorbitol, and phytol. Molecular docking studies against essential protein showed that certain compounds possessed strong insecticidal potential (such as squalene with -8.7kcal/m binding affinity against ACHE1), but their low abundance (squalene = 1.51%) in the raw extract may explain the elevated LC_{50} values. These findings suggest that while the crude extract of E. japonica offers limited practical application, specific

compounds such as squalene demonstrate promising potential for development as targeted botanical insecticides.

Keywords: Phytochemical profiling, *Eriobotrya japonica,* leaf extract, Insilco analysis

Unlocking the Power of OMICS: Next-Gen Tools for Precision Pest Management in Agriculture

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The integration of OMICS technologies genomics, transcriptomics, proteomics, and metabolomics into agriculture has opened unprecedented avenues for sustainable pest management. These high throughput, molecular level approaches offer a detailed understanding of pest biology, plant defense mechanisms, and the intricate interactions within agroecosystems. Genomic sequencing aids in identifying genes responsible for resistance and virulence in pests, enabling the development of species specific interventions such as RNA interference (RNAi) based biopesticides. Transcriptomic studies provide insights into pest adaptation to control measures and environmental stress, while proteomic and metabolomic analyses reveal the functional molecules involved in plant-insect interactions and the biochemical basis of plant defense. Collectively, these technologies enhance early pest detection, support the design of precision-targeted control strategies, and reduce dependency on broad spectrum chemical pesticides. Moreover, OMICS facilitates the protection and utilization of natural enemies by elucidating their ecological functions at a molecular level. As agriculture moves toward climate resilience and ecological intensification, OMICS stands out as a critical enabler of data driven, sustainable pest management practices. This abstract discusses the transformative potential of OMICS in revolutionizing pest control while supporting global food security and environmental safety.

Keywords: OMICS technologies, Pest Management, Genomics, and RNAi

Prospecting Antimicrobial Peptides from Hymenoptera and Assessing Their Synergistic Roles in Antimicrobial Defense

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Insects living and evolving closely with other dominant life forms such as microbes, have developed an amazingly strong resistance to pathogenic microbes. This resistance is mediated by cellular and humoral immune system, the humoral system, among other constituents, chiefly comprises anti-microbial peptides (AMPs). The AMPs present in the haemolymph offer protection against pathogens. Interestingly, the AMPs are found as major constituents in the venom of Hymenoptera. This study explored the potential of wasp venom as a source of AMPs. Among four species of wasps and one bee species screened for AMPs, only two wasp species *viz*., *Ropalidia marginata* and *Vespa tropica* showed strong antimicrobial activity against *Staphylococcus aureus* strain (MTCC 3160), a major Gram +ve bacteria and *Escherichia coli* strain (MTCC 2692), a major Gram -ve bacteria. RP-HPLC was carried out with peptide specific protocol to separate fractions of peptides in venom. A total of 13 and 12 fractions were recorded from *V. tropica* and *R. marginata* respectively. All these fractions were found to have antimicrobial activity against *S. aureus* and *E. coli*. In order to test for possible antagonistic or synergistic role of peptide constituents of the venom extracts, the fractions were pooled into all possible combinations and evaluated for antimicrobial activity. An important finding of this study was that isolation and purification of crude venom extract recovers the antimicrobial properties and variable response of the test microorganisms to the crude venom and in different combinations upholds the synergistic action between the constituent of the venom.

Keywords: Venom, Anti-microbial peptides, Wasps, Gram +ve bacteria, Gram-ve bacteria, RP-HPLC, synergism.

Harnessing Nanotechnology for Insect Pest Management

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Nanotechnology is the ability to create and manipulate atoms and molecules on the smallest of the scales (0.1-100nm). Nanotechnology in insect pest management refers to the application of nanoscale materials, tools and techniques to control, monitor or manage insect pests in agriculture. Nano-insecticides are plant protection chemicals in which either the active ingredient or the carrier molecule is developed through nanotechnology. The amount required from nanopesticides is very small for effective pest management and it can reduce the pesticide load on the environment. Nanofertilizers are type of fertilizers that utilize nanotechnology to improve efficiency, controlled release and target delivery of nutrients to crops. Nano Sensors are the devices that detect physical, chemical or biological changes at nanoscale. These sensors help in early detection of pests and precise pest monitoring. Nanopesticides are pesticides that utilize nanotechnology to improve the delivery, effectiveness and safety of active ingredients used to control pests. In nanoemulsion the active ingredient is dispersed in the form of oil in water or water in oil emulsions. Metallic nanoparticles metal and refers to the metal oxide nanoparticles have insecticidal efficacy. Nano encapsulation includes droplets of solid or liquid core material surrounded or covered with a continuous film of polymeric material through which chemicals are slowly but efficiently released. Nanopesticides have the potential to improve targeted delivery, reduce environmental impact, increase crop yields and minimize health risk to humans and non-target organisms.

Keywords: Encapsulation, nanofertilizers, nanopestcides, nanotechnology

Theme 6

Industry Sessions

Theme 6

The Role of Innovation: Making Regeneration Work for Farmers

Bayer Crop Science | Global Sustainability & Public Affairs Division

A regenerative system must be both ecologically sound and economically viable. Our role is to provide the tools and technologies that enable this balance:

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- Digital Agriculture: Empowering farmers through precision tools like Climate FieldView™ to optimize inputs, manage variability, and measure regenerative outcomes.
- Carbon Farming & Ecosystem Markets: Pioneering market mechanisms that reward farmers for ecosystem services, including carbon sequestration and water stewardship.

We recognize that one-size-fits-all does not work. Our approach is region-specific and farmer-centered, recognizing the socio-economic realities and agronomic conditions on the ground.

Science-Based Metrics: Redefining Agricultural Success

To avoid greenwashing and ensure credibility, regenerative agriculture must be underpinned by science-based metrics and transparent reporting. Bayer is working with global partners to define and standardize indicators around:

- Soil organic carbon
- Biodiversity indices
- Input efficiency
- Yield stability and resilience
- Water use efficiency

These metrics are being integrated into our digital tools and field programs, allowing farmers to track both economic and environmental outcomes over time.

Partnerships for Scale: Regeneration is a Team Sport

We cannot achieve a regenerative future alone. Bayer is building an ecosystem of collaboration across:

- Farmers, as primary agents of transformation
- Policy-makers, to create enabling environments
- Finance and insurance, to de-risk transitions
- Food companies and retailers, to align value chains toward regenerative sourcing
- Academia and NGOs, to validate science and build trust

Through initiatives like the Bayer Carbon Initiative and global regenerative pilot programs, we are generating scalable models and insights to guide this transition globally.

Call to Action: From Momentum to Movement

We are at an inflection point. The transition to regenerative agriculture is no longer a question of if - but how fast, how fair, and how far we can go.

At Bayer Crop Science, we are committed to:

- Advancing 100 million hectares of regenerative farming by 2030
- Investing in innovation that aligns profitability with sustainability
- Building trust and transparency with science-based claims
- Supporting farmers with the tools, knowledge, and market access they need

Let us seize this moment - together - to unlock a regenerative revolution in agriculture that secures food, restores ecosystems, and empowers rural communities for generations to come.

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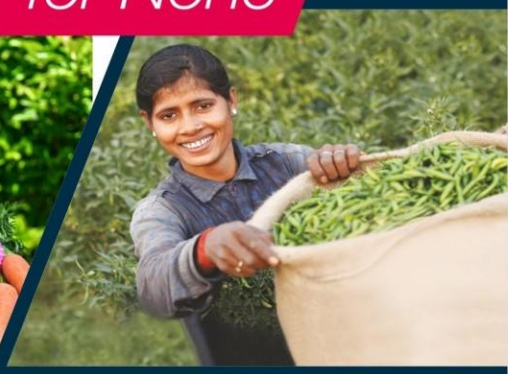

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As approved by the competent authority and the provision made therein for members, the following members of various committees as per the consent of Conveners for making effective arrangements to convene three days National Conference on **"National Congress of Entomology and Emerging Agrotechnologies" (NCEEA-2025)** from 27th to 29th July, 2025 jointly organized by Entomological Science Academy (ESA) and IIT-Jammu at Alpine Meadows of Sanasar and its surroundings.

1. ORGANIZING & TECHNICAL SESSIONS PROGRAMME COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Dr. R. K. Gupta	Professor & Head, Entomology	Convener
2.	Dr. Kamlesh Bali	Professor & Head, Sericulture	Co-convener
3.	Dr. Akhtar Ali Khan	Professor & Head, Entomology, SKUAST-K	Co-convener
4.	Dr. Magdeshwar Sharma	Professor, Entomology	Co-convener
5.	Dr. Uma Shankar	Professor, Entomology	Co-convener
6.	Dr. Amit K. Singh	Professor, Entomology	Member
7.	Dr. Devinder Sharma	Professor, Entomology	Member
8.	Dr. Muzafar Riyaz	SRF, Entomology	Member
9.	Ms. Marvi Khajuria	Res. Scholar	Member
10.	Ms. Shallu Choudhary	Res. Scholar	Member
11.	Mr. Abhishek TS	Res. Scholar	Member
12	Ms. Vishrawa Katoch	Res. Scholar	Member
13.	Ms. Yashavini Goswami	Res. Scholar	Member

Job chart:

i. To coordinate all activities related to the Technical sessions of Conference
ii. To receive and screen the material for publishing the proceedings.
iii. To conduct different Technical Sessions.
iv. Formulating a time table for the Technical sessions.
v. To execute all the purchases and process the bills.

2. PRESS, MEDIA AND PUBLICITY COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Dr. Devinder Sharma	Professor, Entomology	Convener
2.	Dr. Muzafar Riyaz	SRF, Entomology	Member
3.	Dr. Mushtaq Guroo	Technical officer/Asstt. Professor	Co-convener
4.	Dr. Ranjana Bali	YP-3	Member
5.	Ms. Monika Attri	Res. Scholar	Member
6.	Ms. Bhumika Rathore	Res. Scholar	Member

Job chart:

i. Publicity of the event through print and electronic media before the commencement of the event.
ii. Coverage of the event in both print and electronic media.
iii. Extending invitation to press and media persons and ensuring their participation.

3. BANNER COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Dr. Uma Shankar	Professor, Entomology	Convener
2.	Dr. Manoj Thakur	Research Assistant	Co-convener
3.	Dr. Ranjana Bali	YP-3	Member
4.	Ms. Monika Attri	Res. Scholar	Member
5.	Mr. Abhishek TS	Res. Scholar	Member

Job chart:

i. Publicity of the event through Banner, Posters and Certificates before the commencement of the event.
ii. Finalization of rates for all sort of printing of banners / posters etc.

4. PUBLICATION & CERTIFICATE COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Dr. Rakesh Kumar Gupta	Professor & Head, Entomology	Convener

2.	Dr. Kamlesh Bali	Professor, Sericulture	Co-convener
3.	Dr. Uma Shankar	Professor, Entomology	Co-convener
4.	Dr. Muzafar Riyaz	SRF, Entomology	Member
5.	Dr. Amit Kumar Singh	Professor, Entomology	Member
6.	Ms. Vishrawa Katoch	Research Scholar	Member
7.	Ms. Marvi Khajuria	Research Scholar	Member
8.	Ms. Goldy Fhonsa	M.Sc. Scholar	Member

Job chart:

i. Finalization of rates for all sort of printing.
ii. Publishing of all material.

5. HALL ARRANGEMENT COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Dr. Devinder Sharma	Professor, Entomology	Convener
2.	Ms. Marvi Khajuria	Research Scholar	Member
3.	Ms. Bhumika Rathore	Research Scholar	Member
4.	Ms. Yamini Singh	Research Scholar	Member

Job chart:

i. To arrange all the facilities for inaugural and technical sessions at PY Resorts / Conference Hall.
ii. To make the seating arrangements in the hall/ auditorium.

6. REGISTRATION COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Dr. Kamlesh Bali	Professor, Sericulture	Convener
2.	Dr. Ajay Gupta	Prof., KVK, Poonch	Co-convener
3.	Dr. Muzafar Riyaz	SRF, Entomology	Member
4.	Ms. Monika Attri	Res. Scholar	Member
5.	Ms. Ramandeep kour	Research Assistant	Member
6.	Ms. Yashashvini	Research Scholar	Member
7.	Ms. Harshika Slathia	Research Scholar	Member
8.	Ms. Neha Sudan	Research Scholar	Member
9.	Ms. Chitwan Kotwal	M.Sc. Scholar	Member

Job chart:

i. To register and guide the delegates
ii. To receive all the materials from the purchase committee related to registration kit.

7. INVITATION COMMITTEE

S. No.	Name of the Officer	Designation	Position
1.	Dr. R. K. Gupta	Prof. & Head, Entomology	Convener
2.	Dr. Vishal Gupta	Professor, Plant Pathology	Co-Convener
3.	Dr. Kamlesh Bali	Professor, Sericulture	Member
4.	Dr. Uma Shankar	Professor, Entomology	Member
5.	Dr. Amit K. Singh	Professor, Entomology	Member
6.	Dr. Muzafar Riyaz	SRF, Entomology	Member
7.	Mr. Kapil Attri	Research Scholar	Member
8.	Ms. Shriya Sharma	M.Sc. Scholar	Member

Job chart:

i. To invite the important personalities of University and other concerned personel for the grand success of the programme.

8. TRANSPORT COMMITTEE

S. No.	Name of the Officer	Designation	Position
1.	Mr. Varinder Yadav	Research Assistant	Convener
2.	Mr. Abhishek TS	Research Scholar	Co-Convener
3.	Mr. Rana Udhay Pratap Singh	M.Sc. Scholar	Member
4.	Ms. Ranjana Bali	Research Scholar	Member
5.	Mr. Kapil Attri	Research Scholar	Member

Job chart:

i. To arrange the vehicles for receiving delegates from Airport, Bus stand, Railway Station and shifting them to venue for conference/accommodation.
ii. Providing transport facility to delegates / various committees/research scholars

1. ACCOMMODATION COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Dr. R. K. Gupta	Professor & Head, Entomology	Convener
2.	Dr. Amit Kumar Singh	Professor, Entomology	Member
3.	Mr. Ashish Katoch	CEO, PY Resorts, Sanasar	Member
4.	Dr. Manoj Thakur	Research Assistant	Member
5.	Mr. Shivam Bains	M.Sc. Scholar	Member
6.	Tafseen Ajmal	M.Sc. Scholar	Member
7.	Ms. Bhumika Sharma	M.Sc. Scholar	Member

Job chart:

i. Providing suitable accommodation to invited dignitaries / delegates for their comfortable stay.

2. FOOD AND HOSPITALITY COMMITTEE

S. No.	Name of the Officer	Designation	Position
1.	Dr. Magdeshwar Sharma	Professor, Entomology	Convener
2.	Dr. Amit Kumar Singh	Professor, Entomology	Member
3.	Mr. Ashish Katoch	CEO, PY Resorts, Sanasar	Member
4.	Mr. Surya Rajpurohit	Research Scholar	Member
5.	Ms. Monika Attri	Research Scholar	Member
6.	Ms. Shailla Hussain	Research Scholar	Member
7.	Ms. Mariya Farid	Research Scholar	Member
8.	Mr. Mridul Sharma	M.Sc. Scholar	Member
9.	Mr. Hari Om	M.Sc. Scholar	Member
10.	Ms. Swati Sharma	M.Sc. Scholar	Member
11.	Mr. Amir-U-Ddin	M.Sc. Scholar	Member
12.	Mr. Rohit Yadav	M.Sc. Scholar	Member
13.	Mr. Ramandeep Singh	M.Sc. Scholar	Member
14.	Mr. Pradeep Kumar	M.Sc. Scholar	Member

Job chart:

i. Arranging suitable caterer(s) and making all arrangements for catering.
ii. To arrange food point at suitable location.

3. REPPOURTERS

S.No.	Name of the Officer	Designation	Position
1.	Ms. Shallu Choudhary	Research Scholar	Convener
2.	Ms. Ranjana Bali	Research Scholar	Member
3.	Ms. Marvi Khajuria	Research Scholar	Member
4.	Mr. Abhishek T.S.	Research Scholar	Member
5.	Ms. Ellula Parveena	Research Scholar	Member

Job chart:

i. To record the proceeding and compiled of the different session.

4. CULTURAL PROGRAMME COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Ms. Marvi Khajuria	Research Scholar	Convener
2.	Ms. Bhumika Rathore	Research Scholar	Co-convener
3.	Ms. Vishrawa Katoch	Research Scholar	Member
4.	Mr. Joopaka Ramu	Research Scholar	Member
5.	Ms. Toko Naan	Research Scholar	Member
6.	Ms. Harshita Thakur	Research Scholar	Member
7.	Ms. Mitali Choudhary	M.Sc. Scholar	Member
8	Ayushi Sharma	M.Sc. Scholar	Member
9	Tannu Sain	M.Sc. Scholar	Member

Job chart:

i. To make the arrangement of the cultural programme for the delegates/ participants.

5. POSTER SESSION COMMITTEE

S. No.	Name of the Officer	Designation	Position
1.	Dr. Uma Shankar	Professor, Entomology	Convener
2.	Dr. Kamlesh Bali	Professor, Sericulture	Co-convener
2.	Dr. Amit K. Singh	Professor, Entomology	Member
3.	Dr. Magdeshwar Sharma	Professor, Entomology	Member
4	Ms. Shailla Hussain	Research Scholar	Member
5	Zeenat Un-Nissa	Research Scholar	Member
6	Sandeep Yadav	M.Sc. Scholar	Member

Job chart:

i. To make the arrangement for poster presentation of different technical sessions
ii. Appointment of three judges of repute for evaluation of posters under each session.

6. FINANCE & PURCHASE COMMITTEE

S.No.	Name of the Officer	Designation	Position
1.	Dr. R. K. Gupta	Prof. & Head, Entomology	Convener
2.	Dr. Kamlesh Bali	Professor, Entomology	Co-convener
3.	Dr. Magdeshwar Sharma	Professor, Entomology	Member
4.	Dr. Amit K. Singh	Professor, Entomology	Member

The Conveners of all the Committees are requested to initiate the work as per their assigned job chart.

No.: AUJ/Entom/25-26/NCEEA/F-29/
Date: 19.06.2025

Dr. R. K. Gupta
President ESA


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