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

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 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.

Key words: 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 (Vaishampayan 2007). Since many insects are innately positively phototrophic, using light traps to catch insects produces useful faunistic evidence. 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 (2014). 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. Material 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 KrishiVishwaVidyalaya 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 (2016).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 (Helicoverpaarmigera), Black cutworm (*Agrotisipsilon*), Tiger moth (*Creatonotosgangis*), Field cricket (*Gryllusbimaculatus*), Mole cricket (*Gryllotalpaorientalis*), Cabbage semilooper (*Plusiaorichalcea*), 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 No.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 No.1:

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

Table No. 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 3rdwk	00	00	00	0	31.75	6.24	00	00
2	Oct 4thwk	00	00	00	0	27.66	4.43	00	00
3	Nov 1stwk	00	00	00	0	11.71	1.27	00	00
4	Nov 1stwk	00	00	00	0	7.28	1.56	00	00
5	Nov 3rdwk	00	00	00	0	12	3.36	00	00
6	Nov 4thwk	00	00	00	0	8.57	4.74	00	00
7	Dec 1stwk	00	00	00	0	8.42	5.13	00	00
8	Dec 2ndwk	00	00	00	0	4.42	3.72	00	00
9	Dec 3rdwk	00	00	00	0	3	2.874	00	00
10	Dec 4thwk	0.251	.143	00	0	1.125	1.72	00	00
11	Jan 1stwk	0.143	0.141	00	0	1.56	1.142	1.141	0.428
12	Jan 2ndwk	00	00	00	0	1.56	1.143	1.143	0.142
13	Jan 3rdwk	00	00	00	0	2.374	1.0	1.856	0.857
14	Jan 4thwk	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 2ndwk	0.284	0.143	1.0	0.573	1.56	1.0	0.572	0.285
17	Feb 3rdwk	0.285	.284	0.714	0.711	0.43	1.27	1.856	0.428
18	Feb 4thwk	0.874	.427	1.141	0.871	3.84	2.0	3.624	2.285
19	Mar 1stwk	1.140	0.286	2.427	1.427	10.72	2.72	3.856	1.428
20	Mar 2ndwk	1.0	0.715	2.281	0.713	11.56	2.27	2.715	1.428
21	Mar 3rdwk	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**
i.	Oct 3rdwk	22.4	3.124	1.2	00	8.751	3.124
ii.	Oct 4thwk	12.624	2.27	00	0.21	9.331	2.881
iii.	Nov 1stwk	5.281	1.1	1.1	0.570	2.850	1.713
iv.	Nov 2ndwk	3.56	0.56	2.856	1.0	1.710	0.571
v.	Nov 3rdwk	1.0	2.143	4.124	3.141	4.421	1.856
vi.	Nov 4thwk	1.13	0.856	2.74	3.67	7.250	3.251
vii.	Dec 1stwk	0.84	0.858	2.427	2.0	9.424	5.001
viii.	Dec 2ndwk	1.0	0.287	2.713	1.84	6.284	3.143
ix.	Dec 3rdwk	00	00	1.715	1.427	4.0	5.002
x.	Dec 4thwk	0.13	0.572	0.856	0.624	4.421	2.874
xi.	Jan 1stwk	1.0	0.421	0.714	0.429	2.852	2.572
xii.	Jan 2ndwk	0.427	1.0	0.570	0.141	1.423	1.141
xiii.	Jan 3rdwk	0.286	0.570	0.427	0.76	2.251	1.284
xiv.	Jan 4thwk	1.284	0.74	0.876	1.0	5.770	5.124
xv.	Feb 1stwk	0.427	0.42	1.0	0.143	6.0	1.421
xvi.	Feb 2ndwk	1.0	0.715	0.143	0.141	4.421	1.284
xvii.	Feb 3rdwk	0.570	0.284	0.572	0.250	4.855	2.001
xviii.	Feb 4thwk	0.284	0.286	0.713	0.572	7.284	6.374

xix.	Mar 1stwk	2.0	0.284	1.427	0.713	11.141	6.856
xx.	Mar 2ndwk	2.284	0.572	2.01	1.284	9.001	6.711
xxi.	Mar 3rdwk	2.286	1.429	1.570	0.427	12.001	5.831

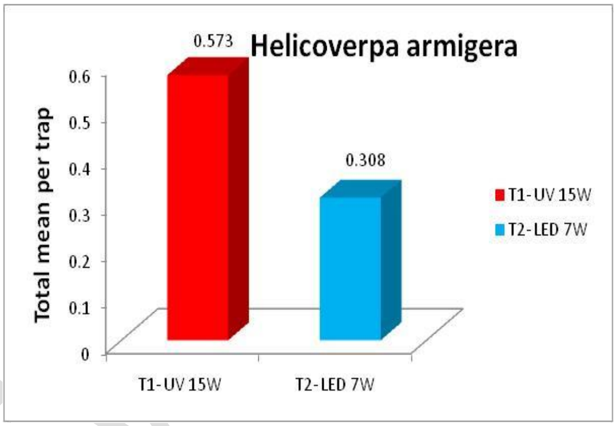
3.1. Comparative response according to species given below-

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

Statistical Details for Light Sources: T-1: SMV-4 UV T-2: SOLAR UV	*Helicoverpaarmigera*	
	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	

Figure : Response of Gram pod borer

*(Significant at 5%)



- t 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.

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

Statistical Details of light sources T-1=SMV- 4 UV &T-2=SOLAR UV	***G. bimaculatus***	
	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	

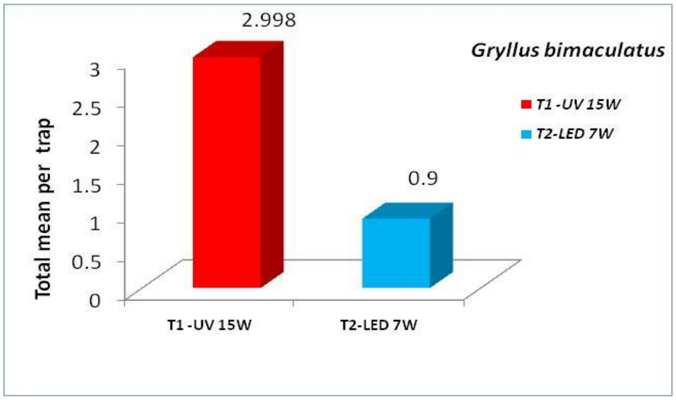


Figure :Response of field cricket (*Gryllusbimaculatus)*

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.

3. Mole cricket *G.orientalis*(Burmeister)

Statistical Details of light sources T-1=SMV-4 and T-2=SOLAR UV	***Gryllotalpaorientalis***	
	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	
$\mathbf{T}_{\textbf{caculatedl}}$	3.476*	
$\mathbf{T}_{\textbf{tabulated at (0.05)}}$	2.092	
$\mathbf{T}_{\textbf{tabulated at (0.01)}}$	2.862	

Significant at 5% and 1%

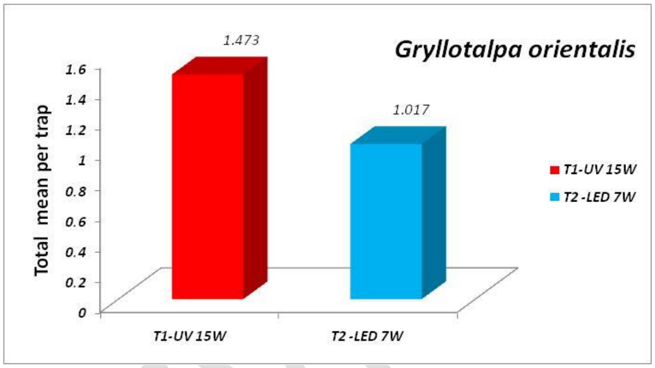


Figure: Response of mole cricket (*Gryllotalpaorientalis)*

- 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.

4. Tiger moth's*C.gangis*(Linnaeus)

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

*Significant at 5% and 1% level

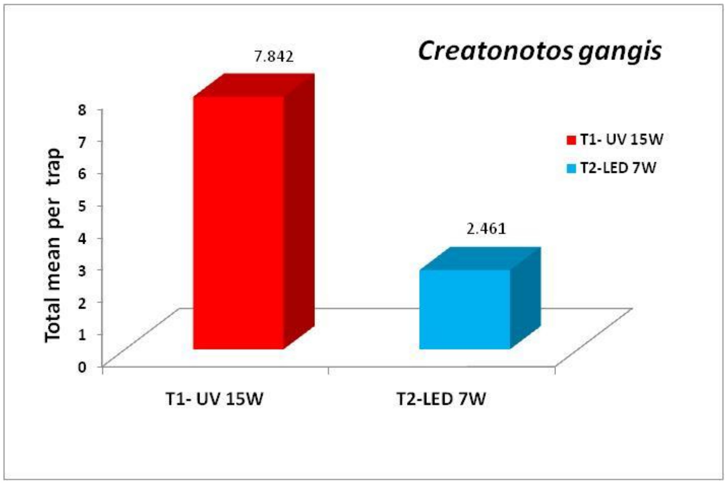


Figure: Graphical response of Tiger moth

The calculated t-value (3.361) is greater than both the tabulated values (20df, 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.

5. Cabbage semilooper*P.orichalcea*

Statistical Details of light sources T-1=SMV-4 and T-2=SOLAR LED	***Plusiaorichalcea***	
	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	

*Significant at 5% and 1%

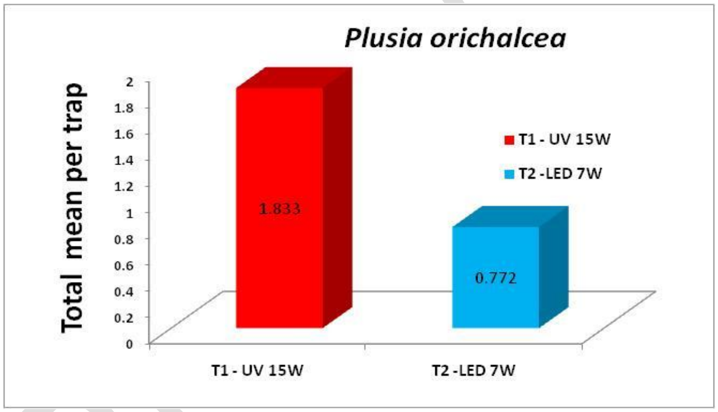


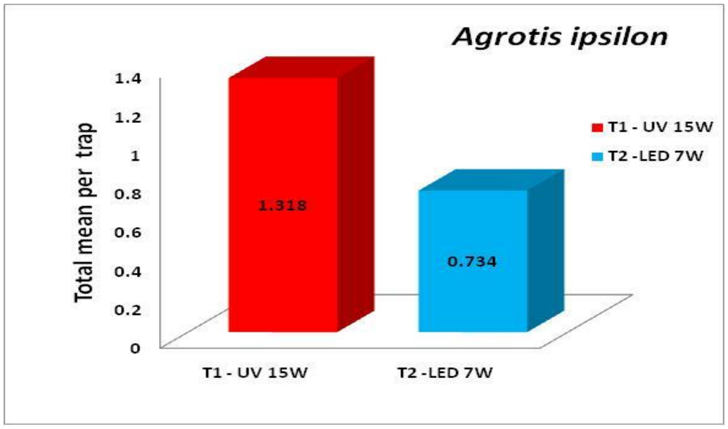
Figure :Response of cabbage semilooper (*Plusiaorichalcea)*

- 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.

6. Cutworm {*A. ipsilon* (Hufnagel)}

Statistical Details of light sources T-1=SMV-4 and T-2=SOLAR LED	***Agrotisipsilon***	
	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	



***Significant at 5** **Figure**

:Cutworm'sResponse

- 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.

7. Un-identified Lepidopteran moths

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

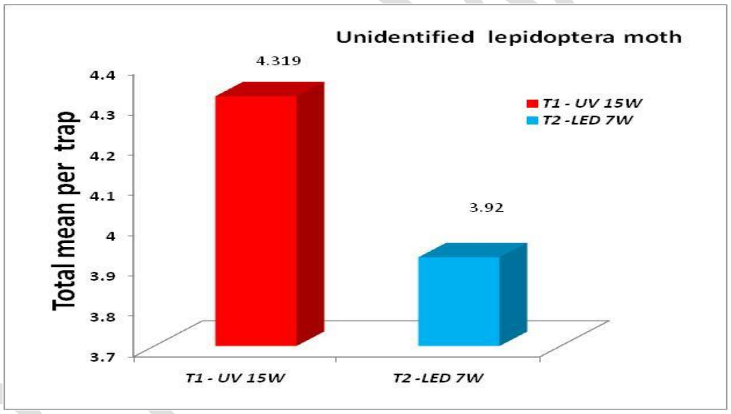


Figure: Response of Unidentified Lepidoptera moth

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. (2019) 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. (2019a), 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 (1983) 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 (2010) 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 SermsriNichanant and ChonmapatTorasa (2015), 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.

6. Reference

1. Band, S. S., Vaishampayan, Sanjay, ShrikantPatidar, and NavyaMatcha. (2019a). Comparative efficiency of ultra violet black light lamp and mercury vapour lamp as light sources in light trap against major insect pest of Kharif crops. *Journal of Entomology and Zoology Studies, 7*(1), 532-537.

2. Dadmal, S. M., &Khadakkar, S. (2014). Insect faunal diversity collected through light trap at Akola vicinity of Maharashtra with reference to Scarabaeidae of Coleoptera. *Journal of Entomology and Zoology Studies, 2*(3), 44-48.

3. Dalvaniya, D. K. (2010). *Ph.D. thesis submitted to C.P. College of Agriculture, S.D.A.U. India.*

4. Sermsri, Nichanant, &Torasa, Chonmapat. (2015). Solar energy-based insect pest trap. *Procedia - Social and Behavioral Sciences, 197*, 2548–2553. 7th World Conference on Educational Sciences, (WCES-2015), 05-07 February 2015, Novotel Athens Convention Center, Athens, Greece.

5. Shrikant, Sanjay Vaishampayan, & Band, S. S. (2019a). Comparative efficiency of 125 watt mercury lamp and 15 watt UV (Black light) tube against the major insect pest in paddy ecosystem. *Journal of Entomology and Zoology Studies, 7*(5), 1163-1167.

6. Vaishampayan, S. M., &Vaishampayan. (2016). *Light trap: an ecofriendly IPM tool*. New Delhi: Daya publishing House/Astral International Pvt.Ltd.

7. Vaishampayan, S. M. (2007). Utility of light trap in integrated pest management. In P.C. Jain & M. C. Bhargava (Eds.), *Entomology: Novel approaches* (pp. 193-210). New Delhi: New India Publishing Agency.

8. Verma, R., &Vaishampayan, S. M. (1983). Seasonal activity of major insect pests on light trap equipped with mercury vapour lamp at Jabalpur (pp. 173-180).