International Journal of Plant & Soil Science

Volume 35, Issue 22, Page 923-934, 2023; Article no.IJPSS.105054
ISSN: 2320-7035

Comparative Analysis of UV and UV-LED Light Traps for Pest Control: A Cost-Efficiency Perspective

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Authors' contributions

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

Article Information

DOI: 10.9734/IJPSS/2023/v35i224203

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/105054

Original Research Article

Received: 02/10/2023
Accepted: 09/12/2023
Published: 12/12/2023

ABSTRACT

This research, conducted between October 2019 and March 2020 at the Biotechnology Centre, Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur, Madhya Pradesh, aimed to compare the effectiveness and cost-efficiency of UV and UV-LED light traps in attracting and capturing insect pests. The study utilized UV 15-watt (model SMV-4) and UV LED 7-watt solar trap (model Rakshak) to assess their respective performances in capturing Gryllusbimaculatus, unidentified Lepidoptera moths, Helicoverpaarmigera, Gryllotalpaorientalis, Plusiaorichalcea, Agrotisipsilon, and Creatonotosgangis. The results revealed that the UV 15-watt trap demonstrated superior efficacy in

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capturing Gryllusbimaculatus and unidentified Lepidoptera moths, while no significant difference was observed between UV 15W and 7W UV LED traps.Furthermore, the UV 15-watt trap outperformed the UV LED 7-watt in capturing Helicoverpaarmigera, Gryllotalpaorientalis, Plusiaorichalcea, Agrotisipsilon, and Creatonotosgangis, with significant differences noted in the catches. Despite these variations, considering the total wattage consumption, the UV 7-watt solar trap emerged as a more cost-effective alternative, showcasing economic advantages over the UV 15-watt electric-powered counterpart. Conclusively, the solar-powered UV 7-watt light trap proves to be a promising substitute for the UV 15-watt model in pest control applications. However, it is crucial to acknowledge the higher initial cost associated with the solar-powered light trap, highlighting a potential trade-off between cost and efficiency in light trap selection for pest management.

Keywords: Light trap; 07 watt UV; 7W UV LED light sources; economic light source.

1. INTRODUCTION

The integration of light traps has become significantly prevalent in Integrated Pest Management (IPM) strategies globally. These traps serve various purposes, such as conducting comprehensive surveys to assess insect diversity. Typically, these traps are straightforward interception devices designed to attract and capture insects traversing a particular area. Moreover, light traps play a pivotal role in detecting new invasions of insect pests in both temporal and spatial dimensions. They are also instrumental in delineating the extent of infested areas and monitoring population levels of established pests.At JNKVV Jabalpur, Vaishampayan and his coworkers worked extensively on light trap studies from 1973 to 2001 with financing from ICAR. The best light source against a number agricultural pest species turned out to be a mercury vapour lamp (125 and 160 watts), with a 15 watt UV black light lamp (18 inch tube length) coming in second [1]. Since many insects are innately positively phototrophic, using light traps to catch insects produces useful faunistic evidence [2,3]. Such data can be used as an indicator of the geographical biodiversity's condition. The knowledge obtained from light trap catches could provide insight on when insects are most active, according to Dadmal & Khadakkar [4]. Considerable benefits over the electrical light trap makes the solar light trap a viable alternative. In order to achieve the goal, a suitable type of solar light trap was identified taking into account the following qualities, namely its portability and ease of installation anywhere in the field.

2. MATERIALS AND METHODS

The experiment spanned from the third week of October to the third week of March (2019 – 2020) and took place in the vicinity behind the Biotechnology Center on the campus of Jawaharlal Nehru Krishi Vishwa Vidyalaya in Jabalpur, Madhya Pradesh. The initial treatment in the study utilized Dr. S. M. Vaishampayan's light trap model SMV-4, which was established in 2014. Specific design details of the light trap can be found in the book titled "Light Trap: an Eco-friendly IPM Tool" authored by Vaishampayan & Vaishampayan [5]. Both MV and UV lights perform well as a light source for the trap. The light source for this experiment was a UV 15 watt 18" tube light. The monitoring of insect pests was done employing the solar-powered Rakshak light trap device as a second treatment. The experiment was conducted in the field to align with the objectives of the study. Every night, light traps were activated, and the following morning, collection was noted. Daily observations were made during the rabi season. On the basis of the major species, the total insect fauna was studied and identified. Data on the daily capture from traps was maintained. In the experimental area, a total of two light traps were set up. Approximately 5 hectares of agricultural land were covered in the experiment. Gram was utilized as a medium to cover this extensive area, with traps spaced approximately 100 meters apart. The fumigating agent Dichlorvos 76 EC vapors were dispensed using a scrubber-equipped dispenser placed in a collection tray to ensure swift extermination of trapped insects. The insects collected in the collection bag were exposed to the Dichlorvos 76 EC vapors. Each morning, the insects were extracted from the collection bag.

2.1 "Comparative Assessment of Two Light Sources for Pest Attraction and Capture"

The study involves two treatments aimed at comparing the effectiveness of the SMV-4 model, utilizing a 15-watt UV tube light (18"), against a solar light trap with a 7-watt UV LED tube (Model Rakshak). The objective is to evaluate their relative efficiency in trapping and collecting various insect species associated with different crops.

Treatment 1 (T1): 15-watt UV tube light (SMV-4 Model)
Treatment 2 (T2): 7-watt UV LED tube (Solar light trap) Model Rakshak

3. RESULTS AND DISCUSSION

Results of an investigation on how different insect pest species react to light sources are briefly detailed below. Seven insect pest species were selected for assessing the efficacy of SMV-4 UV and SOLAR LED light sources. These species include Gram pod borer (*Helicoverpa armigera*), Black cutworm (*Agrotis ipsilon*), Tiger moth (*Creatonotos gangis*), Field cricket (*Gryllus bimaculatus*), Mole cricket (*Gryllotalpa orientalis*), Cabbage semilooper (*Plusia orichalcea*), and Unidentified Lepidoptera moth. These species were identified as significant positively phototropic insect pests in rabi crops due to their regular and notably high occurrences in trap catches. Table 1 presents the names of the major species recorded in trap catches, providing a species-wise description. The detailed comparative response of these insect pests to the different light sources is elaborated in the following Table 1.

3.1 Comparative Response According to Species Given Below

- At the 5% significance level, the calculated t-value (2.263) surpasses the tabulated value (2.261) for both T-1 (degree of freedom =9) and T-2 (degree of freedom =9). Consequently, the null hypothesis is rejected, indicating a significant difference between SMV-4 UV 15 Watt and SOLAR UV LED 7 Watt.
- In numerical terms, SMV-4 UV exhibited a higher trap catch compared to SOLAR UV LED.

Table 1. The major species recorded in trap catches with a species-wise description

S. No.	Scientific name	Common name	Family	Order
1.	*Helicoverpa. armigera*	Pod borer of gram	Noctuidae	Lepidoptera
2.	*A. ipsilon*	Black cutworm	Noctuidae	Lepidoptera
3.	*C. gangis*	Tiger moth	Noctuidae	Lepidoptera
4	*P. orichalcea*	Cabbage semilooper	Noctuidae	Lepidoptera
5	*G. bimaculatus*	Feild cricket	Gryllidae	Orthoptera
6	*G. oreintalis*	Mole cricket	Gryllotalpidae	Orthoptera
7	Miscellaneous species	Unidentified Lepidoptera moth	-----	Lepidoptera

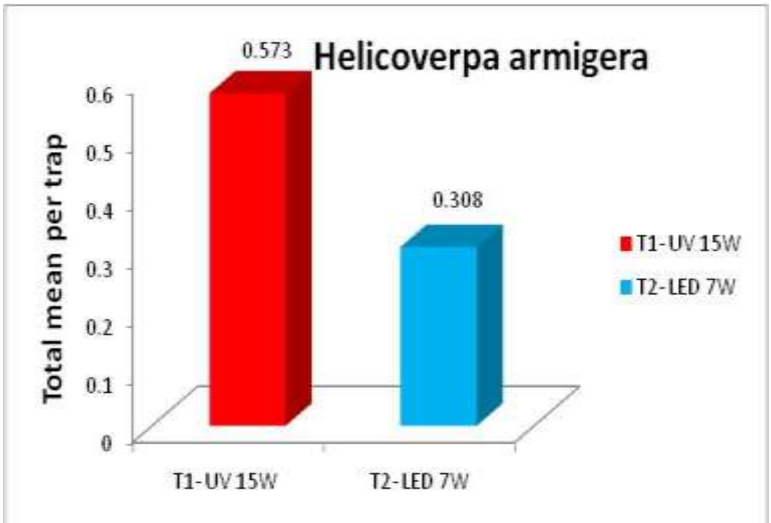

Fig. 1. Response of Gram pod borer
**(Significant at 5%)*

Table 2. The comparative response or behavior of insect pest species towards different light sources was evaluated. Treatment 1 involved the use of SMV-4 UV 15-watt, while Treatment 2 utilized SOLAR UV LED 7-watt

S. No.	Observation period weekly	Species wise mean /day / trap							
		H. armigera		*A. ipsilon*		*C. gangis*		*P. orichalcea*	
		T-1	T-2	T-1	T-2	T-1	T-2	T-1	T-2
1	Oct 3rd wk	00	00	00	0	31.75	6.24	00	00
2	Oct 4th wk	00	00	00	0	27.66	4.43	00	00
3	Nov 1st wk	00	00	00	0	11.71	1.27	00	00
4	Nov 1st wk	00	00	00	0	7.28	1.56	00	00
5	Nov 3rd wk	00	00	00	0	12	3.36	00	00
6	Nov 4th wk	00	00	00	0	8.57	4.74	00	00
7	Dec 1st wk	00	00	00	0	8.42	5.13	00	00
8	Dec 2nd wk	00	00	00	0	4.42	3.72	00	00
9	Dec 3rd wk	00	00	00	0	3	2.874	00	00
10	Dec 4th wk	0.251	.143	00	0	1.125	1.72	00	00
11	Jan 1st wk	0.143	0.141	00	0	1.56	1.142	1.141	0.428
12	Jan 2nd wk	00	00	00	0	1.56	1.143	1.143	0.142
13	Jan 3rd wk	00	00	00	0	2.374	1.0	1.856	0.857
14	Jan 4th wk	0.141	0.143	0.713	0.426	1.4	0.624	1.123	0.500
15	Feb 1th wk	0.143	0.141	0.427	0.144	1.56	1.143	0.284	0.142
16	Feb 2nd wk	0.284	0.143	1.0	0.573	1.56	1.0	0.572	0.285
17	Feb 3rd wk	0.285	.284	0.714	0.711	0.43	1.27	1.856	0.428
18	Feb 4th wk	0.874	.427	1.141	0.871	3.84	2.0	3.624	2.285
19	Mar 1st wk	1.140	0.286	2.427	1.427	10.72	2.72	3.856	1.428
20	Mar 2nd wk	1.0	0.715	2.281	0.713	11.56	2.27	2.715	1.428
21	Mar 3rd wk	1.429	0.67	1.833	1.0	12	2.26	2.01	0.571

S.No.	weekly Observation period	Species wise weekly mean/day / trap					
		G. bimaculatus		*G. oreintalis*		Unidentified Lepidoptera moth	
		T-1	T-2	T-1	T-2	T-1	T-2
1	Oct 3rdwk	22.4	3.124	1.2	00	8.751	3.124
2	Oct 4thwk	12.624	2.27	00	0.21	9.331	2.881
3	Nov 1stwk	5.281	1.1	1.1	0.570	2.850	1.713
4	Nov 2ndwk	3.56	0.56	2.856	1.0	1.710	0.571
5	Nov 3rdwk	1.0	2.143	4.124	3.141	4.421	1.856
6	Nov 4thwk	1.13	0.856	2.74	3.67	7.250	3.251
7	Dec 1stwk	0.84	0.858	2.427	2.0	9.424	5.001
8	Dec 2ndwk	1.0	0.287	2.713	1.84	6.284	3.143
9	Dec 3rdwk	00	00	1.715	1.427	4.0	5.002
10	Dec 4thwk	0.13	0.572	0.856	0.624	4.421	2.874
11	Jan 1stwk	1.0	0.421	0.714	0.429	2.852	2.572
12	Jan 2ndwk	0.427	1.0	0.570	0.141	1.423	1.141
13	Jan 3rdwk	0.286	0.570	0.427	0.76	2.251	1.284
14	Jan 4thwk	1.284	0.74	0.876	1.0	5.770	5.124
15	Feb 1stwk	0.427	0.42	1.0	0.143	6.0	1.421
16	Feb 2ndwk	1.0	0.715	0.143	0.141	4.421	1.284
17	Feb 3rdwk	0.570	0.284	0.572	0.250	4.855	2.001
18	Feb 4thwk	0.284	0.286	0.713	0.572	7.284	6.374
19	Mar 1stwk	2.0	0.284	1.427	0.713	11.141	6.856
20	Mar 2ndwk	2.284	0.572	2.01	1.284	9.001	6.711
21	Mar 3rdwk	2.286	1.429	1.570	0.427	12.001	5.831

Table 3. Pod borer of Gram {*H. armigera* (Hubner)}

Statistical Details for Light Sources:	*Helicoverpa armigera*	
• T-1: SMV-4 UV • T-2: SOLAR UV	**T-1**	**T-2**
No. of Observation	10	10
Total mean	0.308	0.573
Variance	0.048	0.247
d.f	9	9
t_{cal}	2.263 *	
$t_{tab\ (0.05)}$	2.261	

Table 4. Field cricket {*G. bimaculatus* (De Geer)}

Statistical Details of light sources	*G. bimaculatus*	
T-1=SMV- 4 UV &T-2=SOLAR UV	**T-1**	**T-2**
Number of Observations	20	20
Total mean	2.998	0.9
Variance	28.921	0.617
d.f.	19	
$T_{calculated}$	1.968NS	
$T_{tabulated\ at\ (0.05)\ level}$	2.092	

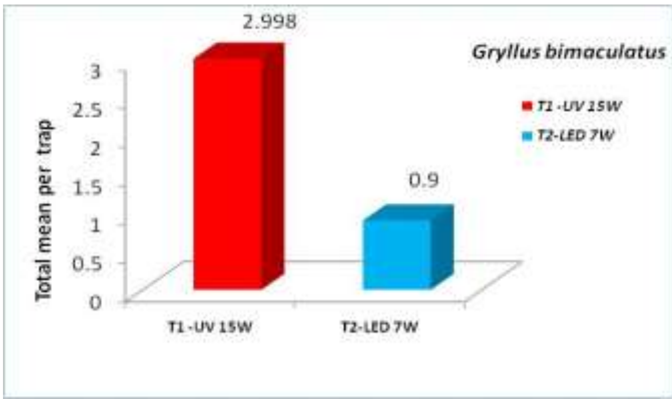

Fig. 2. Response of field cricket (*Gryllusbimaculatus)*
NS (non -significant)

- At the 5% significance level, the calculated t-value (1.968) is found to be less than the tabulated t-value (2.092) for 19 degrees of freedom. Consequently, we accept the null hypothesis, indicating that the mean of SMV-4 15 Watt and SOLAR UV 7 Watt does not exhibit a significant difference.In numerical terms, the trap catch was higher in SMV-4 UV compared to SOLAR LED.
- At the 5% significance level, the calculated t-value (3.476) exceeds the tabulated value (16df, 2.092). Therefore, the null hypothesis is rejected, indicating a significant difference between the means of SMV-4 15 Watt and SOLAR LED 7 Watt.Numerically, the trap catch was higher in SMV-4UV than SOLAR UV LED. This numerical difference supports the conclusion that SMV-4UV had a higher response in attracting insect pest species compared to SOLAR UV LED.

The calculated t-value (3.361) is greater than both the tabulated values (20 df, 2.844) at both 5% and 1% significance levels. Consequently, the null hypothesis is rejected, indicating a significant difference between the means of SMV-4 and SOLAR LED. Numerically, the trap catch was higher in SMV-4 compared to SOLAR LED. This numerical difference supports the conclusion that SMV-4 had a higher response in attracting insect pest species compared to SOLAR LED.

Table 5. Mole cricket *G. orientalis* (Burmeister)

Statistical Details of light sources T-1=SMV-4 and T-2=SOLAR UV	*Gryllotalpa orientalis*	
	T-1	T-2
Number of Observations	20	20
Total(Sum up) mean	1.472	1.018
Variance,	1.074	0.965
d.f.	19	
$T_{caculatedl}$	3.476*	
$T_{tabulated\ at\ (0.05)}$	2.092	
$T_{tabulated\ at\ (0.01)}$	2.862	

Significant at 5% and 1%

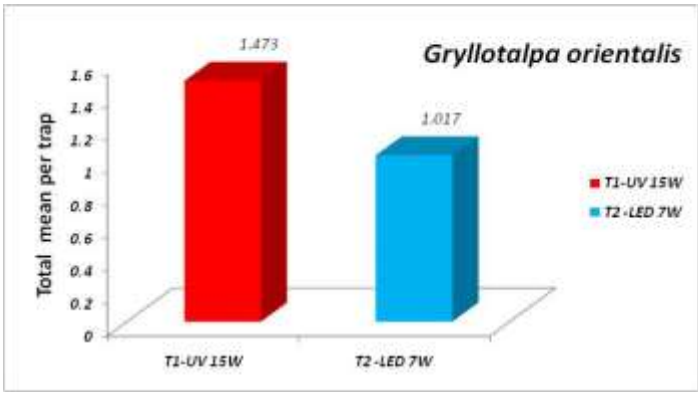

Fig. 3. Response of mole cricket (*Gryllotalpa orientalis)*

Table 6. Tiger moth's *C. gangis* (Linnaeus)

Statistical Details of light sources T-1=SMV-4 and T-2 SOLAR LED	*Creatonotos gangis*	
	T-1	T-2
Number of Observations	21st	21st
Total (Sum)mean	7.843	2.462
Variance,	70.767	2.530
d.f.	20	
$T_{calculated}$	3.361*	
$T_{tabulated\ at\ (0.05)}$	2.844	

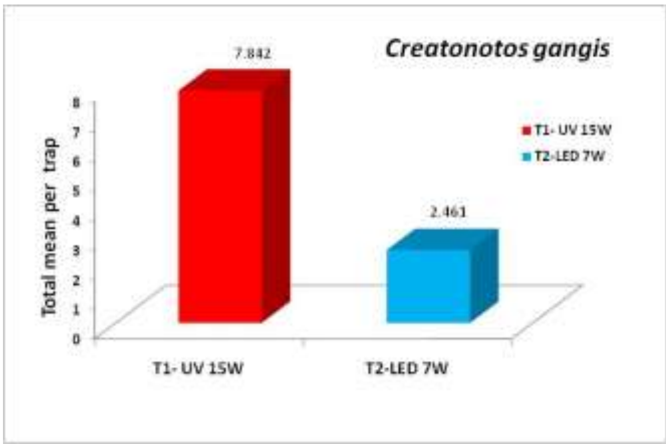

Fig. 4. Graphical response of Tiger moth
**Significant at 5% and 1% level*

Table 7. Cabbage semilooper *P. orichalcea*

Statistical Details of light sources T-1=SMV-4 and T-2=SOLAR LED	*Plusia orichalcea*	
	T-1	**T-2**
Number of Observations	11th	11th
Total (Sum up) mean	1.834	0.771
Variance	1.352	0.455
d.f.	10	
$T_{calculated}$	5.557*	
$T_{tabulated\ at\ (0.05)}$	2.227	
$T_{tabulated\ at\ (0.01)}$	3.168	

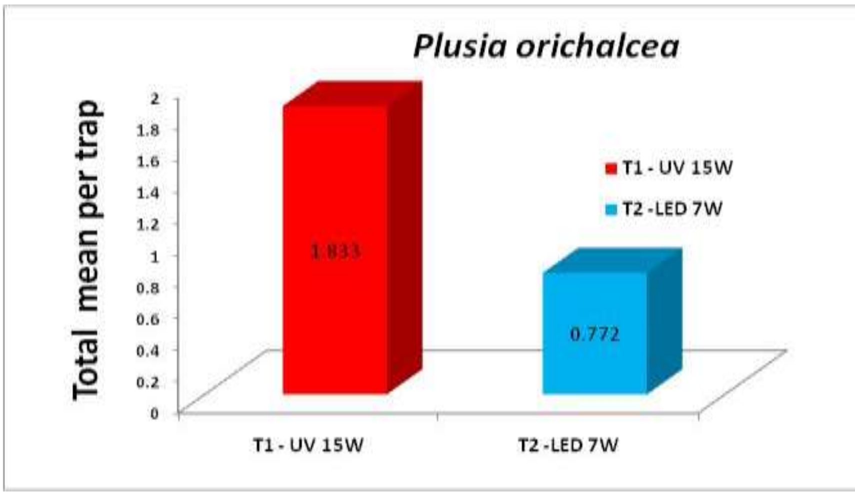

Fig. 5. Response of cabbage semilooper (*Plusia orichalcea*)
**Significant at 5% and 1%*

- The calculated t-value (5.557) exceeds the tabulated t-value (10df, 2.227) at the 5% significance level. Consequently, the null hypothesis is rejected, signifying a significant difference between the means of SMV-4 and SOLAR LED.
- Numerically, the trap catch was higher in SMV-4 compared to SOLAR LED. This numerical difference further supports the conclusion that SMV-4 had a higher response in attracting insect pest species compared to SOLAR LED.
- The calculated t-value (3.212) surpasses the tabulated t-value (7df, 2.364) at the 5% significance level. As a result, the null hypothesis is rejected, indicating a significant difference between the means of SMV-4 and SOLAR LED. Numerically, the trap catch was higher in SMV-4 compared to SOLAR LED. This numerical difference supports the conclusion that SMV-4 had a higher response in attracting insect pest species compared to SOLAR LED.

Table 8. Cutworm {*A. ipsilon* (Hufnagel)}

Statistical Details of light sources T-1=SMV-4 and T-2=SOLAR LED	*Agrotis ipsilon*	
	T-1	**T-2**
Number of Observations	8	8
Total (sum up) mean	1.317	0.735
Variance	0.585	0.148
d.f.	7	
t_{cal}	3.212*	
$t_{tab\ (0.05)}$	2.364	

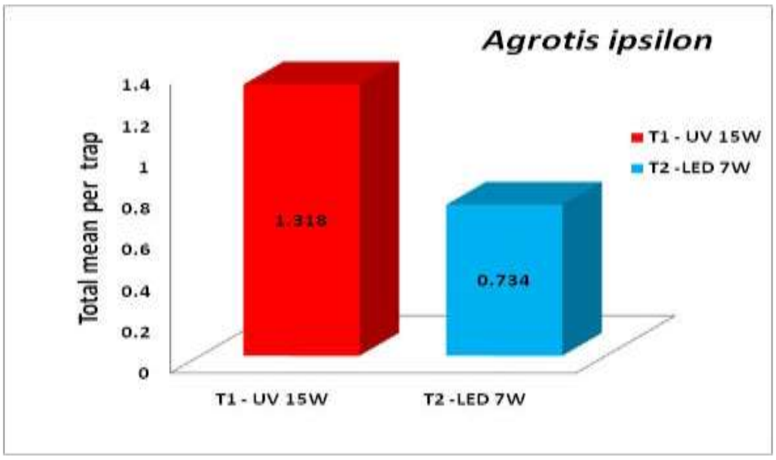

Fig. 6. Cutworm's response
**Significant at 5*

Table 9. Un-identified Lepidopteran moths

Statistical Details of light sources SMV-4 and SOLAR UV	***Unidentified* lepidoptera *moth***	
	T-1 SMV 4 UV 15 watt	**T-2 SOLAR UV LED 7 watt**
Number of Observations	21	21
Total (sum) of mean	4.319	3.92
Variance	5.482	6.798
d.f.	20	
t_{cal}	1.957 NS	
$t_{tab\ (0.05)}$	2.844	
$t_{tab\ (0.01)}$	3.168	

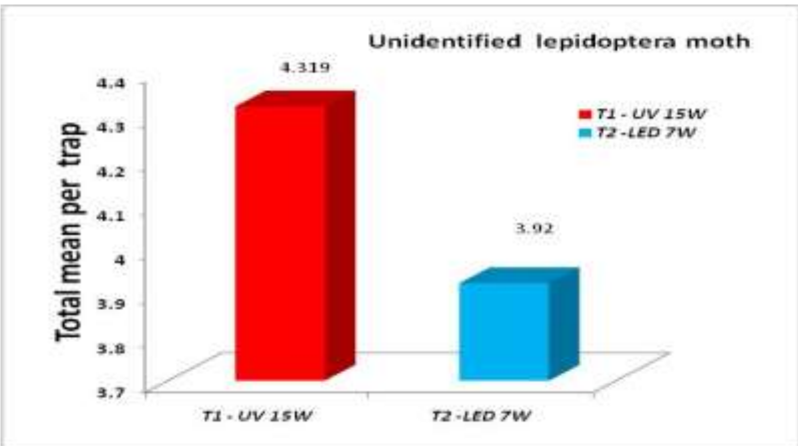

Fig. 7. Response of unidentified lepidoptera moth
NS (non-significant)

1. At the 5% significance level, the calculated t-value (1.957) is lower than the tabulated t-value (20df, 2.844). As a result, the null hypothesis is accepted, indicating that the mean of SMV-4 and SOLAR LED do not significantly differ from each other.
2. In terms of numerical trap catches, SMV-4UV outperformed SOLAR LED. This suggests that SMV-4UV had a higher response compared to SOLAR LED in attracting insect pest species.

The comparison was conducted based on the impact of the two light sources (SMV-4 and SOLAR LED) on the relative response of insect pest species, measured in trap catches per week, utilizing paired t-test statistical analysis.

3.2 A Higher Response was Observed in SMV-4 Compared to SOLAR LED

The species exhibiting a greater response in SMV-4 are as follows:

- *H. armigera (Hubner)
- *G. bimaculatus (De Geer)
- *Unidentified Lepidoptera moth

In the case of these three species, SMV-4 numerically outperformed SOLAR LED in terms of trap catches. However, it is important to note that statistically, the differences in trap catches for these three species were not deemed significant.

3.3 Greater Response in SMV-4 Compared to SOLER LED (Significant)

The species that exhibit a stronger response to SMV-4 UV 15 watts are listed below:

- *G*. orientalis (*Burmeister)
- **C. gangis*(Linnaeus)
- **P. orichalcea*
- **A. ipsilon* (Hufnagel)

In the mentioned four species, SMV-4 exhibited a higher numerical response (based on trap catches) compared to SOLAR LED. Importantly, these differences were statistically significant for all four species.

Consequently, when contrasting UV 15-watt with SOLAR UV LED 7-watt, the UV 15-watt light source appears to be not only more affordable and economical but also more effective as a pest control, survey, and monitoring tool due to its relatively higher response and trap catches.

The findings align with previous light trap studies conducted since 1935 in various parts of the USA and other countries, emphasizing the significance of ultraviolet light, particularly the 15-watt black light (UV) lamp (18" tube), as a preferred light source for use in light traps for surveys and pest control.

In a study conducted by Band et al. [6] on the effectiveness of different light sources in light traps against insect pests of Kharif crops, ultraviolet 16-watt (8+8 watt) outperformed the mercury lamp 160-watt based on comparison studies of trap catches for several species.

In a study conducted by Shrikant et al. [7], a comparison between a 125 watt mercury lamp and a 15 watt UV tube in a light trap within the paddy ecosystem revealed varying responses among species. UV 15 watts showed a greater response in certain species compared to MV 125 watts, while in other species, MV demonstrated a higher response. The study suggested that ultraviolet light sources with a 15-watt output can serve as an effective substitute for MV 125-watt lamps.

Vaishampayan and Verma [8] conducted paired tests in the field between 1977 and 1978 to assess the effectiveness of different light sources in attracting night-flying adults of Heliothisarmigera (Hubner), Spodopteralitura (Boisd), and Agrotisipsilon. The results indicated that UV light sources followed by mercury vapor were the most effective attractants.

Dalvaniya [9] investigated the response of white grubs to different colored light sources. The study revealed that the majority of insects (42.1%) were attracted to black light (UV). In both studies conducted at different locations, white light emerged as the next attractant source (22.4%), followed by blue light (18%).

In the study by Sermsri Nichanant and Chonmapat Torasa [10], they proposed a Solar Energy-Based Insect Pests Trap equipped with an automatic control system. This system was designed to attract insect pests in the absence of sunlight and automatically cease its operation when exposed to sunlight. The results of the system installation test demonstrated that this innovative trap effectively attracted various types of insect pests found in vegetable and coconut plantations, including Brotispa, Elephus beetles, Aphis, and others.

4. CONCLUSION

In conclusion, our study underscores the superior performance of SMV-4 UV as a light source in insect pest survey and management light traps, attributed to its higher response time. The UV light emerges as a more cost-effective and practical option in comparison to the SOLAR LED light source.

Building on earlier research findings, our investigations advocate for the UV 15 watt (18" tube length) light source as the optimal choice for operating a light trap. The UV LED 7 watt proves to be a considerably more affordable and economical alternative, especially when considering the total wattage of consumption—UV 15 watt (electric powered) versus UV LED 7 watt (solar powered). For those aiming to operate a light trap as a pest control device, the solar light source (7-watt LED UV) stands out as a highly viable substitute for the 15-watt option. However, it is essential to note that, despite its effectiveness, the solar-powered light trap is notably more expensive when comparing the prices of the two devices.

CONFERENCE DISCLAIMER

Some part of this manuscript was previously presented and published in the conference: 6th International Conference on Strategies and Challenges in Agricultural and Life Science for Food Security and Sustainable Environment (SCALFE-2023) dated April 28-30, 2023 in Himachal Pradesh University, Summer Hill, Shimla, HP, India, Web Link of the proceeding: https://www.shobhituniversity.ac.in/pdf/Souvenir-Abstract%20Book-Shimla-HPU-SCALFE-2023.pdf

ACKNOWLEDGEMENT

We extend our sincere gratitude to Dr. S.M. Vaishampayan, retired professor at JNKVV Jabalpur, for his invaluable guidance and generous provision of the SMV 4 light trap model, which played a crucial role in conducting our experimental trials.We would also like to express our heartfelt thanks to Dr. A. Shukla, Director of Instruction, and Dr. A.K. Bhowmick, Professor & Head of the Department of Entomology at JNKVV, Jabalpur. Their unwavering guidance, continuous encouragement, and indispensable support throughout the course of this investigation were instrumental in the successful completion of our research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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