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Design and Development of Solar Multi-spectral Cum Electrified Mesh Insect Trapper with IoT-Based Ultrasonic Animal Repellent System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

The insects, pest and intrusion of some wild animals become one of the major constraint in Indian agriculture, especially western arid and semi-arid region of Rajasthan. Traditionally, chemical application were practiced for pest control, which leads the production cost and severely effect on environment. The present study emphases on the design and development of solar powered multi spectral insect trapper with an electrified mesh cum IoT based ultrasonic animal repellent system which protect the crop and increases agricultural productivity. The developed system enables UV (365-395 nm), blue (450-470 nm), and white LEDs which

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attracts the crepuscular and nocturnal insects. The insects were deactivated by supplying low current in electrified mesh powered by 40 W solar panel. Also, the ultrasonic sound waves (>20 kHz) were generated using two amplifier to protect agriculture field from wild animals. The efficiency of multi spectral light for insect trapping was in the range of 32-45% than single spectrum light system. Whereas animal intrusion in agricultural field were significantly reduced around 70-80 % by using ultrasonic system. The IoT based sensors can easily judge the movement of animal in the radius of 4-5 m and transmits the signal to ultrasonic system. This technology creates a new window for the farmers for implementation in sustainable agriculture and smart farming systems.

Keywords: Pest control; smart farming systems; IoT based ultrasonic animal repellent system; sustainable agriculture.

1. Introduction

India is one of the developing country globally has witnessed for sudden growth and installation in the field of renewable energy. The solar, wind, bio-energy, geothermal energy, etc. received significant attention globally due to its multiple environmental applications. The total installed capacity in solar energy in India as of 2026 has crossed of 143 GW, which indicates the one of the major share in India's total renewable energy generation of 267 GW. In the year of 2025, the India has marked a huge installation of solar energy in the range of 35-38 GW solar capacity by installing different solar parks, which justifies the strong policy making and minimum capital investment cost. India is almost achieved more than half of the target by achieving the National mission of 500 GW of renewable energy by 2030. Recently, schemes of government of India especially solar roof top programme and PM surya ghar yojana received a significant attention for achieving India's energy transition and making green India (Ministry of New And Renewable Energy., 2026).

Agricultural crops are adversely affected by moment of insects, wild animals, pest etc, and results in decrease in crop productivity. Annually, as reported in recent studies insect pest are responsible for almost 15 to 25 % crop losses. Farmers are using excessive pesticide for controlling the insects and other diseases which leads adverse environmental effects, serious health issues and resistance development, therefore there is need to develop a sustainable technology. Integrated Pest Management (IPM) programs generally used light traps for controlling the movement of insects on the crops. Many research studies investigated that ultraviolet light (UV) having a wavelength in between 365 to 395 nm are mainly recommended as a highly attractive for many nocturnal insects, whereas white and blue light are also attracts different insect species. Therefore, practical approach of multi spectral light can enhance the attraction efficiency of different insects results in increase in trapping performance. Additionally, the farmers of western Rajasthan are facing intrinsic issue related to animal intrusion particularly nilgai, wild boar, stray cattle which causes damage in crop productivity especially in arid and semi-arid region. Some ultrasonic systems are getting widespread attention because these ultrasonic repellents can able to emits the frequency of 20 kHz which results in repelling the wild animals from agriculture field without any harm (FAO, 2021). Whereas solar photovoltaic technology can creates a eco and environmentally friendly sustainable energy option to operate this insect trapping as well as animal repellent system in remote agricultural field. Integration of IoT enables the real time monitoring of the moment of wild bore animals and also automated control of insect by improving the crop productivity. Based on the above discussion in present study a solar powered multi spectral insect trapper cum animal repellent system was designed and developed, also solar powered electrified mesh was also provided for killing the insects, IoT based animal repellent system which enables the bioacoustics mechanism to protect the agriculture field from the entry of wild bore animals (Ministry of Agriculture & Farmers Welfare, 2023). The detail performance and economics analysis of developed system was carried out in present study.

2. Materials and Methods

2.1 Design of Solar Insect Trapper Cum Animal Repellent System

2.1.1 Selection of Solar Photo Voltaic Panel

In present study one polycrystalline type solar panels were used for conversion of sunlight into electricity. The energy generated from solar panel was used to operate the LEDs and amplifiers. The solar PV panel of 50 W, 12 V capacity was fitted on system (Kim et al., 2019).

2.1.2 Selection of Solar Charge Controller

A solar charge controller play an important role in regulating the voltage and current received from solar panel. The position of charge controller is fixed in between solar panel and Battery. The charge controller of 12 V capacity was used to protect the battery from overcharging and discharging (Kalogirou, 2014).

2.1.3 Selection of Battery

The battery was used to store the energy generated from solar panel, here in present study 12 V 20 A battery capacity was used to store the DC energy obtained from solar panel, and the battery enable to transmit power to operate LEDs and amplifier (IoT Applications in Smart Agriculture, 2022).

2.1.4 Selection of LEDs

In present study, multispectral LEDs were used having a different wavelength which are enable to attract the insects in agricultural field. UV LED (365-395 nm), Blue LED (450-470 nm), and white LED were used in developed device for wide range of insect attraction (Sermsri and Chonmapat, 2015).

2.1.5 Selection of Electrified Mesh

For neutralizing the insects a low current electrified mesh was fitted over the multispectral LEDs with a supply of low current 800-1200 V. This provision restrict the movement of trapped insects.

2.1.6 Selection of Ultrasonic Speaker and Sensors

For animal intrusion in agriculture field a solar powered >20 kHz two ultrasonic speakers were fitted in opposite direction. The speakers will enable to operate as signal received from PIR sensors, which can easily detect the animal movement in the range of 5-7 m (Khairi et al., 2022). The system components along with specification and function is listed in Table 1.

Table 1. Components of developed system along with specification and functions

S. No	Component	Specification	Function
1	Solar PV Panel	50 W, 12 V	Power generation
2	Battery	12 V, 20 Ah	Energy storage
3	Charge Controller	12 V PWM	Battery protection
4	UV LED	365–395 nm	Insect attraction
5	Blue LED	450–470 nm	Insect attraction
6	White LED	6000K	General attraction
7	Electrified Mesh	800–1200 V low current	Insect killing
8	Ultrasonic Speaker	>20 kHz	Animal repellent
9	PIR Sensor	5–7 m range	Motion detection

2.2 Working Principle

The whole system mainly composed of two subsystems firstly insect trapper unit and secondly the animal repellent system powered by solar energy for protection of agricultural field. The multi spectral LEDs are programmed in insect trapper which are automatically turn ON during sun set time with the assist of timer. The lights emits specific wavelength which enables the attraction of various insects. When the insect come towards the light it also comes in contact with an electrified mesh, where a low current but high voltage is supplied results in neutralize the moment of insects. After deactivation of insects all dead insects fall down Inside the cyclone separator below the mesh, which can easily dispose the insects. Additionally, animal repellent system using ultrasonic speaker was operated using an animal motion detector sensors. The passive Infrared (PIR) sensors can easily detect the movement of animals, and activated the ultrasonic emitters that generates sound waves more than 20 kHz (Madduri et al., 2025). These sound waves can act as a repellent system, unpleasant to

animal's results in restriction of animal entry in agriculture field. Some design specifications are listed in Table 2.

Table 2. The design specifications of solar powered insect trapper cum animal repellent system

S. No.	Parameter	Value
1.	Operating Voltage	12 V DC
2.	Solar Panel Capacity	40 W
3.	Battery Backup	8–10 hours
4.	Light Operation	6 PM – 6 AM
5.	Ultrasonic Frequency	20–40 kHz
6.	Mesh Voltage	800–1200 V
7.	Coverage Area	1–1.5 acre

The material used for fabrication of the system was mild steel with an anti-corrosion coating. The multispectral LEDs were fitted centrally, surrounded by electrified mesh made of stainless steel. Whereas the solar panels mounted on roof top of the system with a title angle of 25^0 for getting uniform solar radiations (Mohammed et al., 2018).

2.3 Field Testing

The field study was carried out at instructional farm of Agriculture University Jodhpur for 30 days and collected data about how many insects trapped per night, diversification of species, animal intrusion event, power consumed and battery voltage. The isometric view of developed system is shown in Fig. 1.

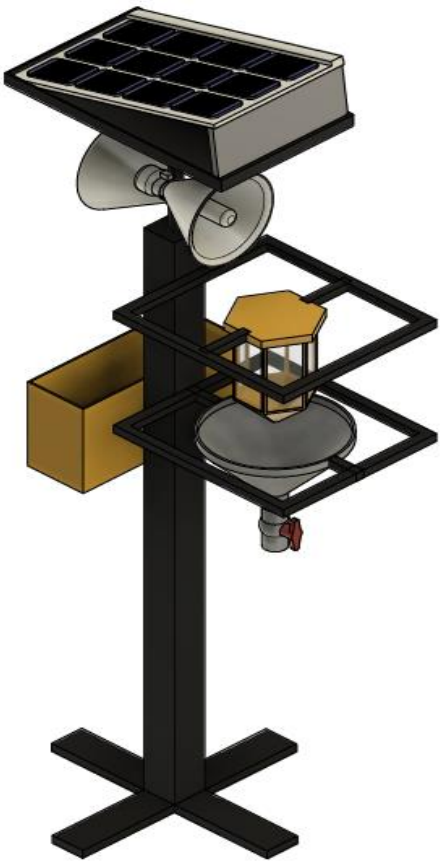

Fig. 1. Isometric view of developed solar insect trapper cum animal repellent system

3. Results and Discussion

3.1 Insect Attraction Efficiency

The insect capture performance was carried out by comparing the single spectrum and multispectral light performance, the obtained results proved that the multi spectral light system exhibited 32-45% higher trapping efficiency than single spectrum trap. UV light justified for major contribution for the attraction of insects followed by blue light and white light during the night hours. The insect tracking efficiency is one of the important parameter which to be used to minimize the agricultural pest. The system is enable to estimate the overall performance using the different spectral wavelength of light powered by solar energy especially, blue light, ultraviolet and near violet light etc. For maximize the attraction of insects the multi spectral light source like UV LEDs (350-400 nm) and blue LED (420-470 nm) are most particularly used or combination of both (Balamurugan et al., 2021). The insect capture efficiency is mostly influenced by the light intensity, trap height, wavelength of light, other environmental conditions, and ecosystem. The hours of insect moments and the positioning of multispectral light significantly increases the trapping efficiency. Many studies reported that UV light exhibited greater attraction efficiency for insect such flies, moths, and beetles, therefore highly recommended for integrated pest management in agricultural field (Ramesh et al., 2025). The execution of solar based insect trapping system creates a remarkable option especially those farmers who are farming in country side area where scarcity of other commercial sources. The adoption of multi spectral light combination with operating schedules, the solar insect trap system can justified highly efficient for pest management, and dependency on other chemical fertilizers in crop protection. The result finding are listed in Table 3.

Table 3. Insect capture performance

S. No.	Light type	Average insect captured during night time
1.	UV only	320
2.	Blue only	210
3.	White only	180
4.	Multi-Spectral (Combined)	465

3.2 Animal Repellent Performance

The animal repellent system was also performed to determine the animal intrusion events occurred during the night duration of a week. The animal intrusion was reduced almost 75% by using sensor based ultrasonic sound system. It was observed that the average intrusion of animals per week without system average of 10-12 whereas with ultrasonic system results in 2-3 animals intrusion per week (Kalogirou, 2014). There is need to execute the system which can become promising option to deter the wild animals without any harm to living organism and the environment. The system enable to generate the emission of bioacoustics and ultrasonic frequencies , generally more than 20 kHz, which causes alarm to wild boars, nilgai, monkeys and other wild animals. The predator alarm from repellent system may include high frequency ultrasonic waves, distress signals, which creates discomfort to the animals. The interesting invention is application of passive infrared sensors (PIR) which only activate the technology when there is any movement of animal detected, results in increasing the energy efficiency and also restriction of animals to became the habit of continuous sound. The solar powered invention is sustainable and uninterrupted solution, especially in remote areas where grid power is unavailable. The effectiveness of the solar animal repellent system can be influenced by different factors such as range of coverage, intensity and frequency of sound, strategic installation of the device, etc. In present study the field observation reflected that the emission of different variable frequency in bioacoustics signals may reduce the crop damage followed by protection of field area. Therefore, solar powered bioacoustics system create a reliable option for development of eco-friendly and energy manageable solution for field protection and sustainable agricultural practices.

3.3 Energy & Economic Performance

The daily energy generation from solar panel was recorded to be around 160-180 Wh, whereas energy consumption daily to operate the solar insect trapper and for the operation of ultrasonic sound were in between 110-130 Wh/day. The battery backup is also adequate even in also cloudy days to be around 1-2 days of

autonomy. Additionally, the design and development cost required for fabrication of system was found around ₹ 20000 INR. Whereas the benefit cost ration and payback period of developed system was found 1.12 and 15 Months, respectively. The feasibility and adoption of the developed system in agricultural field was determined using the energy and economic performance of developed system. Nugroho The hybrid system entirely powered by solar photovoltaic panel connected with rechargeable battery, ensuring the efficient operation in even country side area particularly off-grid rural areas. During day time the mounted solar panels converts sunlight into electricity, which is stored in battery and after that it was used to power the multispectral lights for capturing the insects, electrified mesh system, ultrasonic animal repellent system, etc. especially during nighttime operations (Kiarie et al/. 2021). The overall energy consumption to operate the system was found very negligible as solar power is used to switch ON the LED bulbs, control the electronic generator, and operate the electronic device which allows appropriate consumption of solar energy. From the economic point of view, the developed system can significantly reduce the dependence on chemical pesticides and also reduces the crop loss suffered by insects and pests, which results in reduction for agriculture farm protection practices by enhancing the crop productivity (Mhandu et al., 2023, Ibrahim, 2017). However, the capital cost to develop the system was found slightly higher due to solar components and other electronic devices such as LED lights, amplifiers, sensors, speakers, etc. interestingly negligible recurring expenditures, zero electrical cost as well as pesticides expenditures makes the system economically feasible for longer duration. Additionally, the system provides durability of the structure, and negligible maintenance contribute to a favorable cost benefit ratio, making this technology self-sustainable and cost-effective solution for integrated pest and animal management in agriculture (Tenali et al., 2023).

4. Conclusion

The developed solar multi-spectral cum electrified mesh insect trapper integrated with IoT-based ultrasonic animal repellent system proved effective for sustainable crop protection. The multi-spectral light significantly improved insect capture efficiency compared to conventional single-spectrum traps. The ultrasonic repellent reduced animal intrusion by approximately 75%, minimizing crop damage. Solar power ensured off-grid operation, making the system suitable for remote agricultural areas. IoT integration enhanced automation, monitoring, and data-driven pest management. The system promotes eco-friendly agriculture by reducing chemical pesticide use and supporting integrated pest management strategies. Future improvements may include AI-based insect identification, GSM connectivity for remote areas, and large-scale deployment studies.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

References

Balamurugan, R., & Kandasamy, P. (2021). Effectiveness of portable solar-powered light-emitting diode insect trap: Experimental investigation in a groundnut field. *Journal of Asia-Pacific Entomology*, 24(4), 1024–1032. https://doi.org/10.1016/j.aspen.2021.09.013

Food and Agriculture Organization (FAO). (2021). *Integrated pest management guidelines*.

Ibrahim, A. G. (2017). Performance evaluation of a designed stand-alone solar powered ultrasound weaver bird pest control device. AIMS.

Kalogirou, S. (2014). *Solar energy engineering: Processes and systems*. Academic Press.

Khairi, M. A. F. F. M., & Jumaat, S. A. (2022). The prototype of pest repellent system and insect light trap using solar energy for small agriculture. *Evolution in Electrical and Electronic Engineering*, 3(1), 243–251. https://publisher.uthm.edu.my/periodicals/index.php/eeee

Kiarie, G., & Maina, C. W. (2021). Raspberry Pi based recording system for acoustic monitoring of bird species. In *2021 IST-Africa Conference (IST-Africa)* (pp. 1–8). IEEE.

Madduri, K., Hiremath, S., Chiniwar, D. S., & Shrishail, M. H. (2025). Environment-friendly experimental solar-powered UV light pest trapping mechanism for open agricultural fields. *Environmental Research Communications*, 7(3), 035002. https://doi.org/10.1088/2515-7620/adb8a5

Mhandu, M. M., Musarurwa, A., & Gudukeya, L. K. (2023). Design of a solar automated scarecrow. In *Proceedings of the IEOM International Conference on Smart Mobility and Vehicle Electrification* (pp. 440–451).

Ministry of Agriculture & Farmers Welfare, Government of India. (2023). *Agricultural statistics report*.

Ministry of New and Renewable Energy, Government of India. (2026). Physical progress. Retrieved March 17, 2026, from https://mnre.gov.in/en/physical-progress/

Mohammed, M. E. A., El-Shafie, H. A. F., & Al-Hajhoj, M. B. R. (2018). Design of an automated solar-powered light trap for monitoring and mass trapping of major date palm pests. *Ecology, Environment and Conservation*, 24(1), 177–185. https://www.eminternational.com/journals/ecology-environment-conservation

Ramesh, D., Chandrasekaran, M., Soundararajan, R. P., Subramanian, P. P., Palled, V., & Kumar, D. P. (2022). Solar-powered plant protection equipment: Perspective and prospects. *Energies*, 15(19), 7379. https://doi.org/10.3390/en15197379

Sermsri, N., & Torasa, C. (2015). Solar energy-based insect pest trap. *Procedia - Social and Behavioral Sciences*, 197, 2548–2553. https://doi.org/10.1016/j.sbspro.2015.07.620

Tenali, O. S., & Ranga, J. C. N. S. (2023). Solar panel protection from birds and land animals.

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