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Research Article

Optimizing light trap height and installation timing for effective monitoring of insect pests in rice field

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Abstract

The use of chemical pesticides in the agriculture are widely used but have harmful environmental and health impacts. However, it is hazardous to human health with the environment and is often used more than the prescribed amount. The solar light trap is a popular renewable and environment-friendly device. Although light traps are effective, their ideal height and deployment timing in rice fields remain not clear. This study was undertaken with a specific objective of selecting the appropriate installation height, and lighting time period of the solar light trap where LED bulbs were used in capturing insect pests and beneficial insects in rice fields in BRRI regional station Rajshahi, Bangladesh. The findings demonstrated significant variations in pest capture efficiency across different lighting durations. Early-night trapping recorded the highest captures of green leafhoppers (96.67 individuals) and rice bugs (39.67 individuals), while late-night trapping was most effective for stem borers (577.00 individuals) and rice leaf folders (35.33 individuals). The height of trap installation also influenced pest captures, with canopy-level traps (1.0 m) proving most effective for pests such as green leafhoppers and caseworms. Beneficial insects, including carabid beetles and earwigs, similarly exhibited a preference for traps set at higher positions. These results underscore the significance of optimizing operational parameters for light traps to improve their effectiveness in pest management. By minimizing dependence on chemical pesticides, the use of canopy-level (1.0 m) light traps supports sustainable rice cultivation and provides valuable guidance for integrating them into IPM programs tailored to specific agro-ecological conditions.

Keywords: Integrated Pest Management (IPM), insect monitoring, natural enemies, solar light trap, sustainable insect management

Introduction

Download citation Rice (*Oryza sativa* L.) is a staple crop that underpins the livelihoods of billions globally and plays a pivotal role in ensuring food security. Approximately half of the world's population relies on rice as their primary food source (Seck *et al.*, 2012; Sangeetha *et al.*, 2020). However, rice production is

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frequently threatened by insect pests, which cause substantial yield losses each year in both field and storage condition (Roy *et al*., 2025). Among the most damaging pests in rice cultivation are the brown planthopper (*Nilaparvata lugens* Stål), stem borers (*Scirpophaga incertula* Walker), rice leaf folder (*Cnaphalocrocis medinalis* Guenée), green leafhopper (*Nephotettix virescens* Distant), rice hispa (*Dicladispa armigera* Oliver), gall midge (*Orseolia oryzae*, Wood-mason), and white-backed planthopper (*Sogatella furcifera* Horváth) and various species of moths and beetles (Roy *et al*., 2024). Globally, around 800 insect species are associated with the rice ecosystem (Yadav *et al*., 2018), with 267 insect pest species, 185 parasitoids, and 192 predators documented in Bangladesh alone. Of these, 20 to 33 species are considered major pests that can inflict significant yield losses when infestations are severe (Ali *et al*., 2020; Roy *et al*., 2024). In Bangladesh, the excessive use of chemical pesticides has become a common practice among farmers aiming to mitigate crop losses from pest attacks. Over recent decades, there has been a dramatic increase in pesticide application. Shammi *et al.* (2020) reported that approximately 77% of Bangladeshi farmers used pesticides during a single cropping season, with 37% applying them once, 31% applying them twice, and the remainder using them three to five times. This overreliance on chemical pesticides not only poses severe health risks to farmers handling these substances (Salazar and Rand, 2020) but also leads to inefficiencies and increased production costs due to excessive and improper pesticide use. During the years 2011 and 2012, approximately 20,000 to 24,000 metric tons of formulated insecticides were utilized in Bangladesh, with a significant proportion exceeding fifty percent allocated specifically for the management of insect pests affecting rice crops (BCPA, 2013). Furthermore, the excessive application of pesticides has the potential to induce the emergence of pesticide resistance within insect populations, thereby rendering pest management increasingly challenging. So, an environment friendly pest management strategies is needed which is safe for the animal, less hazardous and alternative of pesticide.

Environmentally friendly pest management strategies, such as light traps (usually known for insect monitoring), offer a promising alternative to chemical pesticides. Light traps are devices that exploit phototaxis (light attraction) and chemotaxis (energy attraction) to lure pests into contact with a high-voltage power grid, killing or collecting them in a receptacle (El-Shafie, 2020). Widely used in agriculture for pest monitoring and control, most conventional light traps are electrically powered and stationary, limiting their applicability in areas lacking reliable electricity (Erler and Bayram, 2022). Light trap are considered as an effective and economically viable approach for the surveillance and mitigation of pest populations and can provide significant insights for scholarly research and pest management initiatives (Young, 2005). Light traps are capable of attracting a diverse array of insects, encompassing moths, beetles, and other nocturnal species (Fayle *et al*., 2007). The efficacy of light traps can be influenced by a multitude of variables including the specific type of trap employed, the time of day or night, the season, and the length of the sampling period (Beck & Chey, 2007). Solar-powered light traps, however, provide a practical solution in remote regions. These portable devices can be installed easily in fields using bamboo poles or concrete columns available locally (Meshram *et al*., 2018). Solar traps address the electricity constraints of conventional systems and offer greater flexibility in pest management. Light traps are invaluable tools for agricultural pest management, attracting nocturnal pests and supplying critical data on pest population dynamics, species diversity, and activity peaks. By enabling precise and timely pest control measures, light traps reduce both crop damage and reliance on chemical pesticides. However, the effectiveness of light traps depends significantly on operational parameters, including installation height and the timing of deployment (Rabbani *et al*., 2022). Optimizing these factors is crucial to enhancing their efficiency in pest management programs. Despite the known effectiveness of light traps, the optimal height and timing for their deployment in rice fields have not been thoroughly studied.

This study investigates the influence of light trap height and installation timing on the monitoring efficiency of insect pests in rice fields. By determining optimal configurations, this research aims to improve the accuracy and utility of light traps for pest monitoring. The findings will offer actionable recommendations for farmers and agricultural researchers, supporting integrated pest management (IPM) practices that promote sustainable rice cultivation.

Materials and Methods

Experimental site

The investigation was conducted at the at the experimental farm of the regional station Rajshahi (24°22′ N latitude, 88°40′ E longitude, 21 masl) of the Bangladesh Rice Research Institute (BRRI), Bangladesh (Figure 1). Geographically, the site is situated in the High Ganges River Floodplain agro-ecological zone (AEZ-11). The soil is mildly alkaline, with a pH of 8.1, and has a silty loam texture (BARC, 2012).

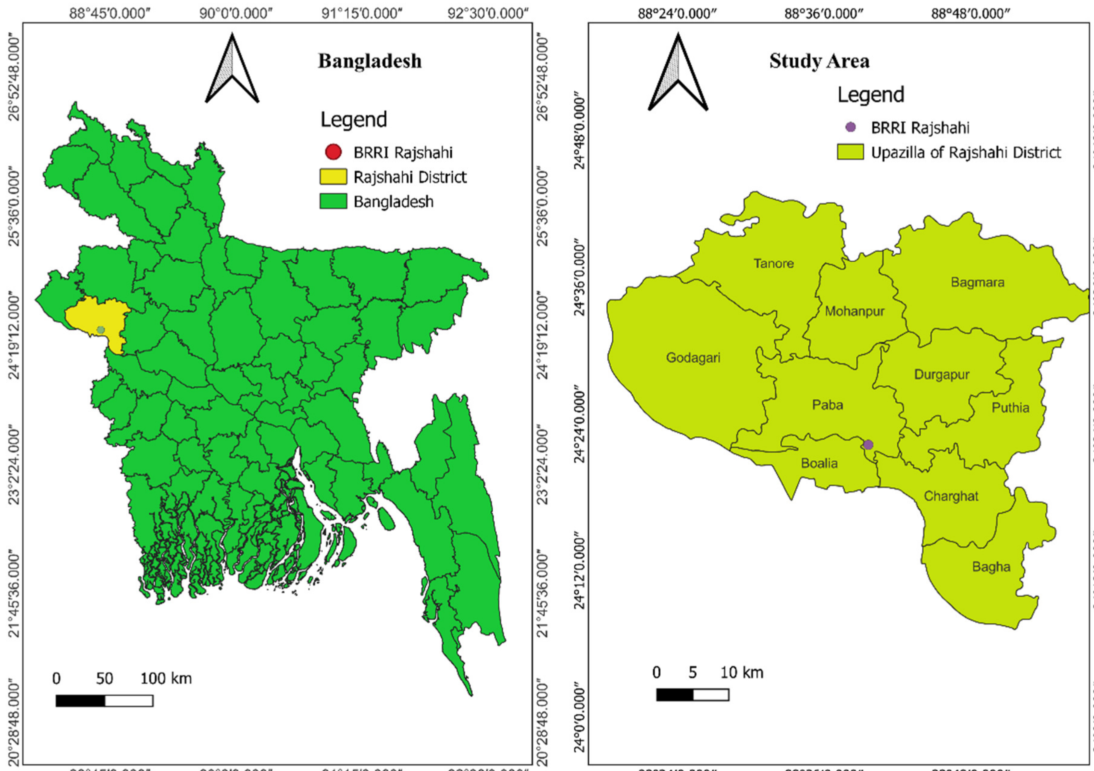

Figure 1. Study area map

Weather is low-temperature and drought-prone upland ecosystems (average annual rainfall, 1400 mm) and for developing agronomically suitable and economically profitable rice-based cropping systems for farmers of the Barind Tract of northern Bangladesh with strongly alkaline, low-fertility soils. The experiment was conducted during the T. Aman season, 2022. The weather data of experimental site during T. Aman season, 2022 was recorded and presented in Table 1.

Table 1. Weather information during the experimental period from July to November 2022

Year	Month	Tmax °C	Tmin °C	Tmean °C	RH %	Total rainfall (mm)
2022	June	34.96	26.27	30.62	83.00	70.00
2022	July	36.41	27.05	31.73	80.19	60.00
2022	August	34.71	26.69	30.70	83.65	263.00
2022	September	34.07	26.13	30.10	87.27	329.00
2022	October	33.06	23.78	28.42	81.97	57.00
2022	November	30.33	17.00	23.67	76.57	0.00

Trap setting heights

Three different light-setting heights were evaluated. Heights were below the plant canopy (0.50 m from the ground), at the plant canopy (1.00 m from the ground), and above the plant canopy (1.50 m from the plant canopy) based on the rice plant growing stage and time of maximum infestation of insects. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. A solar light trap was set up for lighting and it was put on from dusk to dawn, then the next morning, dead/killed insect populations were collected and preserved in refrigerator. After-then collected insects was counted and identified and recorded.

Lighting period of trapping

Three different lighting periods were evaluated. These are early night (7 pm to 9 pm), mid night (9 pm to 11 pm) and late night (11 pm to 6 am) due to the peak activity period of different insects of rice. All the light traps were installed at the rice field. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The trapped insect pests and natural enemies were collected every day and their number was counted and recorded. Light traps were operated for 13 days.

Statistical analysis

The trap catches were monitored daily, and the captured species, along with their respective numbers, were identified and recorded. Data collection accounted for the timing of each trap setup. The recorded information was analyzed using analysis of variance (ANOVA) to identify patterns and differences. Statistical analyses were conducted in R software (version 2024.04.1) utilizing the "doebioresearch" package for ANOVA execution. To determine differences among treatment means, the Least Significant Difference (LSD) test was employed, maintaining a significance level of 5%.

Results

The highest number of Green Leafhopper (GLH) catches was recorded during the early-night period (96.67 individuals), followed by mid-night (68.33 individuals) and late-night (49.33 individuals) (Table 2). The early-night and mid-night periods had similar catch rates of White Leafhopper (WLH) with 139.67 and 144.00 individuals, respectively, both of which were significantly higher than the late-night period (106.67 individuals). Late-night trapping yielded the highest number of Stem Borer (SB) catches (577.00 individuals), significantly exceeding those of the early-night (302.67 individuals) and mid-night periods (358.33 individuals). The late-night period resulted in the highest capture of Rice Leaf Folder (RLF) (35.33 individuals), which was significantly greater than the early-night (21.00 individuals) and mid-night periods (22.00 individuals) (Table 2).

Table 2. The influence of lighting periods on capturing various insect pests in light traps in rice fields

Lighting period	GLH	WLH	SB	RLF	CW	RB
Early night (7-9 pm)	96.67a	139.67b	302.67b	21.00b	51.67c	39.67a
Mid night (9-11 pm)	68.33b	144.00a	358.33b	22.00b	72.67a	33.00b
Late night (11 pm - 6 am)	49.33c	106.67c	577.00a	35.33a	63.33c	28.33c
Levels of significance	***	**	**	**	***	**
LSD	11.93	14.11	114.03	6.46	6.32	4.26
CV%	8.36	5.42	13.83	12.38	5.06	6.34

Note: ^{ns}: Non-significant; *: 5% level of significance; **: 1% level of significance; ***: less than 1% level of significance; LSD: least significant difference; CV%: coefficient of variation; GLH: green leaf hopper; WLH: white leaf hopper; SB: stem borer; RLF: rice leaf folder; CW: case worm; RB: rice bug

The mid-night period had the highest Case Worm (CW) catches (72.67 individuals), followed by late-night (63.33 individuals) and early-night periods (51.67 individuals). Early-night trapping recorded the highest number of Rice Bug (RB) catches (39.67 individuals), which was significantly higher than mid-night (33.00 individuals) and late-night (28.33 individuals). Significant differences were observed across lighting periods for all pest types, highlighting the importance of optimizing light trap timing to enhance pest monitoring. The low coefficients of variation (5.06% to 13.83%) indicate high reliability and consistency in the results (Table 2). These findings underscore the impact of lighting period on the effectiveness of light traps for capturing different insect pests in rice fields.

In Figure 2 each labeled with a variable name and grouped by three treatment categories: early night (T1), mid night (T2) and late night (T3). For LBB T1 has the highest median value, followed by T2, with T3 having the lowest. There is variability within the treatments, with T3 showing a larger spread. In case of STPD T2 has the highest median, while T1 and T3 are lower and close in value. T2 has a narrow range of variability, whereas T1 and T3 show wider distributions. Damsel Fly shows the highest values in T1, followed by T2, with T3 having the lowest. Variability is visible, particularly for T1 and T2. As for SPD, T3 has the highest median value, while T1 and T2 are lower. T3 shows more variability compared to T1 and T2. EW has the highest median value in T1, with T2 and T3 having lower but similar medians. Variability is minimal across treatments, with tight interquartile ranges.

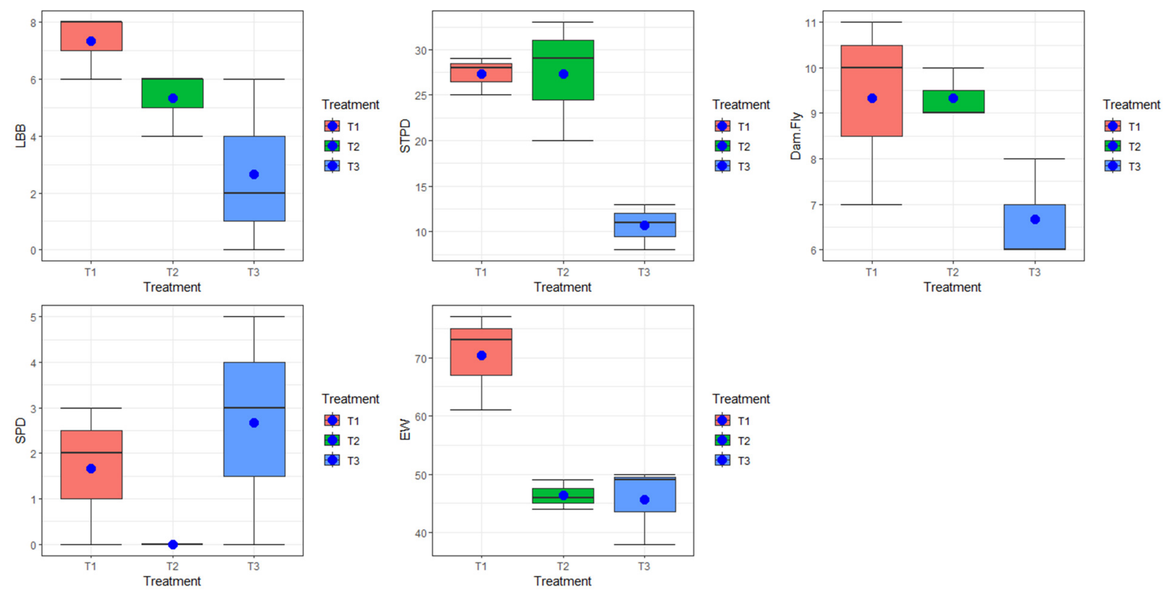

Figure 1. The influence of lighting periods on capturing various beneficial insects in light traps in rice fields
Note: LBB: ladybird beetle; STPD**:** staphylinid beetle; DamFly: damsel fly; SPD: spider; EW: earwig; T_1: early night (7.00 pm-9.00 pm); T_2: mid night (9.00 pm-11.00 pm); T_3: late night (11.00 pm-6.00 am)

The Table 3 presents data on the effect of trap setting heights on the mean population counts of six insect pests: Green Leafhopper (GLH), White Leafhopper (WLH), Stem Borer (SB), Rice Leaf Folder (RLF), Caseworm (CW), and Rice Bug (RB). The highest mean count (594.00) of GLH was observed when traps were set at plant canopy height (1.00 m), which was significantly higher ($p < 0.01$) than other heights. On the other hand below the plant canopy (0.50 m) recorded the lowest mean (498.50), significantly lower than the other two heights. In case of WLH, the highest mean count (680.83) was recorded above the plant canopy (1.50 m), followed by plant canopy height (616.00). The above plant canopy height (1.50 m) had the highest mean count (687.50) for SB, and below plant canopy height had the lowest mean count (474.50). The highest mean count (24.00) of RLF was observed at plant canopy height (1.00 m), and the lowest mean count (15.50) was recorded above the plant canopy. The above plant canopy height recorded the highest mean count (64.00) for CW, 135.00 for RB and below plant canopy height had the lowest mean count (49.50) for CW.

Below plant canopy height recorded the lowest mean count (93.00) for RB. Significant differences were observed for GLH, SB, RLF, CW, and RB at varying levels. WLH showed no significant difference across heights. Among the values reflect the relative variability in the data, with RLF and RB showing higher variability.

Table 3. The influence of trap setting height on capturing various insect pests in light traps in rice fields

Trap Setting Heights	GLH	WLH	SB	RLF	CW	RB
Below plant canopy (0.5 m high from the ground)	498.5b	552.5	474.5c	19.0b	49.5c	93.0b
At plant canopy (1.0 m high from the ground)	594.0a	616.0	599.0b	24.0a	57.0b	122.0ab
Above plant canopy (1.5 m high from the ground)	585.5a	680.8	687.5a	15.5c	64.0a	135.0a
Level of Significance	**	ns	***	**	**	*
LSD	43.44	-	62.26	3.13	6.85	31.67
CV%	3.89	8.90	5.31	8.50	6.03	13.59

Note: ns: Non-significant; *:5% level of significance; **:1% level of significance; ***: less than 1% level of significance; Least significant difference; CV%: coefficient of variation; GLH: green leaf hopper; WLH: white leaf hopper; SB: stem borer; RLF: rice leaf folder; CW: case worm; RB: rice bug

The Table 4 presents the effect of trap setting heights on the mean population counts of six insect pests and natural enemies: Carabid Beetle (CBB), Staphylinid (StPD), Earwig, Ladybird Beetle (LBB), Damsel fly, and Spider.

Table 4. The influence of trap setting height on capturing various beneficial insects in light traps in rice fields

Trap Setting Heights	CBB	StPD	Ear Wig	LBB	Dam.Fly	Spider
Below plant canopy (0.5 m high from the ground)	370.5b	67.0	119.0c	11.5a	12.5	1.0
At plant canopy (1.0 m high from the ground)	537.5a	72.5	149.5b	13.0a	22.0	0.0
Above plant canopy (1.5 m high from the ground)	542.0a	72.0	154.0a	6.0b	10.5	0.0
Level of Significance	**	ns	***	**	ns	ns
LSD	83.12	-	4.35	3.31	-	-
CV%	8.61	6.03	1.55	16.31	39.72	-

Note: ns: Non-significant; **: 1% level of significance; ***: less than 1% level of significance; CBB: carabid beetle; StPD: staphylinid beetle; Dam.Fly: damsel fly; LBB: ladybird beetle; Least significant difference; CV%: coefficient of variation

The highest mean counts of CBB were recorded at plant canopy height (1.0 m) (537.50) and above the plant canopy (1.5 m) (542.00), which were significantly higher ($p< 0.01$) than below plant canopy (370.50). Mean counts ranged from 67.00 to 72.50 across heights of StPD, but there was no significant difference (ns) between the trap heights. In case of Earwig the highest mean count (154.00) was recorded above the plant canopy (1.5 m), followed by plant canopy height (1.0 m) (149.50). On the other hand, the lowest count (119.0) was recorded below the plant canopy (0.5 m), significantly lower ($p< 0.001$) than the other two heights. The highest LBB mean count (13.00) was observed at plant canopy height (1.0 m), which was statistically similar to below the plant canopy (11.50) and the lowest mean count (6.00) was observed above the plant canopy, which was significantly lower ($p < 0.01$) than other heights. Mean counts of Damselfly ranged from 10.50 to 22.00, with the highest count recorded at plant canopy height (1.0 m) (22.00). But no significant differences (ns) were observed across heights. Spider counts were low across all heights, with no significant differences (ns). StPB, Damselfly, and Spider showed no significant differences across heights.

Discussion

The solar light trap proved to be an environmentally friendly tool for monitoring and managing harmful insects in the experimental fields. Alam (2013) utilized light traps as an insect management strategy within rice ecosystems in various districts, including Chittagong, Rajshahi, Gaibandha, Tangail, and Jalukathi. An analysis of pesticide usage costs revealed that fields equipped with solar light traps required a reduced amount of pesticides. Siddiquee *et al.* (2019) noted that pesticide expenses accounted for 12.8–13.6% of the total production costs. By decreasing the frequency of pesticide applications for managing harmful rice pests, solar light traps effectively lowered overall production costs. Rabbani *et al.* (2022) conducted an experiment demonstrating that an increase in light intensity and trap height correlated with a higher number of insects captured. Light traps predominantly attract nocturnal insects due to their affinity for specific light wavelengths at night. Studies by Park and Lee (2017) and Sridhar and Kumaran (2018) revealed that insects exhibit varying levels of attraction to different light wavelengths. Additionally, light traps can attract beneficial insects, such as ladybird beetles, ground beetles, rove beetles, and damselflies, indicating that nocturnal insects can be both beneficial and harmful (Rashid *et al.*, 2022). Similarly, Singh *et al.* (2018) and Kammar *et al.* (2020) reported the capture of both harmful and beneficial insects using light traps. Common pests captured by solar light traps in rice fields include the rice yellow stem borer, rice leaf roller, green leafhopper, brown planthopper, rice bug, rice ear-cutting caterpillar, white-backed planthopper, grasshopper, and rice beetle (Rashid *et al.*, 2022). Meena *et al.* (2018) reported capturing 40 insect species belonging to the order Lepidoptera using light traps in rice fields. Additionally, light traps have shown efficacy in managing pests of other crops. Sridhar and Kumaran (2018) demonstrated their effectiveness in controlling Lepidopteran pests in tomato cultivation. Al Mamun *et al.* (2023) noted fluctuations in light intensity over time when using light traps. Farmers can maximize insect pest capture by setting up light traps at specific times. Green Leafhopper (GLH) and Rice Bug (RB) are most active in the early-night period (7-9 PM), so traps should be deployed during this time to reduce their population. White Leafhopper (WLH) is best controlled during both early-night and mid-night (7-11 PM), as their numbers are significantly higher in these periods. Stem Borer (SB), a major rice pest, is most abundant late at night (11 PM-6 AM). Farmers should keep light traps running overnight to target them effectively. Rice Leaf Folder (RLF) and Case Worm (CW) are also more active in the late-night and mid-night periods, respectively, making extended trap use necessary. At 6:00 PM, with residual sunlight, light intensity was low (28 lux). At 7:00 PM, light intensity increased sharply due to the absence of sunlight and reliance on the LED light source. The intensity peaked at 8:00 PM (245 lux) before gradually declining, reaching 85 lux by 11:00 PM due to battery depletion. During the time intervals between 6:00–7:00 PM, 7:00–8:00 PM, 8:00–9:00 PM, 9:00–10:00 PM, and 10:00–11:00 PM, the majority of captured insects belonged to the orders Coleoptera and Hemiptera, with Hymenoptera representing the lowest proportion (Mamun *et al.*, 2010; Singh *et al.*, 2018). Kabir *et al.* (2023) reported that 69.28% of insect pests were caught during the first four hours after dusk, with the capture rate decreasing during the initial three hours (5:20–8:20 PM). Similarly, the number of natural enemies caught declined during the first four hours (5:20–9:20 PM). Consequently, the period from twilight to the first three to four hours post-dusk is critical for maximizing pest capture. Furthermore, it was observed that insect pests were caught at a rate more than 8.5 times higher than that of natural enemies during the time interval from 5:20–9:20 PM. The overall percentage of insect pests captured (89.65%) was significantly higher compared to natural enemies (10.34%). Light traps are therefore a relatively safe method for preserving beneficial natural enemies in rice fields at the farmer level while effectively managing insect pests.

An evaluation of the performance of the solar light trap was conducted by Rabbani *et al.* (2022) where the highest number of harmful insects was caught at 1.5 m height for the white color bulb, and the lowest number of harmful insects was 143 for blue color bulb at 1 m height. The maximum number of beneficial insects were counted at 1.5 m height, and the minimum number was trapped at 1.0 m height. The most efficient height of the bulb was 1.5 m from the ground. Proper use of light traps at optimal heights and times can reduce the need for chemical pesticides, lowering costs and minimizing environmental damage. By targeting peak pest activity times, farmers can effectively reduce insect populations without excessive pesticide application. Reducing pesticide use helps prevent resistance buildup in pests, ensuring long-term effectiveness of pest control methods. So, the use of light trap might be beneficial as a part of integrated pest management practices, by monitoring insect infestation as well as management tools when peak infestation of insects occurred.

Conclusions

This study highlights the potential of solar light traps as a sustainable, cost-effective tool for integrated pest management (IPM) in rice cultivation. Key findings show that trap height and lighting periods significantly affect the capture efficiency of pests and beneficial insects. The early-night period (7–9 PM) was most effective for capturing Green and White Leafhoppers and Rice Bugs, while late-night hours (11 PM–6 AM) were optimal for Stem Borers and Rice Leaf Folders. Traps installed at canopy level (1.00 m) captured the highest number of both pests and beneficial insects. By reducing pesticide use, solar light traps lower costs and mitigate environmental risks, supporting sustainable rice production. Farmers can easily installed the solar light trap, can monitor of insects infestation and can manage them by using light trap. Install light traps at the plant canopy level (1.0 m) for the best balance of pest management and beneficial insect conservation. Monitoring beneficial insect populations and adjusting trap use to avoid unnecessary harm to natural pest predators. Light trapping should be integrated with other pest management strategies such as crop rotation, natural predators, and biological control to ensure sustainable pest management. Further research on light intensity, wavelengths, and placement can optimize their effectiveness across different regions. These findings advocate for integrating solar light traps into IPM strategies to boost yields and promote eco-friendly farming practices.

Authors' Contributions

Conceptualization–AAU, ASI, TKR and SA; Experiments and statistical analysis–AAU, TKR, SA; Writing-original draft preparation–AAU, TKR, SA, AA, MHH, JYJ; Writing-review and editing–AAU, TKR, SA, AA, MHH, JYJ; Supervision–AAU, AA.

All authors read and approved the final manuscript.

Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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References

Al Mamun MR, Keya AC, Alim MS, Hossen MA, Mondal MF, Soeb MJA (2023). Potentiality assessment of solar based LED light trap as pest management tool in tea (*Camellia sinensis* L.). Smart Agricultural Technology 5:100304. *https://doi.org/10.1016/j.atech.2023.100304*

Alam MZ (2013). Survey and assessment of insect management technologies and environmental impact on rice ecosystem of Bangladesh. International Journal of Applied Research and Studies 2(4):1-16.

Ali MP, Kabir MM, Haque SS, Qin X, Nasrin S, Landis D, Holmquist B, Ahmed N (2020). Farmer's behavior in pesticide use: Insights study from smallholder and intensive agricultural farms in Bangladesh. Science of the Total Environment 1747:141160. *https://doi.org/10.1016/j.scitotenv.2020.141160*

BARC (2012). BARC – Bangladesh Agricultural Research Council. Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council. Farm Gate, Dhaka pp 22.

BCPA (2013). BCPA – Bangladesh Crop Protection Association. List of Registered Agricultural, Bio & Public Health Pesticide in Bangladesh 142 p. Available online at: *www.bcpabd.com*

Beck J, Khen CV (2007). Beta-diversity of geometrid moths from northern Borneo: effects of habitat, time and space. Journal of Animal Ecology 76(2):230-237. *https://doi.org/10.1111/j.1365-2656.2006.01189.x*

El-Shafie HAF (2020). Insect pest management in organic farming system. In: Moudrý J, Mendes KF, Bernas J, Teixeira RS, Sousa RN (Eds). Multifunctionality and Impacts of Organic and Conventional Agriculture. IntechOpen pp 137-156. *https://doi.org/10.5772/intechopen.84483*

Erler F, Bayram Y (2022). Mass trapping using a new-designed light trap as a viable alternative to insecticides for the management of dipteran pests of cultivated mushrooms. Journal of Plant Diseases and Protection 129(1):63-69. *https://doi.org/10.1007/s41348-021-00539-7*

Fayle TM, Sharp RE, Majerus ME (2007). The effect of moth trap type on catch size and composition in British Lepidoptera. British Journal of Entomology and Natural History 20(4):221-232.

Kabir MM, Ali MP, Datta J, Topy SN, Debonath A, Nasif SO, Roy TK, Uddin A (2023). Period of effective catching of insect pests and natural enemies in light traps. International Journal of Agricultural and Applied Sciences 4(1):12-16. *http://dx.doi.org/10.52804/ijaas2023.412*

Mamun MSA, Iyengar AVK (2010). Integrated approaches to tea pest management in south India. International Journal of Sustainable Agricultural Technology 6(4):27-33.

Meena SK, Sharma AK, Aarwe R (2018). Total insect fauna of order Lepidoptera collected through light trap installed in paddy field. Journal of Entomology and Zoology Studies 6(3):1362-1367.

Meshram SA, Kapade AD, Chaudhari, Nagane KB (2018). Design a solar light trap for control of field crop insects. International Research Journal of Engineering and Technology 5(12):1252-1254.

Park JH, Lee HS (2017). Phototactic behavioral response of agricultural insects and stored-product insects to light-emitting diodes (LEDs). Applied Biological Chemistry 60(2):137-144. *https://doi.org/10.1007/s13765-017-0263-2*

Rabbani MAE, Basir RMS, Aliuzzaman M, Rahman A (2022). Optimization of a solar light trap for controlling the pest in rice field. Agricultural Engineering International: CIGR Journal 24(2):43-50.

Rashid M, Ridoy MK, Rahman MM, Rahman MM, Mondal MF (2022). Does solar light trap reduce the cost of pesticides used in rice field? SAARC Journal of Agriculture 20(1):171-183. *https://doi.org/10.3329/sja.v20i1.60615*

Roy TK, Kabir MMM, Akter S, Nayeem A, Alam Z, Hasan MR, Bari MN, Sannal A (2024). Seasonal variations of insect abundance: Correlating growth stage-specific metrics with weather patterns in Rangpur Region, Bangladesh. Heliyon 10(18):e38121. *https://doi.org/10.1016/j.heliyon.2024.e38121*

Roy TK, Sannal A, Akter S, Kabir MM, Bari MN, Haque SS (2025). Efficacy assessment of different botanicals against rice weevil (*Sitophilus oryzae*) in stored rice. SAARC Journal of Agriculture 22(2):197–207. *https://doi.org/10.3329/sja.v22i2.76521*

Salazar C, Rand J (2020). Pesticide use, production risk and shocks. The case of rice producers in Vietnam. Journal of Environmental Management 253:109705. *https://doi.org/10.1016/j.jenvman.2019.109705*

Sangeetha J, Thangadurai D, Fayeun LS, Akinwale JA, Habeeb J, Maxim SS, Hospet R, Islam S (2020). Origin and evolution of rice as domesticated food crop. In: Roychoudhury A (Ed). Rice Research for Quality Improvement: Genomics and Genetic Engineering. Springer, Singapore pp 1-14. *https://doi.org/10.1007/978-981-15-4120-9_1*

Seck PA, Diagne A, Mohanty S, Wopereis MCS (2012). Crops that feed the world 7: Rice. Food Security 4:7-24. *https://doi.org/10.1007/s12571-012-0168-1*

Shammi M, Sultana A, Hasan N, Rahman MM, Islam SM, Bodrud-Doza M, Uddin UM (2020). Pesticide exposures towards health and environmental hazard in Bangladesh: A case study on farmers' perception. Journal of the Saudi Society of Agricultural Sciences 19(2):161-173. *https://doi.org/10.1016/j.jssas.2018.08.005*

Siddiquee AH, Sammy HM, Hasan MR (2019). Assessing profitability, marketing activities and problems in modern rice production in two northern Districts of Bangladesh. The Agriculturists 17(1-2):31-40. *https://doi.org/10.3329/agric.v17i1-2.44694*

Singh S, Sharma AK, Saxena AK, Panday AK, Kakade SH (2018). Taxonomic analysis of phototactic beneficial insects as biocontrol agents (predators and parasites) collected in light trap in rice ecosystem at Jabalpur. Journal of Entomology and Zoology Studies 6(3):850-853.

Sridhar V, Kumaran GS (2018). Light trap, an effective component of integrated management of *Tuta absoluta* (Lepidoptera: Gelechiidae) on tomato. Journal of Horticultural Sciences 13(1):126-128. *https://doi.org/10.24154/jhs.v13i1.59*

Yadav M, Prasad R, Kumari P, Madhu M, Kumari A, Pandey C, … Kumar J (2018). Potential and prospects of natural enemies in rice ecosystem in Jharkhand. International Journal of Current Microbiological Applied Science 7:3389-3396.

Young M (2005). Insects in flight. In: Leather SR (Ed). Insect Sampling in Forest Ecosystems. Blackwell, Malden pp 116-145. *https://doi.org/10.1002/9780470750513.ch6*