

Biopesticide related climate-resilient strategies for fruit fly management in horticultural crops

Abraham Verghese* and M. A. Rashmi**

ABSTRACT

This article provides an explanation of climate-resilient strategies for the management of fruit flies in horticultural crops. These strategies include biodiversity surveillance using an insecticide-free and climate-resilient liquid lure trap, advanced liquid lure formulation, climate-resilient novel trap hood cap, on-farm demonstrations and validation, as well as commercialization and impact.

MS History: 14.08.2025(Received)-27.08.2025(Revised)- 30.11.2025 (Accepted)

Citation: Abraham Verghese and Rashmi, M. A. 2025. Biopesticide related climate-resilient strategies for Fruit Fly Management in Horticultural Crops. *Journal of Biopesticides*, 18(2):89-92. DOI: 10.57182/jbiopestic.18.1.89-92

India's agricultural sector contributes approximately 16–17% to the India's GDP, supporting millions of rural households. However, persistent pest infestations, particularly from Tephritid fruit flies, pose a serious threat to crop productivity and international trade. Mangoes alone suffer yield losses of up to 31%, while cucurbit crops such as bitter gourds can face complete yield failure under unprotected conditions (Verghese *et al.*, 2002; Verghese *et al.*, 2004). Addressing this challenge calls for a climate-resilient, non-insecticidal solution that is adaptable across India's diverse agro-climatic zones and capable of safeguarding both yield and market viability.

The annual economic damage is estimated at approximately ₹10,000 Crores for mangoes and ₹2,000 Crores for cucurbits. Fruit fly seasonality varies significantly across India's agro-climatic zones: in North India, *Bactrocera* spp. hibernate during winter months (Butani, 1979), while in South India, they remain active year-round, especially when winter minimum temperatures exceed 20 °C (Nair, 1995; Verghese and Devi, 1998). This regional variations in temperature, rainfall and wind speed add complexity to pest management strategies, underscoring the need for climate-resilient, broad-spectrum solutions.

Biodiversity Surveillance with Insecticide Free and Climate Resilient Liquid Lure Trap

Comprehensive fruit fly management begins with accurate species assessment. Our non-insecticidal liquid lure trap attracts a broad spectrum of Tephritids infesting horticultural crops, facilitating biodiversity studies and targeted interventions. In Vegetable Crops such as Ridge Gourd, Cucumber, Snake Gourd, Bitter Gourd, Bottle Gourd, Coccinia, Gherkins, Watermelon, Pumpkin, Tomato and Temperate Fruits such as Peach, Plum, Apple etc., the following fruit flies are recorded.

Zeugodacus cucurbitae, *Bactrocera albistrigata*, *Bactrocera caudate*, *Bactrocera digressa*, *Bactrocera tau*, *Bactrocera scutellaris*, *Bactrocera neonigrotibialis*, *Bactrocera trilineata*, *B. nigrofemoralis*, *Bactrocera divenderi*, and few other *Bactrocera* spp. which have been recorded. In fruits such as Mango, Guava, Custard Apple, Sapota, Pomegranate & Others, *Bactrocera dorsalis*, *Bactrocera caryeae*, *Bactrocera correcta*, *Bactrocera zonata*, *Bactrocera versicolor*, *Bactrocera affinis*, *Bactrocera diversa*. The Rashvee lure trap can also be used to detect potentially invasive pests like *Bactrocera tryoni*.

Advanced Liquid Lure Formulation

Building upon the foundational research of R-IPRS, our BIRAC-funded advanced liquid lure formulation introduces a paradigm shift in Tephritid fruit fly management. Unlike conventional market offerings that rely heavily on insecticide-laced dispenser lures and exhibit short field longevity, this patented solution integrates multiple eco-compatible components to deliver climate-resilient efficacy across agro-climatic zones. The formulation combines highly attractive bioactive pheromone blends tailored to economically significant fruit fly species, gummy substances and plant latex for rapid and sustained adherence to trap surfaces, and herbal resins with phytochemicals that boost olfactory behaviour appeal and species specificity. To enhance stability, lipophilic, non-polar anti-evaporant hydrocarbons form a protective film that preserves lure integrity for over 65 days, even under high wind velocities (>20 km/h), torrential rainfall (>100 mm/day), and temperatures ranging from 15 °C to 40 °C.

As a universal multi-species trap, it outperforms existing single-lure products and two and multi holed receptacles by effectively attracting males of all the pest fruit fly species, especially of *Bactrocera* and *Zeugodacus* species including those commonly overlooked by traditional solutions. The Rashvee trap ensures 100% mortality with no escape, while being free from insecticides, aligning seamlessly with organic farming and sustainable agroecological practices. Its innovative bio-manufacturing approach is environmentally safe and with use of disposable water bottles, which are designed for effective waste management, offering a cost-efficient alternative to high-priced, chemically laced dispenser and holed-box traps. This product as described below, represents a leap towards climate resilient, non-insecticidal pest control with strong national and potential global markets.

Climate Resilient Novel Trap Hood Cap

For the lure, a climate resilient hood cap has been developed with a parachute technology stilt which reduces the air drag, skirt rain hood-guards against

heavy rain and the liquid lure has anti evaporants stable and efficient at high temperatures, high rainfall and high wind velocity and are effective in field for more than 60 days. The lure also has female disorienting olfactory chemical blends. The lure makes use of the disposable water bottles hence the waste management provision. This hooded trap setup with liquid lure was found to be superior over commercial traps in attracting diverse species of fruit flies belonging to Tephritid as also confirmed by state agriculture universities and ICAR. The trap is environment and user friendly (Rashmi *et al.*, 2025b). Extensive evaluations, validations and demonstrations were carried out in diverse fields and feedback from farmers, our main stakeholders, were recorded. Farmers have expressed high acceptability and user-friendliness of the traps in diverse crops. Validation of the trap was done by Indian Council of Agricultural Research (ICAR) and State Agricultural University (SAU) and have given excellent feedback.

On-Farm Demonstrations and Validation

On-farm demonstrations conducted in collaboration with ICAR, State Agricultural Universities (SAUs), and farmer groups across Karnataka, Tamil Nadu, Telengana, Jharkhand and Andhra Pradesh have firmly established the efficacy and impact of our advanced liquid lure system. Field trials across more than 10,000 acres led to a remarkable 70% reduction in overall integrated pest management (IPM) costs, with a cost-benefit ratio of 1:5. These trials further confirmed the complete elimination of non-target mortality, positioning the lure as a genuinely eco-friendly alternative to conventional insecticidal traps. Critically, the system helped restore export-grade fruit quality by reducing infestation levels below quarantine thresholds—a key factor in unlocking international market access.

In the on-farm demonstrations an average rating of 4.8 out of 5 from 400 respondent farmers on positive efficacy was recorded. The diversity complex of fruit flies in comparison to the commercial traps available in market and non-

capture of beneficial insects were evaluated at ICAR- National Bureau of Agricultural Insect Resources (NBAIR). The traps were very specific to Tephritidae and did not attract any beneficial insects like bees, useful predators, parasitoids. Therefore, proving the traps to be ecologically viable. Compared to the commercially available traps these traps cost 70% less. Therefore, making it economical for the farmers. Economically, deploying this non-insecticidal trap has the potential to reclaim crores of rupees annually by minimizing crop losses, enhancing export revenues, and strengthening India's foreign exchange earnings. Unlike chemical-based solutions that harm pollinators and beneficial insects, this innovation is aligned with principles of sustainable and natural farming.

The system is particularly suited for India's marginal and small-scale farmers, many of whom manage fragmented landholdings and cultivate diverse crops like fruits and vegetables. A universal lure capable of cross-crop protection simplifies pest management, reduces operational burdens, and enhances farm productivity.

To drive nationwide adoption, scaling up production through bio-manufacturing units in rural and semi-urban regions will promote employment, enable technology transfer, and expand market penetration. Further supported by advanced statistical modeling including climate-correlated trap performance the lure has proven adaptable across India's vast agro-climatic diversity, offering a resilient and inclusive path toward next-generation pest management. The trap, when used in combination with Rashvee herbal liquid soap and azadirachtin sprays as pre-harvest treatments, has effectively disoriented female fruit flies within horticultural ecosystems. Additionally, the application of Rashvee Phytofer protein baits ensures comprehensive control of Tephritid populations, particularly targeting virgin males and females emerging from the soil (Rashmi *et al.*, 2025a and Rashmi *et al.*, 2025b).

It is noteworthy that in crops such as mango, our standard thermal disinfestation treatment has been officially accepted by EU countries. Currently,

more than 52 operational centers are functioning globally under the supervision of DPPQS (Directorate of Plant Protection, Quarantine and Storage) staff, ensuring compliance with international phytosanitary standards (Verghese *et al.*, 2024).

Commercialization and Impact

The transition from laboratory prototype to full-scale production marks a transformative phase in the commercialization of our eco-safe, climate-resilient trapping system. Designed to empower farmers across India's diverse agro-ecological zones, this innovation not only safeguards crops but also promises to reopen critical export channels for mango, pomegranate, dragon fruit, guava, custard apple, cucurbits, gherkins and tomato, crops frequently targeted by Tephritid fruit flies. India's horticulture footprint is vast, spanning approximately 7.04 million hectares under fruit cultivation and 11.11 million hectares under vegetables. Even a modest 50% market penetration across this nearly 17-million-hectare domain could translate into an enormous opportunity both economically and environmentally.

Beyond domestic impact, all our products holds strong export appeal, particularly in East African countries grappling with similar fruit fly challenges. Strategic market entry through alignment with global regulatory standards offers India an opportunity to assert leadership in sustainable agricultural technology. This two-pronged strategy, targeting both domestic adoption and international expansion, not only amplifies market reach but also fosters inclusive growth through technology transfer, rural employment, and support for both smallholder farmers and agribusinesses. Ultimately, it positions India as a beacon of innovation in climate-smart pest management because, these products are bio-pesticidal and serves to address issues related to residue free products and sustainable ecological farming.

REFERENCES

- Butani, D. K. 1979. Insects and Fruits. Periodical Export Book Agency, New Delhi, 415 P.
- Nair, M. R. G. K. 1995. Insects and Mites of Crops in India. Publication and Information Division, Indian Council of Agricultural Research, New Delhi, 244 P.
- Rashmi, M. A., Varghese, A., David, K. J., and Gundappa, B. 2025a. Innovative climate-resilient liquid lure and trapping system: Enhancing fruit fly (*Bactrocera* spp.) management as a biocontrol component. In: Second International Conference on Biological Control: Biocontrol Contributions to One Health, 25–28 February, Bengaluru, India. Society for Biocontrol Advancement & ICAR–NBAIR, 139 P.
- Rashmi, M. A., David, K. J., and Varghese, A. 2025b. Novel green management strategies for fruit flies (Tephritidae: Diptera) infesting horticultural crops in India: A critical review. *Current Horticulture*, **13**(1): 3–13. DOI: 10.5958/2455-7560.2025.00001.8
- Varghese, A. and Devi, S. 1998. Relation between trap catch of *Bactrocera dorsalis* Hendel and abiotic factors. pp. 15–18. In: Proceedings of First National Symposium on Pest Management in Horticultural Crops: Environmental Implications and Thrusts (Eds. Reddy, P. P., Krishnakumar, N.K., and Varghese, A.). Association for Advancement of Pest Management in Horticultural Ecosystem, Bangalore.
- Varghese, A., Madhura, H. S., Jayanthi, K. P. D., and Stonehouse, J. M. 2002. Fruit flies of economic significance in India, with special reference to *Bactrocera dorsalis* (Hendel). *Proceedings of the 6th International Fruit Fly Symposium*, 6–10 May 2002, Stellenbosch, South Africa, **PP**. 317–324.
- Varghese, A., Nagaraju, D. K., Rashmi, M. A., and Singh, J. P. 2024. Ramification of post-harvest thermal disinfestation technology for mango fruit flies [*Bactrocera* spp. (Diptera: Tephritidae)] across India. *Current Horticulture*, **12**(2): 90–93. DOI: 10.48165/chr.2024.12.1.012
-
- Abraham Varghese^{a*} and M. A. Rashmi^b**
- ^aFormer Director, ICAR-NBAIR, Former Head and Scientist, ICAR-IIHR, Bengaluru, India
- ^bRashvee-International Phytosanitary Research and Services Pvt. Ltd., Bengaluru, India
- *Corresponding author**
E-mail: abraham.avergis@gmail.com
- Presented at 7th Biopesticides International Conference**