Research Article

Evaluation of Different Trapping Devices for the Management of Rice Yellow Stem Borer

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Abstract | Yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) is one of the most important noxious insect pests of rice crop and is responsible for 10-60% yield losses globally. For the management of YSB of rice, growers frequently apply unnecessary and excessive pesticide that is leading to environmental pollution, human health risk, and insect-resistant development globally. Therefore, there is a need for alternative eco-friendly management strategies to combat the insect pest population, which minimize the application of synthetic pesticides in the agroecosystem. The current research focused on the efficiency of different eco-friendly trapping devices against YSB in rice field conditions during August 2023. The maximum seasonal adult moths (102.45±20.58) were caught by pheromone traps followed by light traps (86.35±10.72), yellow sticky traps (30.92±6.25), and yellow water pan traps (20.00±5.64). After the application of pheromone traps, the minimum white ears and dead hearts (07.86±1.89%) and (06.36±1.32%) were recorded, followed by light traps (10.43±2.06%) and (08.93±1.50%), yellow sticky trap (13.66±2.10%) and (11.95±1.90%), and yellow water pan trap (17.45±2.00%) and (13.10±1.95%), respectively. The highest (4:20) cost-benefit ratio was recorded after the application of pheromone traps, while the control plots showed a minimum (4:1) cost-benefit ratio. The highest moth attraction, lowest crop damage intensity, and maximum yield were observed after the application of pheromone and light traps; both are convenient tools for monitoring and controlling the adult moth population for the sustainable management of rice yellow stem borer. Thus, it is recommended as an important component for the eco-friendly management of YSB to ensure food security.

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Introduction

Rice (*Oriza sativa* L.) is considered an essential edible food cereal crop, and it is being largely consumed by human being after wheat (Solangi *et al.*, 2024; Rahimoon *et al.*, 2021, 2023). The production of rice holds a specific position in the agriculture sector of Pakistan and the economy as well. It is the 2nd most important food crop after wheat and it stands 2nd position as an exportable commodity, after cotton in 2022-2023, it contributed 3.1% to the total value added in agriculture and 0.6% to GDP (GOP, 2024). Rice productivity is affected by several biotic and abiotic factors, and these factors are responsible and causing a reduction in rice by 10-60% yield globally (Peng *et al*., 2007). Pallavi *et al*. (2017) reported that approximately more than a hundred various insect pest species (biotic factor) attack rice from nursery to harvesting, and among them, more than 50 insect pest species are found in the Pakistan, one of them is well-known as the rice stem borer complex, which causes a huge yield reduction of up to 30% (Saleem *et al*., 2014). Among them, the rice yellow stem borer (YSB), *Scirpophaga incertulas* (Crambidae; Lepidoptera) is one of the economic pests of rice crops (Solangi *et al*., 2024; Chen *et al*., 2011). The losses caused by YSB are determined in Pakistan as 18-40% in every cropping season (Saleem *et al*., 2014). The YSB is a polyphagous pest feeding on rice and wild rice, and the larva is largely an internal feeder and feeds the internal plant nutrients, resulting in "dead hearts" at the vegetative stage and "whiteheads" at the reproductive stage (Jiang and Cheng, 2003). The YSB remains active from April to October and passes 4-5 generations in this period, the larvae of the last generation hibernate in rice stubbles from November to the end of March and early April (Solangi *et al*., 2024). The dusk and dawn period is the active time of YSB, but the peak active time at night has been recorded in different rice-growing areas of Pakistan (Rahimoon *et al*., 2021). For the management of these noxious insect pests, several control measures have been taken worldwide, one of them is the application of chemical insecticides (Khan *et al*., 2010; Li *et al*., 2015), because of the widespread and usage of these chemicals, these are causing greater impact on natural adversaries and antagonists than on the target species (Oerke, 2006). As a result, insect-resistant development, environment pollution, insecticide-related food poisoning, grower's health concern, and in addition other ecological problems were regularly accounted (Li *et al*., 2015), further insecticides do not efficient due to the cryptic feeding habitat of larvae (Wang *et al*., 2014). Therefore, alternative and eco-friendly control strategies are needed to control or kill adult moths. Sticky-colored traps are one of the most useful monitoring methods for insect pest scouting in agricultural ecosystems (Shehnaz *et al*., 2023). Sticky traps provide a simple method for monitoring relative pest population assessments with minimal effort, which is typically employed in integrated pest control programs in a variety of crops (Gencsoylu, 2018). Recently, different colored sticky traps have been employed to monitor and detect the presence of several significant insect pests of different crops including adult moths (Allsopp, 2010). Three different sex pheromone blends have been recognized from the pheromonal glands of the female of Lepidoptera species such as Z11-16: Ald, Z9-16: Ald, and Z13-16:Oct. Several studies reported that such type of substance blend mixture was also identified from other related lepidopteran moth species such as rice yellow stem borer (Shambharkar *et al*., 2006). The creation of this pheromone composition allowed for the execution of multiple field tests for mating disruption and monitoring aimed at managing this pest (Yan *et al*., 2015). Agricultural pests including noctuid moths, weevils, and scarab beetles have long been monitored and controlled on-site using light traps (Shimoda and Honda, 2013). Thus, in recent years, a wide variety of economically significant pests have been monitored and controlled with the use of LED-equipped traps, LEDs may be used to treat noctuid moths and show a clear preference for specific wavelengths (Laszlo and Puskas, 2012). Yellow pan traps capture several insects that are related to certain host crops under field conditions (Duan *et al*., 2020). The application of trapping devices is one of the most substitute control methods to monitor and control adult moths on a large scale. The aim of the present research was to evaluate different trapping tools against rice YSB moths, which could reduce the oviposition rate and larval infestation caused by it in the rice fields and monitor the efficacy of different trapping devices to determine the effectiveness of trapping devices against borer moths and to evaluate the efficient trap devices based on the crop damage symptoms and yield.

Materials and Methods

Experiment detail

Super basmati rice variety was sown during the first week of August 2023, and four weeks after the plantation of the nursery, the rice crop was transferred into the main field. The experimental design was a completely randomized block design (RCBD) with five treatments, i.e., yellow sticky traps, light traps, pheromone traps, yellow water pan traps, and untreated (only for crop damage and yield assessment) with three replications of each treatment, the size of each plot was 12m x 24 m. All the agronomical practices, such as land preparation, timely sowing, proper weeding, irrigation, and fertilizer applications were carried out according to the requirements of the crop.

Installation of trapping devices

Preparation of yellow sticky traps: Yellow plates were purchased separately (12 × 8 inches in length and width) and fixed with wooden sticks at 3 feet height, a total of 8 traps/ha were installed in the rice field for adult capturing, and the adhesive material was replaced every week from the plates.

Preparation and installation of light traps

The light trap (Jermy type) consists of four main components: A collecting chamber, a funnel-shaped lid, a light source, and a top lid to shield against sudden downpours. To kill moths, potassium cyanide was used, and 12-watt standard electrical bulbs were utilized as the light source. The Jermy-style light traps were set up and hung at a height of around 3.5 feet with the support of an iron raid, a total of 8 traps/ha were installed in the rice field for moth capturing.

Pheromone traps installation

Commercial traps and synthetic sex pheromones were brought from Zafar Shani Chemical Company, Multan. The installation of the pheromone traps was supported by wooden stands, In the present study, the blend ratio of 50 µg/10ul mixed with methanol and fixed in a rubber tube of two sex pheromone components such as (Z)-11-hexadecenal and (Z)-9-hexadecenal was used at unique concentrations such as 50µg/10ul in rubber tube with each capsule which was exploited in rice field, total 8 traps/ha were installed in the rice field for adult moths capturing.

Installation of yellow water pan traps

Yellow cobalt (15 inches in diameter and 18 inches in height) was filled with 10 liters of normal water, and 10 milliliters (ml) of mobile oil was mixed in water for density purposes. In this regard captured moths are fully dipped with oily water, yellow water pan traps per acre were kept at the soil surface for adult population traps, total of 8 traps/ha were installed in the rice field for adult capturing.

Evaluation of crop damage assessment

The impact of treatments was determined by capturing the population of yellow stem borer and evaluating the crop damage assessment by inspecting the two major types of symptoms (white ears and dead hearts). However, for the assessment of crop damage symptoms, a control untreated plot was also arranged. Rice crop damage symptoms were assessed by counting the infested plants in the rice field, stems and tillers of plants with symptoms confirmed that the damage was caused by borer. For damage appraisal, 50 plants were randomly selected from each replication, including control plots. Crop damage was examined from the start of September to November 2023 in the rice season. Further, the percentage of dead hearts and white ears was calculated with the help of previously standard formulas of Onate (1965).

$$DH\ or\ WE\ \% = \frac{Number\ of\ DH\ or\ WE}{Number\ or\ total\ tillers} \times 100$$

Whereas, DH= Dead heart in rice crop, WE= White ears of rice crop.

Rice yield analysis

Rice yield per plot (12m x 24 m) was noted and recorded from all replications of each treatment, and average data values were converted into standard units per hector and subjected to appropriate statistical analysis for interpretation and to find out the difference among the treatments.

Data analysis

Average data values for adult moths caught from all treatments and crop damage symptoms percentage and grain yield per plot were analyzed by one-way analysis of variance (ANOVA), followed by the LSD test to determine treatment differences. Efficiency was considered significantly different at ($P<0.05$). All analyses were performed by using software (SPSS) and graphs were generated with the assistance of Microsoft Excel 2007.

Results

Weekly captured adult moths by yellow sticky traps

There was no (00.00±0.0) adult population captured on 4th September but gradually increased during the subsequent weeks. Moth activity started on 11th September and captured (1.00±0.57 moths), maximum (14.10±2.64) moths were captured on 16th September, and the moth remained active and captured (0.67±0.42) up to 4th December. Data revealed a significant difference at (df: 13,72: f=12.99; P<0.001) among the weekly captured adult population (Figure 2).

Figure 1: *Installation of different trapping devices in rice fields. (a) Installation of yellow color sticky traps, (b and c) installation and night view of light traps, (d) installation of pheromone traps, and (e) installation of yellow pan traps.*

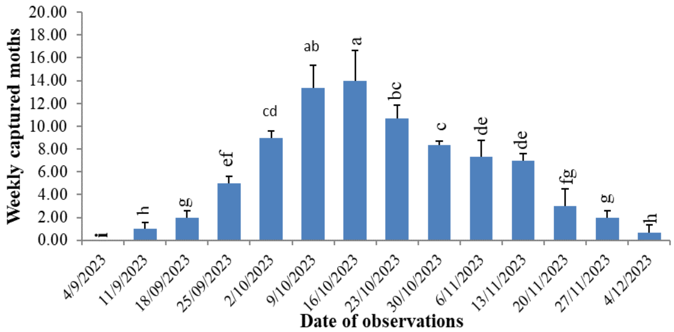

Figure 2: *Weekly average adult moths of yellow stem borer captured by yellow color sticky traps.*

Weekly captured adult moths by light traps

The adult population was captured on 4th September (00.67±0.30) and gradually increased during the subsequent weeks. Specifically weekly adults were captured on 11th September (0.67±0.33), 18th September (4.00±1.15), 25th September (13.00±1.73), 2nd October (13.35 ±2.40), 9th October (14.67±2.02), 16th September (19.00 ±1.75), 23rd September (15.34±1.85), 30th September (10.00±1.73), 6th November (12.67±2.10), 13th November (08.67±0.88), 20th November (1.67±0.88), 27th November (3.00±0.58) and 4th December 2023 (0.69±0.42) was recorded, respectively. Further, data revealed a significant difference at (df: 25,72: f=15.78, P <0.001) among the weekly captured adult population (Figure 3).

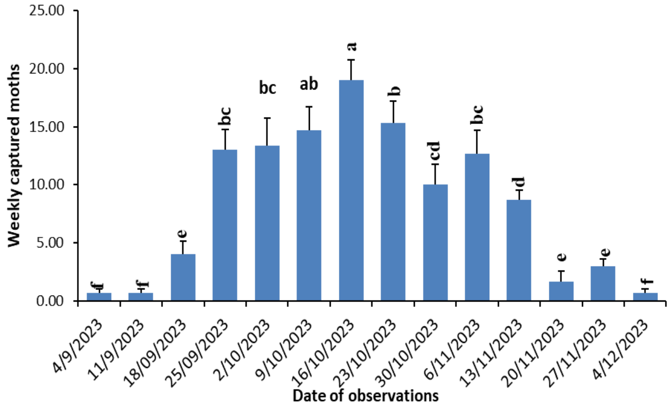

Figure 3: *Weekly average adult moth population of yellow stem borer captured after installation of light traps.*

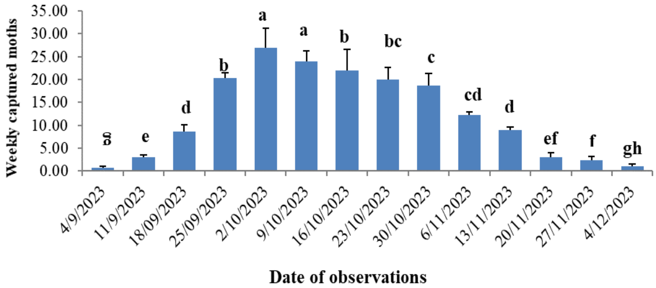

Figure 4: *Weekly average adult moth population of yellow stem borer captured after installation of pheromone traps. The different alphabetical letters indicate the significant differences between observation dates.*

Weekly captured adult moths by pheromone traps

The adult population was captured on 4th September (00.67±0.30) and gradually increased during the subsequent weeks. Specifically weekly adults were captured on 11th September (3.00±0.54), 18th September (8.67 ±1.45), 25th September (20.35±1.20), 2nd October (27.00±4.16), 9th October (24.10±2.30), 16th September (24.45±3.60), 23rd September (20.00±2.64), 30th September (18.67±2.60), 6th November (12.33±1.65), 13th November (9.12±0.58), 20th November (3.0±1.00), 27th November (2.33±0.88) and 4th December 2023 (1.00±0.57) was recorded respectively. Further, data revealed a significant difference at (df: 30,72: f=13.20: P <0.001) among the weekly captured adult population (Figure 1).

Weekly captured adult moths by yellow water pan traps

The adult population was captured on 4th September (00.00±0.00) and gradually increased during the subsequent weeks. Specifically weekly adults were captured on 11th September (1.00 ±0.33, 18th September (1.33±0.33), 25th September (3.00±0.57), 2nd October (3.56±0.88), 9th October (3.76±0.87), 16th September (6.67±1.25), 23rd September (8.33±1.20), 30th September (5±1.52), 6th November (4.00±1.15), 13th November (2.00±0.56), 20th November (2.0±1.00), 27th November (1.00±0.57) and 4th December (1.00±1.00) was recorded, respectively. Further, data revealed a significant difference at (df: 25,72: f= 09.68; P <0.001) among the weekly captured adult population.

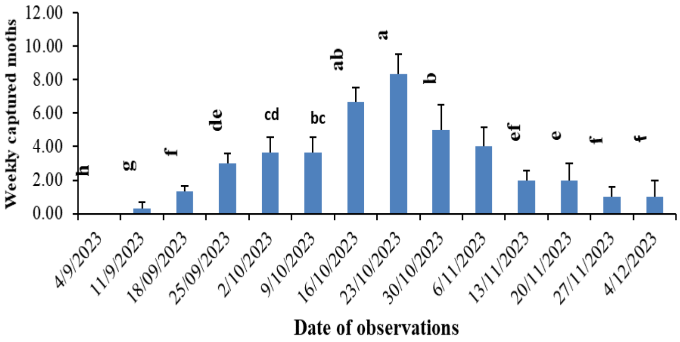

Figure 5: *Weekly average adult moth population of yellow stem borer captured after installation of yellow pan traps.*

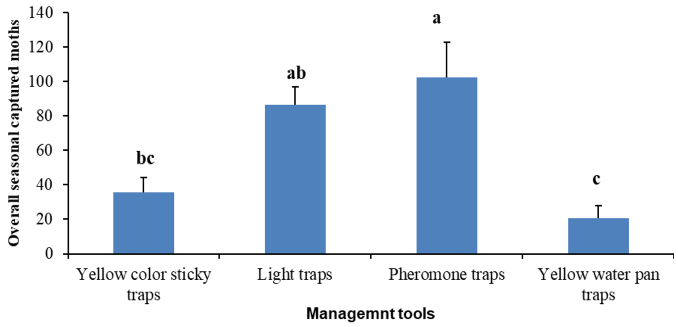

Figure 6: *Overall seasonal adult moth population of yellow stem borer captured after installation of different trap devices. The different alphabetical letters indicate the significant differences between treatments.*

The overall seasonal captured adult moth population

Subsequently, surprising variation was seen in different trapping devices seasonally captured adult populations after the installation of different trap devices in rice fields with significant differences (df=25,72, f= 06.29; P<0.001). However, the maximum (95.45±12.58) seasonal adult population was captured by pheromone trap followed by light traps (80.35±10.72), yellow sticky traps (30.92±10.25), and yellow pan trap (13.00±5.64) (Figure 6).

Crop damage assessment

Data from this trial demonstrated a distinctly significant difference in both crop infestation symptoms (White ear and dead hearts) among all tested trapping devices. A significant difference was observed in white ear damage symptoms between the trapping devices at (df; 03,72: f: 9.90: P<0.005) (Figure 5). The minimum crop damage symptoms of white ears (7.86±1.89%) were recorded in pheromone traps followed by light traps (10.43±2.06%), yellow color sticky trap (13.66±2.10%) and yellow water pan trap (17.45±2.00) were recorded, respectively. In addition, minimum crop damage symptoms of dead hearts (6.36±1.32%) were recorded in pheromone traps followed by light traps (8.93±1.50%), yellow sticky traps (11.95±1.90%) and yellow water pan traps (13.10±1.95) respectively. However, a significant difference was observed in dead heart crop damage symptoms between the trapping devices at (df; 25,72: f=8.16; P<0.002) (Figure 7).

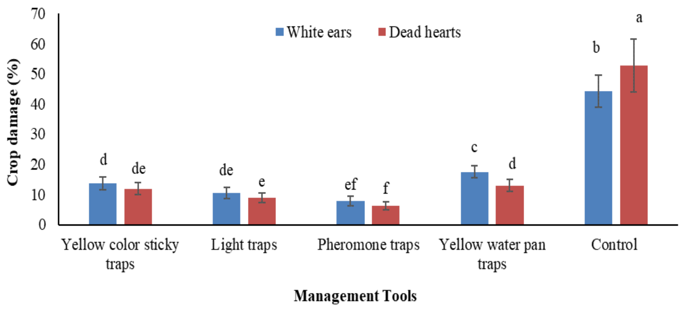

Figure 7: *Crop damage (white ears and dead hearts) caused by yellow stem borer after installation of different trap devices in rice crop. The different alphabetical letters indicate the significant differences between management tool treatments.*

Cost-benefit ratio after installation of different traps

After the installation of various trapping devices in rice fields for the monitoring and control of the adult population of rice yellow stem borer, the cost-benefit ratio and yield of rice crop were also examined. The highest average yield (4874.00 kg/ha) was obtained in the plots where pheromone traps were installed, followed by light traps (4625.00 kg/ha), yellow sticky traps (4874.50 kg/ha), yellow water pan traps (4160.0 kg/ha) and in control (3955 kg/ ha). Further statistical analysis revealed a remarkable difference (df= 5, 72: f=15.84; P<0.003) in the yield within the trapping devices (Table 1).

Discussion

Current research emphasizes eco-friendly management strategies to minimize the application of synthetic pesticides. Results of current study demonstrated that overall seasonal mean captured population of rice yellow stem borer *S. incertulas* that maximum seasonal population was caught by

Table 1: *Cost benefit ratio of rice crop after the installation of different moth capturing devices or traps against yellow stem borer during 2023.*

Treatment	Dose/ha	Yield kg/ha	Common cost/ha (PKR.)	Cost of treatment (PKR.)	Total cost (PKR.)	Gross income/ha (PKR.)	Net income/ha (PKR.)	Cost; Benefit ratio
Yellow Sticky Traps	8 traps	4230.50	52700	5600	58300	371,000	312,700	4:9
Light Traps	8 traps	4625.00	52700	4800	57500	40600	348500	4:12
Pheromone Traps	8 traps	4874.00	52700	5440	58140	427000	368,860	4:20
Yellow Water Pan Traps	8 traps	4160.50	52700	4000	56700	364,000	307,300	4:10
Control (Untreated plots)		3955.00	52700	-------	52700	346,000	293,300	4:5

pheromone trap devices followed by light traps, yellow color sticky traps and yellow pan traps, and significant variation was seen in different trapping devices (df= 25,72 f= 6.29, P<0.001). Findings of the current study is similar to the recent studies (Witzgall *et al*., 2008; Stelinski *et al*., 2013) who used different pheromone dispensers with different densities to monitor and control the *Phyllocnistis citrella* (Su *et al*., 2003) as well as *C. suppressalis* (Wang *et al*., 2011) in rice fields. The current research was also inspired by these researchers to control the same group of pests and quite similar results were obtained. Because the perception mechanism of the olfactory system in moth species is directly associated with the detection of pheromone plumes (Alfaro *et al*., 2015). The present work revealed the effect of light traps on *C. suppressalis* at weekly basis and light traps also showed the potential trapping devices against the capture of adult rice YSB in rice fields. These findings agreed with Bhutto *et al*. (2016) and Lima *et al*. (2015) reported that light sources were found the most attractive source for attraction in the rice YSB in the rice field. Further previous studies (Kakde and Patel, 2014) recorded the attraction of adults of rice YSB from the 1st week of August to the last week of November. A smaller number of adults were attracted because their eye systems are made to be sensitive to tiny light photons, nocturnal insects have behavior that avoids bright lighting. The performance of insect visual receptors will be affected by excessive photon exposure. Certain light intensities seem to attract nocturnal insects Szentkiralyi (2012) claimed that ultraviolet colors are the ones that attract rice stem borer the most. However, according to Shimoda and Honda (2013) insects particularly nocturnal ones have sensors for UV radiation. Plant stress increases because of retaining by UV as a light trap (Kuhlmann and Muller, 2009).

Conversely, yellow color sticky and yellow pan traps are also able to attract the few numbers of adults of YSB but lowest as compared to pheromone and light traps. This might be because adults of the YSB are noctuid by nature and mainly active during the dark period, further color sticky water pant traps are effectively used to capture the diurnal insect in field crops. However, several studies documented the trapping efficiency of yellow color sticky traps against insect pest species such as according to Wallis and Shaw (2008) who reported that out of all the sticky cards that were placed the adults of *Elatobium abietinum* were mostly attracted to the sticky yellow cards and Mainali and Lim (2010) revealed that *Franklinville occidentalis* attraction was by yellow color sticky traps. These mostly utilized in integrated pest management programs in a variety of crops, sticky traps provide a simple way to monitor relative assessments of the insect population with minimal effort (Gencsoylu, 2018). Although water pan traps are commonly employed to monitor and control adult species, their trapping efficiency is inadequate when it comes to monitoring the flying insect species. The effectiveness of yellow water pan traps as a monitoring tool might be enhanced by the attraction rate of noctuid adult seasonal abundance.

In the present study, the yellow pan trap also trapped a few numbers of adults of rice YSB in rice fields and these findings are similar to the findings of Duan *et al*. (2020) who stated the lower catch rates and numbers of emerald ash borer *Tetrastichus planipennisi* might have resulted from a new sampling procedure which utilized in the earlier research. These traps are favored due to their simplicity and ease of deployment, collection, and ability to capture the moths. Additionally, they eliminate the need for destructive sampling methods on host crops (Petrice *et al*., 2019). Targeting the monitoring and control of the adult population rice

YSB by using different trapping devices; assessment of the crop damage can directly provide the clues related to the treatment potential. In the present research, the frequency of damage symptoms indicates that pheromone traps could significantly reduce both white ears and dead hearts caused by stem borer more efficiently than followed by light traps and control plots. This might be the maximum number of adults caught by pheromone traps as compared to other treatments. These findings agree with Alfaro *et al.* (2015) they conducted the experiment of application of sex pheromones and stated that applications of pheromones might decrease the critical both white ears and dead hearts caused by *C. suppressalis* more proficiently than control strategies. Further based on light traps our finding agreed with Sharma *et al.* (2011) who recorded 5.98 % dead hearts and 5.79% white ears during rice kharif season. Further similar to Kumar and Sudhakar (2017) who examined damage caused by YSB (18.48% dead heart and 24.21% white ear). Pheromones and light traps could play a crucial part in controlling the adult moths of YSB of rice in the field. The utilization of trapping devices is largely cheap and can be used for the management of noxious insect pests of rice crops which offer assistance and support to rice growers.

Conclusions and Recommendations

It is concluded that, the adult moths were caught during the first week of September and gradually increased subsequently in all trapping devices up to mid-November, although peak attraction was noted during the October month. Further, the highest overall seasonal adult moths were caught by pheromone trap devices followed by light traps, yellow color sticky traps, and yellow pan traps. In addition, the minimum crop damage symptoms of white ears and dead hearts were observed after the application of pheromone and light traps compared to yellow sticky and yellow water pan traps, respectively. Pest surveillance is the most important and integral part of an integrated pest management (IPM) program which involves direct measurement of pest development in terms of either population or damage at regular intervals. Based on the present research findings, it is recommended that light and pheromone traps are the convenient tools to monitor and control the adult moth population of YSB, rice growers should install light and pheromone traps from nursery fields till the harvesting, to get the maximum yield of rice.

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Novelty Statement

The results of current research are innovative and will help in the management of rice yellow stem borers to avoid pesticide application in the rice agroecosystem.

Author's Contribution

Abdul Waheed Solangi: Conceptualization, formal analysis, funding acquisition, resources, supervision.
Aneeta Lashari: Data curation, formal analysis, investigation
Khalid Hussain Dhiloo: Data curation, writing review and editing.
Jamal Uddin Hajano: Data curation, visualization.
Mehar Ul Nissa Rais: Software, validation.
Muhammad Usama Mahar: Investigation, methodology, writing original draft.

Generative AI and AI-assisted technology statement
The authors declare that they have not used any Generative AI or AI-assisted technology.

Conflict of interest
The authors have declared no conflict of interest.

References

Alfaro, C., L. Navarro and J. Primo. 2015. Optimization of dispenser density to control the rice striped stem borer *Chilo suppressalis* walker by mating disruption. J. Plant Sci., 55(4): 654-660.

Allsopp, E., 2010. Investigation into the apparent failure of chemical control for management of western flower thrips, *Frankliniella occidentalis* (Pergande), on plums in the Western cape province of South Africa. Crop Protec., 29: 824-831. https://doi.org/10.1016/j.cropro.2010.03.009

Bhutto, A.A., J. Chandio, I. Ursani, K.H. Dhiloo and F. Khan. 2015. Light trap study to determine emergence and peak of adult moths of yellow rice stem borer and sex ratio study to collect male and female moths under field conditions.

Eur. Acad. Res., 3(6): 6068-6078.

Chen, X.M., C.R. Peng, F.X. Yao, X.J. Guan, H.L. Wang and G.Q. Deng. 2011b. Study on the technique and effect of vetiver for trapping and killing rice borer. Acta Agric. Jiangxi, 19(12): 51-52.

Duan, J.J., L.S. Bauer, V. Driesche, R. Schmude, J.M. Petrice, T. Chandler, J.L. and J. Elkinton. 2020. Effects of extreme low winter temperatures on the overwintering survival of the introduced larval parasitoids *Spathius galinae* and *Tetrastichus planipennisi*: Implications for biological control of emerald ash borer in North America. J. Econ. Entom., 113: 1145-1151. https://doi.org/10.1093/jee/toaa048

Gencsoylu, 2018. Seasonal abundance; damage; and comparison of different heights, orientations, and directions of yellow sticky traps for sampling of *Liriomyza trifolii* (Diptera: Agromyzidae) in Cotton. Great Lakes Entom., 39(1): 4-6. https://doi.org/10.22543/0090-0222.2145

GOP, 2024. Pakistan economic survey 2023-2024. Economic advisory wing finance division, government of Pakistan, Islamabad, Pakistan.

Jiang, J. and J. Cheng. 2003. Rice stem borer species in Tanzania: A review. J. Basic Appl. Zool., 81(1): 36.

Kakde, A.M. and K.G. Patel. 2014. Seasonal incidence of rice yellow stem borer (*Scirpophaga Incertulas*, Wlk.) in relation to conventional and Sri methods of planting and its correlation with weather parameters. J. Agric. Vet. Sci., 7(6): 5-10. https://doi.org/10.9790/2380-07620510

Khan, M.J., M.S. Zia and M. Qasim. 2010. Use of pesticides and their role in environmental pollution. World Acad. Sci. Eng. Technol., 72: 122-128.

Kuhlmann, F. and C. Muller. 2009. Development dependent effects of UV radiation exposure on broccoli plants and interactions with herbivorous insects. Environ. Exp. Bot., 66: 61-68. https://doi.org/10.1016/j.envexpbot.2009.01.001

Kumar, A.D. and T.R. Sudhakar. 2017. Incidence of yellow stem borer, *Scirpophaga incertulas* (Walker) on rice in relation to weather parameters. Pest Manage. Econ. Zool., 9(2): 161-164.

Laszlo, N. and J. Puskas. 2012. Light traps catch of the harmful moths depending of moon light in north Carolina and Nebraska States Of USA. Intern. Sch. Res. Netw. Zool., 238(591): 1-6. https://doi.org/10.5402/2012/238591

Li, H., J. Chang, T. Feng and X. Gao. 2015. Differential effects of insecticides on mitochondrial membrane fluidity and ATP as activity between the wolf spider and the rice stem borer. J. Integr. Agric., 14(2): 2574-2580. https://doi.org/10.1016/S2095-3119(15)61074-7

Lima, D.C.B., A.A.V. Costa and F.S Silva. 2015. Abundance and night hourly dispersal of the vesicating beetles of the genus *Paederus* (Coleoptera: Staphylinidae) attracted to fluorescent, incandescent, and black light sources in the Brazilian Savanna. J. Med. Entomol., 2(1): 50-55. https://doi.org/10.1093/jme/tju006

Mainali, B.P. and U.T. Lim. 2010. Circular yellow sticky trap with black background enhances the attraction of *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae). Appl. Entomol. Zool., 45: 207-213. https://doi.org/10.1303/aez.2010.207

Oerke, E.C., 2006. Crop losses to pests. J. Agric. Sci., 144: 31-43. https://doi.org/10.1017/S0021859605005708

Onate, B.T., 1965. Estimation of stem borer damage in rice fields. In: Pathak MD (Ed.). Stem borer and leafhopper-planthopper resistance in rice varieties. Entomol. Expr. Appl., 12: 789-800. https://doi.org/10.1111/j.1570-7458.1969.tb02572.x

Pallavi, D., S. Deshmukh and G.K Girijesh. 2017. Crop loss estimation of yellow stem borer *Scirpophaga incertulas* (Walker) damage on paddy. J. Entomol. Zool. Stud., 5: 635-638.

Peng, M.W., K.G. Patel and H.R. Desai. 2007. Monitoring rice yellow stem borer, *Scirpophaga incertulas* (Walker), using sex pheromone/light traps. Insect Environ., 10: 51-52.

Petrice, T.R., D.L. Miller, L.S. Bauer, T.M. Poland and F.W. Ravlin. 2019. Photoperiodic modulation of diapause induction and termination in *Oobius agrili* Zhang and Huang (Hymenoptera: Encyrtidae), an egg parasitoid of the invasive emerald ash borer. Biol. Control, 138: 1–13. https://doi.org/10.1016/j.biocontrol.2019.104047.

Petrice, T.R., L.S. Bauer, D.L. Miller, J.S. Stanovick, T.M. Poland and F.W. Ravlin. 2021. Monitoring field establishment of the emerald ash borer biocontrol agent *Oobius agrili* (Hymenoptera: Encyrtidae): Sampling methods, sample size, and phenology. Biol. Contr., 156: 104535. https://doi.org/10.1016/j.biocontrol.2021.104535

Rahimoon, Y., A.G. Lanjar, A. Bukero, B.H. Chang, J. Hajano, A. Rajput and Z. Lanjar. 2023. Prevalence position of stem borer species in rice ecosystem in lower and upper Sindh. Pak. J. Sci. Ind. Res., 66B(1): 52-57.

Rahimoon, Y., A.G. Lanjar, A. Bukero, B.H. Chang, J. Hajano, A. Rajput and Z. Lanjar. 2021. *Trichogramma chilonis*, an effective egg parasitoid for control of white stem borer *Scirpophaga innotata* (Walker), (Lepidoptera: Pyralidae) in rice. Abasyn J. Life Sci., 4 (1): 51-60. https://doi.org/10.34091/AJLS.4.1.6

Saleem, M., M. Ramzan, Z. Manzoor and I. Ali. 2014. Effect of various tillage practices on the population of hibernated stem borer larvae in rice-wheat cropping systems. J. Anim. Plant Sci., 14(2): 14-15.

Shambharkar, D.A., P.K. Dharne, T.M. Bahale, D. Anjali, R.T. Surywanshi and A.N. Jadhav. 2006. Assessment of integrated pest management modules in groundnut on farmers fields. Int. Arach. Newsl., 55(4): 31-33.

Sharma, M.K., A. Atsedewoin and S. Fanta. 2011. Fore warning models of the insects of paddy crop. Int. J. Biodiv. Conserv., 3(8): 367-375.

Shehnaz, N., J.M. Mari, A.W. Solangi, S.A. Khuhro and A.G. Lanjar. 2023. Management of *Scriptothrip dorsalis* (Thysanoptera; Thripidae) in chilli crop. J. Appl. Res. Plant Sci., 4(2): 636-640. https://doi.org/10.38211/joarps.2023.04.02.111

Shimoda, M. and K. Honda. 2013. Insect reactions to light and its applications to pest management. Appl. Entomol. Zool., 48: 413-421. https://doi.org/10.1007/s13355-013-0219-x

Solangi, A.W., S.A. Khuhro and M.U.N. Rais. 2024. Optimization of sex pheromone dose and trap density for mating disruption of *Chilo Suppressalis* (Lepidoptera; Pyriladae). J. Anim. Plant Sci., 34(5): 1127-1138. https://doi.org/10.36899/japs.2024.5.0795

Stelinski, L.L., L. Gut and J.R. Miller. 2013. An attempt to increase efficacy of moth mating disruption by co-releasing pheromones with kairomones and to understand possible underlying mechanisms of this technique. Environ. Entomol., 42: 158-166. https://doi.org/10.1603/EN12257

Su, J.W., W.J. Xuan and C.F. Sheng. 2003. Suppression of rice stem borer, *Chilo suppressalis* by mass trapping using synthetic sex pheromone in paddy field. Rice Sci., 11: 52-56.

Szentkiralyi, F., 2012. Fifty year-long insect surveys in Hungry (contribution to light trapping). Acta Zool., 48: 85-105.

Wallis, D.R. and P.W. Shaw. 2008. Evaluation of colored sticky traps for monitoring beneficial insects in apple orchards. N. Z. Plant Prot., 61: 328-332. https://doi.org/10.30843/nzpp.2008.61.6811

Wang, W.H., W. Zhou and Y. Tang. 2011. Using sex pheromone for controlling *Chilo suppressalis* with mating disruption. China Crop Prot., 127: 33-35.

Wang, W.H., W. Zhou and Y. Tang. 2011. Using sex pheromone for controlling *Chilo suppressalis* with mating disruption. China Crop Prot., 127: 33-35.

Wang, Y., L. Zhang, Y. Li, Y. Liu, L. Han, Z. Zhu, F. Wang and Y. Peng. 2014. Expression of Cry1Ab protein in a marker-free transgenic Bt rice line and its efficacy in controlling a target pest, *Chilo suppressalis* (Lepidoptera: Crambidae). Environ. Entoml., 43: 528-536. https://doi.org/10.1603/EN13254

Witzgall, P., L.L. Stelinski, L. Gut and D. Thomson. 2008. Codling moth management and chemical ecology. Annu. Rev. Entomol., 53: 503-522. https://doi.org/10.1146/annurev.ento.53.103106.093323

Yan, Q., H. Peng and L.D. Dong. 2015. Effect of temperature on the sex pheromone communication of *Chilo suppressalis* Walker (Lepidoptera: Pyralidae). J. Appl. Sci., 80(4): 321-333.