**Integrated Light-Acoustic-Chemical free Trap for Sustainable Crop Pest Management**

**Abstract**: The aim of the present study was to observe and evaluate the effectiveness of a newly designed composite light-sound-lure based trap system for monitoring and controlling insect pests. This trap was designed to assess the efficiency of various components installed in a newly developed configuration. The system integrated UV light (365 nm and 395 nm), blue light, sticky cards, an electric grid, and an ultrasonic transducer. Results indicated high attraction rates for several key agricultural pests, including scarab beetles, moths, thrips, whiteflies, mosquitoes, and leafhoppers, with blue light being particularly effective against small flying insects. The sticky surfaces and electric grid contributed to enhanced pest mortality. Notably, the ultrasonic component successfully deterred bats, thereby minimizing non-target interference near fruit-bearing trees. The primary objective of the present investigation is to assess the behavioral responses of various insect and pest species to a newly designed trap. Since this trap has not been previously studied in a quantitative framework, there is currently no data available regarding its effectiveness or insect interaction patterns.

**Key words:** Composite light , Sustainable, eco-friendly, IPM, Multifunctional

**INTRODUCTION:**

In modern farming, insect traps have become an important tool for managing pests in a way that’s both effective and environmentally friendly. Instead of relying only on chemical pesticides, farmers now use a variety of traps like sticky cards, light traps, and pheromone-baited devices to monitor and control harmful insect populations. Hokkanen (1991), was among the first to highlight how trap-based methods, such as trap cropping and attract-and-kill strategies, can reduce pest numbers while protecting helpful insects like pollinators and predators. Shelton and Badenes-Pérez (2006), added that traps are not just for control they also act as early warning systems, helping farmers take action before pests cause serious damage. More recently, Sharma et al. (2019), reviewed how traps have been successfully used in crops like cotton, soybean, rice, and vegetables. Their findings showed that traps are flexible, cost-effective, and easy to include in integrated pest management (IPM) programs. Traps also support the health of the entire farm ecosystem. Using traps can reduce the need for pesticides, protect pollinators, and encourage natural enemies of pests. As agriculture shifts toward more sustainable practices, traps are becoming a key part of pest management strategies, Finstein (2023); Duguma, (2012).

**METHODOLOGY:- Composite Design**

The primary aim of the newly designed trap is to document the diversity of insect crop pests attracted toward it. This innovative trapping system is intended to serve as a monitoring tool to assess pest presence, activity patterns, and species composition within agricultural ecosystems. The main objective of the present study is to observe and analyze the effectiveness of the trap in attracting various insect pests and to evaluate it potential for integrated pest management applications.

The present composite insect trap is specially designed to catch a wide variety of crop pests using different kinds of signals and tools all in one device. It combines attraction, repel and control methods to improve pest management. At the center of the device are two ultraviolet (UV) LED lights one at 365 nm and another at 395 nm which help attract insects that are active at night or early morning, since many pests are drawn to UV light. It also uses blue and white LED lights, which make the trap more visible and attractive to several other insect species. To keep away certain flying creatures like birds, bats, or some insects, a 45 kHz ultrasonic transducer is included. The transducer produces high-pitched sound waves that are irritating to them and help repel or confuse them. The trap also uses chemical lures, such as pheromones or food-based scents, to draw in specific pest species more effectively. For passive trapping, the device includes blue and yellow sticky cards, which are known to attract common sucking pests like whiteflies, thrips, and leafhoppers. Finally, the trap has an electric grid that kills insects immediately on contact. This provides a quick, non-chemical method of pest control. By combining light, sound, scent, sticky surfaces, and electricity, this all-in-one device offers a practical and eco-friendly way to manage insect pests in agriculture as part of an Integrated Pest Management (IPM) approach. The trap was operated for three hours, from 6:30 PM to 9:30 PM.



**FIG 1: Installed Composite Trap**

**RESULT AND DISCUSSION**

In the present investigation, the majority of trapped insect crop pests belonged to the order Coleoptera, encompassing a diverse range of beetle families. A total of 14 families were recorded, including Carabidae, Haliplidae, Dytiscidae, Histeridae, Staphylinidae, Scarabaeidae, Elateridae, Meloidae, Tenebrionidae, Cerambycidae, Chrysomelidae, Mordellidae, Scolytidae, and Curculionidae. It was noted that when both UV light sources (365 nm and 395 nm) were used simultaneously, the highest number of beetles attracted to the trap belonged to the family Scarabaeidae, followed by those from the families Scolytidae, Carabidae, Cerambycidae, and Meloidae, respectively.

Scarab beetles are a major agricultural pest, particularly during their larval stage when they appear as white grubs. These larvae live beneath the soil and feed on the roots of crops such as sugarcane, maize, groundnut, and others. Their feeding weakens the plants, leading to symptoms like yellowing, stunted growth, and sometimes total plant collapse. Adult beetles typically emerge with the onset of the rainy season, laying their eggs in the soil. Once hatched, the larvae continue the cycle underground, making early detection extremely difficult. Because of their hidden lifestyle and damaging behavior, controlling white grubs is a significant challenge for farmers. In this context, the composite trap which uses a combination of UV light, sticky surfaces, lures, and electric grids plays an important role. It helps attract and intercept adult scarab beetles before they reproduce, thereby reducing both immediate damage and the long-term pest population.

*Eudocima homaena* and *Achaea janata* are major crop pest of pomegranate. *Eudocima homaena* is a fruit-piercing moth that causes serious damage to pomegranate fruits. The adult moth uses its sharp mouthpart to poke holes in ripe fruits and suck out the juice. This leads to scars, rotting, fruit drop, and opens the fruit to infection by fungi and bacteria. The damage is worse during the ripening stage and can reduce both the quality and quantity of the harvest. *Achaea janata*, damages pomegranates by piercing the skin of ripening fruits with its sharp proboscis to suck juice. This causes scars, fruit rot, and drop, reducing both yield and quality . The pest is active at night, making early control difficult. The adult moths of both species were attracted to UV light at 365 nm, indicating their sensitivity to this specific wavelength.

During the study, leafhoppers, thrips, mosquitoes, and whiteflies exhibited a strong attraction to blue light. Adult showed maximum response when blue and white light were used simultaneously. thrips and mosquitoes showed strong responsiveness to the trap setup. Many individuals were either captured on sticky cards or killed by the electric grid, confirming their high attraction toward the blue and white light. When the transducer was activated, it emitted ultrasonic frequencies that likely interfered with the bats' echolocation. As a result, the bats stopped flying around the fruit trees and avoided the area entirely. This observation suggests that ultrasound effectively disrupts their navigation, making it a potential tool for bat deterrence in orchards.

Chitra (2018), conducted a field study to understand how nocturnal insects react to different colors of artificial light. The experiment used 25W bulbs of various types—incandescent, CFL, red, green, and blue—suspended above a white sheet. Insects attracted to each light source were collected and analyzed monthly. The results showed that incandescent bulbs attracted the highest number of insects and the greatest variety of species, followed by CFLs. Although blue light attracted fewer insects. In contrast, red and green lights showed very low attraction, especially for certain insect orders. These differences are believed to be caused by insects’ sensitivity to shorter wavelengths of light—particularly blue and UV light (below 420 nm). Chitra concluded that the color or wavelength of light plays an important role in insect behavior. Choosing the right light spectrum—especially blue or UV can improve the effectiveness of light traps.

Kumbhar and Bhusnar (2024), found that Isoptera were equally responsive to blue and white lights, while Blattodea showed a preference for red light, suggesting species-specific visual sensitivities. These results highlight the importance of selecting appropriate wavelengths for effective insect monitoring and control. The findings have practical applications in designing species-targeted light traps, optimizing pest surveillance systems, and minimizing non-target impacts in agricultural and conservation settings. Overall, the study contributes valuable insights into phototactic behaviors of nocturnal insects and supports the use of blue light as a preferred wavelength for eco-friendly pest management strategies. Artificial white light sources, such as streetlights, on insect behavior. Their study revealed that these lights can significantly disrupt natural ecosystems by altering how insects interact with their surroundings. They emphasized that two key factors light intensity and spectral composition—play a crucial role in influencing insect attraction. Differences in these characteristics affect not only the quantity of insects drawn to the light but also the variety of species involved Longcore and Rich (2004).

Chapman et al. (2013), explored the structure of insect compound eyes, highlighting their sensitivity to specific light wavelengths. These eyes contain photoreceptor cells that respond strongly to ultraviolet (UV), blue, and green light. Among these, blue light (450–495 nm) stands out as particularly attractive to many insect species. This is because its wavelength closely mimics the natural twilight spectrum, making it an effective lure in light-based insect traps. Tan et al., (2024), investigated efficiency of various attractant consists of mixture of lures in trap designed for capturing fruit fly, *Bactrocera sps* responsible for massive loss from mango orchards from Saharanpur district captured 3780 and 2129 flies with in the 17 weeks. They concluded that the flies are mor attractive to the methyl eugenol lure than cue lure. Grupe and Meyhöfer (2024), studied how green LED sticky traps work to catch greenhouse whiteflies (*Trialeurodes vaporariorum*) in tomato plants. They tested these traps during two planting cycles inside a greenhouse and compared them with the commonly used yellow sticky traps. The goal of the study was to see if the LED traps could spot pests earlier, helping farmers take action sooner. They concluded that Both types of traps caught about the same number of whiteflies, but the green LED traps were better at early detection.

Brehm et al. (2021), conducted a comprehensive study to examine how nocturnal moths respond to different wavelengths of artificial light. Over 300 replicated trials were performed under controlled indoor conditions, captured more than 6,000 individual moths from 95 species across seven Lepidopteran families. The results revealed that ultraviolet (UV) light at 365 nm was the most effective in attracting moths, drawing up to 84% of individuals in certain trials. Blue light at 450 nm also demonstrated significant attraction, particularly when UV was absent. Furthermore, lamps combining UV and visible wavelengths exhibited attraction levels comparable to those of pure UV sources. They noticed that, male moths were consistently more responsive to light than females, likely due to their increased flight activity. Park and Lee (2021), evaluated the impact of **385 nm UV-LED lighting** on the biological control of *Bemisia tabaci* by simultaneously attracting the pest and its natural predator, *Nesidiocoris tenuis*. Laboratory and growth chamber trials demonstrated a marked increase in predator retention and feeding activity under UV illumination. These results indicate that UV-LED light enhances spatial congruence between predator and prey. Athanasiadou et al. **(2024),** investigated the effects of blue (470 nm) and UV (365 nm) LEDs on *Trialeurodes vaporariorum* and its parasitoid *Encarsia formosa*. Blue light repelled nearly 87% of whiteflies, and the combination with UV further increased repellency. While whitefly behavior was significantly disrupted, the parasitoid remained largely unaffected.

In the present investigation, it was observed that two major insect pests of pomegranate exhibited strong phototactic responses to ultraviolet (UV) light emitted at a wavelength of 365 nm. This finding suggests that UV-based trapping systems may be highly effective for monitoring and managing these key pest species within pomegranate orchards.

**CONCLUSION:**

Field observations revealed that the composite trap system is an exceptionally efficient and eco-friendly tool for pest monitoring and management in fruit orchards. Its engineered design integrates multiple attractant and deterrent mechanisms that enhance both pest capture and environmental sustainability. The trap incorporates ultraviolet light at 365 nm and 395 nm, along with blue light wavelengths, creating a synergistic visual lure highly effective in attracting a broad range of phototactic insect pests. Targeted pest groups included scarab beetles, noctuid moths, thrips, mosquitoes, whiteflies, and leafhoppers species known for causing substantial damage to fruit crops. To augment its efficacy, the trap features sticky adhesive surfaces and an electric grid, providing a dual-action suppression mechanism. This not only ensures accurate pest monitoring but also actively neutralizes insects that are drawn in, contributing to population control in the trap’s vicinity. Additionally, the system employs an ultrasonic transducer emitting high-frequency sound waves that serve to repel non-target organisms, notably bats. This acoustic deterrence mitigates ecological disturbances and protects beneficial fauna, addressing a critical concern in integrated pest management strategies.

The present composite trap demonstrated considerable promise as a multi-functional, non-toxic, and field-adaptable solution for use in Integrated Pest Management (IPM) systems. As the device is newly designed, only an evaluative study was conducted. In the near future, both qualitative and quantitative investigations will be undertaken to improve the efficiency and performance of the trap.

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