## Effectiveness of ecofriendly control measures against fruitfly (*Bactrocera cucurbitae*) infestation in Sponge Gourd (*Luffa cylindrica* L.)

**Abstract**
The melon fruit fly *Bactrocera cucurbitae* (Diptera, Tephricidae) is widely distributed in the tropical, subtropical and temperate regions of the world. Fruit fly infestation poses a significant challenge in cucurbit production, leading to reduced fruit quality and substantial yield losses. The extent of losses may vary from 30 to 100 % depending upon the season and the cucurbit species. This study assesses the efficacy of two eco-friendly fruit fly management techniques ethyl alcohol-based traps (TO1) and the bait application technique (TO2) in comparison with conventional pesticide use (FP) among farmers. The research was conducted through seven on-farm trials in sponge gourd (Kashi Rakshita) cultivation under summer conditions. Results revealed that TO1 significantly reduced fruit infestation (13.84%) and maggot density (8.35 per fruit), resulting in the highest yield (236.5 t/ha) and economic benefits (B:C ratio of 2.93). TO2 also proved effective, with reduced fruit infestation (16.97%) and improved yield (222.0 t/ha; B:C ratio 2.71) compared to FP. The study underscores the importance of Integrated Pest Management (IPM) strategies in enhancing cucurbit productivity and economic viability while promoting sustainable agricultural practices. The use of ecofriendly methods not only enhances soil fertility and microbial activity, but also ensures non-hazardous pest management tactics in long term sustainable farming. Nevertheless, these methods are safer and sustainable but also paves a path towards improved soil microbial activity, biodiversity and healthier crop production.

**Keywords:** Fruit fly, Integrated Pest Management, Sponge Gourd, Eco-friendly Control, Yield Loss, Bait Application Technique.

**Introduction**
Cucurbitaceous vegetables, including sponge gourd (*Luffa cylindrica*), are crucial for nutritional security and economic viability. In India, sponge gourd is known by various names such as vegetable sponge, bath sponge, loofah, dish cloth gourd, *nenua* in hindi as well as *galaka* in Gujrati (Bhardiya *et al.,* 2018). The crop is known to be attacked by a number of insect pests throughout its different growth stages which affects it both quantitively and qualitatively. Among the pests, Melon fruit fly, red pumpkin beetle, whitefly, aphids, jassids, leaf miner etc. are the major threat causing varying degree of losses to the crop (Am *et al.,* 2017). However, fruit fly (*Bactrocera cucurbitae*) infestation remains a critical challenge, causing substantial yield losses. Of the 207 species of fruit flies found in India, nine are the major ones (Dhillon *et al.,* 2005) and amongst those *Bactrocera cucurbitae* and *B. tau* commonly known as melon fruit flies are the prime threats. Melon fruit fly was first described by Coquillett (1899) as *Dacus cucurbitae* on cucurbit from Hawaii. Later on, it was reported from different parts of the world, *viz.*; China, Nepal, Pakistan, Phillippines, Myanmar, Malaysia, Sri Lanka, Australia, East Africa and Taiwan, (Narannan and Batra, 1960; Bhardiya *et al.,* 2017). However, in India, the incidence of the melon fruit fly was first documented by Lefroy (1907) on cucurbits.

*B. cucurbitae* damages over 81 plant species, but plants belonging to the family cucurbitaceae are most preferred hosts (Allwood *et al*., 1999; Weems and Heppner, 2001). The extent of losses varies between 30 to 100%, depending upon the prevailing environmental conditions and susceptibility of the crop species (Dhillon *et al*., 2005; Shooker *et al*., 2006). This pest is reported to cause 50% infestation in sponge gourd (Gupta and Verma, 1992). The female fly usually lays its eggs in the tissues of fruits and the young maggots feed on flesh and makes them appear rotten fruits. The fruit fly also oviposits in tender plant tissues such as terminals, unopened flowers, young stems, roots, and seedlings which ultimately pave a way for death of the plant (Meena et al., 2019). Conventional pesticide applications are often ineffective due to pest resistance and environmental concerns. Hence, sustainable and eco-friendly pest management approaches are essential (Meena *et al.,* 2023). Different botanicals viz., Chilli, Onion Garlic, ginger etc. are very crucial in management of infestation of melon fruitfly in cucurbits by production of defensive enzymes and antioxidants (Sultana et al., 2020; Somegowda et al., 2021). The current investigation focusses on eco-friendly module for management of fruit fly, *Bactrocera cucurbitae* on sponge gourd. This study aims to evaluate the effectiveness of ethyl alcohol-based trap (TO1) and bait application technique (TO2) in reducing fruit fly damage compared to the farmer's practice (FP).

**Research Purpose**

* To comprehensively assess the effectiveness of ethyl alcohol-based traps (TO1) and bait application technique (TO2) in reducing fruit fly infestation in sponge gourd cultivation by analyzing their impact on fruit damage, maggot density, insect attraction, and overall yield performance under field conditions.
* To determine the impact of these eco-friendly management strategies on yield attributes, fruit damage, maggot density, insect population dynamics, and overall crop health to ensure sustainable pest management in sponge gourd cultivation.
* To conduct a detailed economic analysis of adopting these IPM strategies, evaluating factors such as input costs, yield improvements, net returns, and benefit-cost ratios in comparison to conventional pesticide use by farmers. This will provide insights into the long-term sustainability and profitability of eco-friendly pest management approaches.
* To contribute to sustainable pest management by promoting eco-friendly alternatives to synthetic chemical pesticides, thereby reducing environmental pollution and pesticide resistance. This study aims to assess the comparative effectiveness of different Integrated Pest Management (IPM) strategies against fruit fly infestation in sponge gourd cultivation, with a focus on enhancing yield, reducing fruit damage, and improving economic returns for farmers.
* To conduct a comprehensive economic analysis comparing the profitability, cost-effectiveness, and long-term financial sustainability of eco-friendly fruit fly management practices with conventional pesticide use in sponge gourd cultivation.

**Research Gap**
Previous studies have extensively documented the detrimental effects of fruit flies on cucurbit yield, highlighting their role in significant economic losses. However, most research has primarily focused on conventional pesticide applications or isolated eco-friendly approaches, often lacking comparative field evaluations. Limited studies have assessed the effectiveness of different eco-friendly management strategies under real farming conditions, leaving a gap in understanding their practical feasibility and economic viability. This study aims to bridge this gap by scientifically evaluating two eco-friendly methods—ethyl alcohol-based traps and the bait application technique—while comparing their effectiveness with conventional pesticide use in sponge gourd cultivation. The findings will contribute valuable insights into sustainable pest management practices tailored for cucurbit growers.

**Materials and Methods**

* **Location:** The study was conducted at Saran district of Bihar at seven different locations in Farmers field on sandy loam upland soil under an irrigated farming system within a subtropical climatic zone, providing optimal conditions for sponge gourd cultivation and ensuring reliable field assessment of fruit fly management techniques.
* **Season and Year:** Summer 2023 and Summer 2024.
* **Crop:** Sponge gourd (var. *Kashi Rakshita*) cultivated during the summer season, which presents ideal conditions for fruit fly infestation, allowing for a thorough and realistic assessment of management strategies under field conditions.
* **Experimental Design:** The study was structured as On-farm trials (OFT) with seven replications per treatment, ensuring reliable and statistically sound data collection. The experimental layout followed a randomized block design (RBD) to minimize variability and enhance the precision of treatment comparisons, allowing for a robust assessment of the effectiveness of eco-friendly fruit fly management strategies.
* **Technology Options:**
	+ **TO1:** Ethyl alcohol (60 ml) + Cue lure (40 ml) + Malathion/DDVP (20 ml) @ 10 traps/ha.
	+ **TO2:** Bait application with 0.1% malathion + 10% jaggery/ripe banana or 3 cue lure traps/acre.
	+ **FP:** Random pesticide spray by farmers without specific strategy or dose regulation.
* **Performance Indicators:** The study measured multiple key parameters, including the percentage of fruit damage, maggot density per fruit, insect attraction rate per trap, total yield (t/ha), and benefit-cost (B:C) ratio. These indicators provided a comprehensive evaluation of the comparative effectiveness of the different fruit fly management strategies in enhancing yield and economic viability in sponge gourd cultivation.
* **Source of Technology:** The eco-friendly management strategies implemented in this study were based on scientifically validated methodologies recommended by ICAR-ATARI Patna. These strategies align with integrated pest management (IPM) principles and have been developed through rigorous research to ensure their effectiveness in reducing fruit fly infestation while maintaining ecological balance in cucurbit cultivation.
* **Critical Inputs:** The key inputs utilized in this study included Malathion, Cue lure, Ethyl alcohol, and a jaggery solution, which served as essential components for the bait application technique. Additionally, plastic bottles were used for trap construction, ensuring effective field implementation of the eco-friendly pest management strategies. Other necessary materials, such as applicators and sprayers, were employed to facilitate precise and efficient treatment application.
* **Cost of Input:** The total cost of critical inputs was estimated at Rs. 25,000/ha, encompassing expenses for essential materials such as Malathion, Cue lure, Ethyl alcohol, jaggery solution, and plastic bottles. This calculation also includes the cost of trap construction, bait preparation, and application logistics, ensuring effective implementation of the eco-friendly pest management strategies.

**Results and Discussion**
Table 1 presents the yield attributes across different treatments. TO1 exhibited the lowest fruit infestation (13.84%) and maggot density (8.35 per fruit), significantly outperforming TO2 (16.97% infestation; 10.45 maggots/fruit) and FP (21.60% infestation; 15.4 maggots/fruit). The highest insect attraction was observed in TO1 (10.7/trap), followed by TO2 (13.55/trap), suggesting a strong lure efficiency. Yield assessment demonstrated that TO1 (236.5 t/ha) achieved the highest productivity, followed by TO2 (222.0 t/ha) and FP (207.5 t/ha), reinforcing the effectiveness of eco-friendly management strategies.

Table 2 presents the economic analysis. TO1 exhibited the highest economic returns, with a net return of Rs. 1,74,370/ha and a B:C ratio of 2.93, indicating superior profitability. TO2 followed closely with a net return of Rs. 1,56,896/ha and a B:C ratio of 2.71, demonstrating a viable alternative to conventional practices. FP recorded the lowest net return and B:C ratio (2.69), highlighting its relative inefficiency. These results strongly support the economic viability of adopting Integrated Pest Management (IPM) strategies, offering improved financial sustainability while reducing dependency on indiscriminate pesticide applications.

**Table 1: Effect of Fruitfly management on yield attributes of sponge gourd cultivation**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Yield attributes** | **Yield****(ton/ha)** |
| **Mean percentage of fruit infestation** | **Mean no. of maggot /fruit** | **Number of insect attracted /trap** |
| **2022-23** | **2023-24** | **Pooled** | **2022-23** | **2023-****24** | **Pooled** | **2022-23** | **2023-24** | **Pooled** | **2022-23** | **2023-24** | **Pooled** |
| **FP** | 22.37 | 20.82 | 21.60 | 16.10 | 14.7 | 15.4 | - | - | 13.55 | 205.0 | 210.0 | 207.5 |
| **TO1** | 14.92 | 12.76 | 13.84 | 9.30 | 7.40 | 8.35 | 12.4 | 14.7 | 10.7 | 232.0 | 241.0 | 236.5 |
| **TO2** | 18.46 | 15.48 | 16.97 | 11.50 | 9.4 | 10.45 | 9.8 | 11.6 | 13.55 | 218.0 | 226.0 | 222.0 |
| **CD (0.05)** | 0.75 | 0.80 | 0.78 | 0.62 | 0.66 | 0.64 | - | - | 10.7 | 2.86 | 2.28 | 2.57 |

**Table 2: Effect of fruitfly management on economics of sponge gourd cultivation.**

|  |  |
| --- | --- |
| **Treatment** | **Economics** |
| **Fruit yield (q/ha)** | **Cost of cultivation (Rs./ha)** | **Gross return****(Rs. /ha)** | **Net return****(Rs./ha)** | **B:C ratio** |
| **2022-****23** | **2023-****24** | **Pooled** | **2022-****23** | **2023-****24** | **Pooled** | **2022-****23** | **2023-****24** | **Pooled** | **2022-****23** | **2023-24** | **Pooled** | **2022-23** | **2023-24** | **Pooled** |
| **FP** | 205.00 | 210.00 | 207.50 | 92546 | 92245 | 92396 | 246000 | 252000 | 249000 | 118525 | 159755 | 139140 | 2.66 | 2.73 | 2.69 |
| **TO1** | **232.00** | **241.00** | **236.50** | **96544** | **97105** | **96825** | **278400** | **289200** | **283800** | **156644** | **192095** | **174370** | **2.88** | **2.98** | **2.93** |
| **TO2** | 218.00 | 226.00 | 222.00 | 97546 | 98897 | 98222 | 261600 | 271200 | 266400 | 141488 | 172303 | 156896 | 2.68 | 2.74 | 2.71 |

**Conclusion**
Eco-friendly fruit fly management techniques significantly enhance yield and profitability in sponge gourd cultivation. TO1 (ethyl alcohol-based trap) demonstrated the highest efficacy, reducing fruit damage, minimizing maggot density, and achieving the best economic returns. TO2 (bait application) also provided substantial benefits over conventional pesticide-based practices, reinforcing the potential of Integrated Pest Management (IPM) strategies for sustainable cucurbit production. These findings underscore the necessity of adopting eco-friendly pest control measures to ensure long-term productivity and environmental sustainability. Future research should aim at optimizing these techniques and assessing their adaptability across diverse agro-climatic regions to maximize their impact on cucurbit cultivation.

**COMPETING INTERESTS DISCLAIMER**:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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