REVIEW ARTICLE
AGROBIOLOGICAL RECORDS
ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

BIOLOGICAL CONTROL OF RICE INSECT PEST: A CRITICAL REVIEW

Ruhina Iftikhar[1], Sana Hafeez[2], Sadaf Masood[3], Amna Shaheen[4] and Mehak Manzoor[5]

[1]Lahore College for Women University, Lahore, Pakistan
[2]Department of Zoology, Government College University, Lahore, Pakistan
[3]Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad, Pakistan
[4]Department of Entomology, University of Agriculture Faisalabad, Pakistan
[5]Department of Zoology, Riphah International University, Faisalabad Campus, Pakistan

*Corresponding author: mehak.manzoor027@gmail.com

ABSTRACT

Rice, as a vital staple crop, faces significant challenges from pests that can cause substantial yield losses and jeopardize global food security. Conventional pest control methods, predominantly reliant on chemical pesticides, have raised concerns about environmental pollution, human health risks, and the development of pesticide-resistant pests. In response, there is a growing interest in adopting sustainable and eco-friendly approaches, such as biological management, to mitigate rice pest problems. Biological management utilizes natural enemies, ecological processes, and biopesticides to regulate pest populations and promote a balanced ecosystem in rice fields. This review highlights the importance and advantages of biological management in rice pest control. The approach offers long-term solutions while minimizing negative environmental impacts. By conserving and augmenting beneficial organisms, such as predators, parasitoids, pathogens, and antagonistic plants, biological management reduces the reliance on chemical pesticides, conserves biodiversity, and promotes sustainable agricultural practices. Strategies such as the augmentation and conservation of natural enemies, as well as the use of biopesticides, play significant roles in biological management. Biological management offers several key benefits. It provides effective and sustainable pest control solutions while minimizing harm to the environment and human health. Additionally, this approach enhances the long-term viability of pest management by reducing the risk of resistance development. Farmers adopting biological management practices can potentially reduce costs associated with chemical inputs, leading to increased profitability. Integrated pest management (IPM) that combines biological control with cultural, mechanical, and chemical methods further enhances the effectiveness and sustainability of rice pest management. Overall, biological management of rice pests represents a promising and environmentally friendly alternative to conventional pest control methods. By harnessing the power of natural enemies and ecological principles, it is possible to regulate pest populations effectively, maintain ecosystem balance, and ensure the productivity and resilience of rice cultivation. Implementing this approach requires a comprehensive understanding of pest ecology, natural enemy interactions, and the local agroecosystem. By embracing biological management, farmers can contribute to sustainable rice production and the overall well-being of the environment and society.

***Keywords*:** IPM, insect resistance, rice production

Article History (23-119) || Received: 20 Mar 2023 || Revised: 10 Jun 2023 || Accepted: 15 Jun 2023 || Published Online: 21 Jun 2023

1. INTRODUCTION

Rice serves as a fundamental grain crop and a staple food for nearly half of the global population. It is cultivated in approximately 114 countries, predominantly in Asia and Africa. The cultivation of rice holds immense economic significance for these nations, and any potential risks impacting its output greatly affect their economies (Razzaq et al. 2020). In response to the ever-increasing demand for higher rice grain production, farmers worldwide are intensifying their cultivation methods, leading to a rise in pest infestations. Consequently, insecticides and herbicides have often been excessively applied, resulting in adverse environmental and economic repercussions (Razzaq et al. 2023). The utilization of toxic pesticides, chemical fertilizers, and extensive tilling has been acknowledged as crucial factors contributing to pollution of soil, water, air, and the overall environment (Haroon et al. 2022). Intensive agricultural practices significantly impact various ecosystem functions, including nutrient cycling, environmental purification, organic matter decomposition, and the occurrence of disease outbreaks in both aquatic and terrestrial life. These practices, such as the persistent use of insecticides, herbicides, fungicides, and the leaching of nutrients into groundwater, as well as greenhouse gas emissions from agricultural soils, have inflicted

Citation: Iftikhar R, Hafeez S, Masood S, Shaheen A and Manzoor M, 2023. Biological control of rice insect pest: a critical review. Agrobiological Records 12: 68-75. https://doi.org/10.47278/journal.abr/2023.016

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

severe damage on the natural ecosystem (Babendreier et al. 2019). Despite these detrimental effects, both biotic and abiotic stressors lead to a reduction in rice yield of over 200 million megagrams annually. Insects carrying viruses, such as tungro and yellow dwarf disease, are responsible for transmitting numerous devastating diseases to rice crops. The most destructive pests for rice cultivation are the lepidopteran stem borers (*Tryporyza incertulas* and *T. innotata*) and the rice leaf folder (*Cnaphalocrocis medinalis*), causing annual losses of approximately ten million tonnes. While complete crop failure is uncommon, occasional outbreaks have the potential to destroy between 60 and 95% of the crop (Hajjar et al. 2023).

Globally, crop, fruit, and vegetable production face significant challenges from insect pests and diseases. To mitigate the impact of these pests and prevent yield losses, various techniques have been implemented worldwide. Initially, reliance on pesticides and insecticides was widespread, but their detrimental effects on both human health and the environment led to the adoption of alternative methods. These alternative approaches encompass a range of strategies, such as biocontrol (Ren et al. 2019), the use of resistant varieties (Razzaq et al. 2021), application of botanical extracts, utilization of essential oils, and the employment of volatile organic compounds to alter the preference and host selection behavior of insect pests. Major insect pests of rice are yellow stem borer, white stem borer, striped stem borer, pink stem borer, rice leaf folder, white-backed planthopper, white leafhopper, wice grasshopper, small grasshopper, and rice hispa (Babendreier et al. 2019).

In recent years, there has been a growing interest in adopting sustainable and eco-friendly approaches to manage rice pests. Biological management of rice pests has emerged as a crucial strategy in addressing the challenges associated with traditional pest control methods. This approach harnesses the power of natural ecological processes and beneficial organisms to regulate pest populations and maintain a balanced ecosystem within rice fields. Unlike chemical pesticides that often have detrimental effects on non-target organisms, soil fertility, and water quality, biological management offers a more sustainable and environmentally friendly solution. Chemical pesticides, although effective in controlling pests, can have long-lasting effects on ecosystems, contaminating water bodies, reducing biodiversity, and harming beneficial organisms such as pollinators and natural enemies of pests (Babendreier et al. 2019). In contrast, biological management focuses on conserving and promoting the presence of natural enemies, such as predators and parasitoids, which can suppress pest populations naturally, without leaving toxic residues or disrupting the ecosystem balance. Furthermore, the adoption of biological management practices can contribute to the long-term sustainability of rice production systems. Chemical pesticides often lead to the development of resistance in target pests, necessitating the use of higher doses or more potent chemicals, which further exacerbates environmental and health risks. In contrast, biological management, when integrated with other pest control strategies in an approach known as integrated pest management (IPM), offers a more resilient and sustainable solution (Lou et al. 2013). By promoting biodiversity and ecological balance, biological management reduces the reliance on chemical inputs, minimizes the risk of resistance development, and helps maintain the effectiveness of pest control measures over time. Another crucial aspect of biological management is its potential to enhance farmers' livelihoods and economic viability. Chemical pesticides can be costly, and their misuse or overuse can lead to unnecessary expenses for farmers. Biological control methods, on the other hand, can offer cost-effective and long-term pest management solutions. By employing natural enemies, biopesticides, or cultural practices that support beneficial organisms, farmers can reduce their dependency on expensive chemical inputs, leading to potential cost savings and increased profitability (Lou et al. 2013). Several strategies are employed in biological management of rice pests. In this review we will discuss different biological approaches for the management of insect-pest of rice

2. Biological Insecticides

In response to increasing environmental and food safety concerns in China, there has been a growing acceptance and widespread use of environmentally friendly biological pesticides. Among these, *Bacillus thuringiensis* (Bt) has emerged as the most popular biological insecticide for controlling rice stem borers (SSB) and rice leaf folders (RLF), with official recommendations for its use. The efficacy of Bt against SSB and RLF has been reported at 65.31-96.69%, and 88.00-97.17%, respectively. Additionally, the control effect of nuclear polyhedrosis virus *Mamestra brassicae* on RLF has shown more than 83% efficacy after 14 days of spraying. Other insecticidal options employed for managing various rice pests include spinosad, spinetoram, and *Bassian beauvera*, which have proven effective against RLF and SSB of the Lepidoptera order. Another potential biological insecticide for RLF management is *Cnaphalocrocis medine Granulovirus* (Cnme GV), which exhibits synergy with Bt compounds. The combined application of CnmeGV and Bt resulted in a shorter time to initial mortality for RLF treatment, with a mortality rate of 20.23% and a duration exceeding 30% compared to treatment with CnmeGV alone. Furthermore, a highly controllable biological insecticide known as 12 THR, with a nine percent concentration, has shown significant efficacy against RLF, Brown Planthopper (BPH), and White-backed Planthopper (WBPH). This suggests its potential for effective control of these insect pests (Liu et al. 2013; Mo et al. 2014). Biological insecticides have gained significant attention as a sustainable and environmentally friendly approach to managing

Citation: Iftikhar R, Hafeez S, Masood S, Shaheen A and Manzoor M, 2023. Biological control of rice insect pest: a critical review. Agrobiological Records 12: 68-75. https://doi.org/10.47278/journal.abr/2023.016

insect pests in rice cultivation. These insecticides, derived from natural sources such as bacteria, viruses, fungi, and plant extracts, offer an alternative to chemical pesticides, mitigating the harmful impacts on human health and the environment. Bt is one of the most widely used biological insecticides for controlling rice insect pests, particularly rice stem borers (SSB) and rice leaf folders (RLF). Bt produces crystalline toxins that are toxic to specific insect pests but harmless to humans, animals, and beneficial insects. It is available in various formulations and has shown high efficacy against SSB and RLF, with control rates ranging from 65.31% to 97.17% (Xu et al. 2015).

2.1. Nuclear Polyhedrosis Virus

Nuclear polyhedrosis viruses (NPVs) are naturally occurring viruses that infect and kill specific insect pests. The virus particles, called polyhedra, are ingested by the pests, leading to viral infection and subsequent mortality. For example, the nuclear polyhedrosis virus *Mamestra brassicae* has demonstrated control rates of over 83% against RLF after 14 days of application (Babendreier et al. 2019).

2.2. *Cnaphalocrocis Medine Granulovirus* (Cnme GV)

Cnme GV is a granulovirus that specifically targets RLF. When combined with Bt, it exhibits synergistic effects in managing RLF infestations. The combined application of Cnme GV and Bt has shown enhanced control, reducing the time to initial mortality and increasing overall effectiveness against RLF (Babendreier et al. 2019).

2.3. Spinosad and Spinetoram

Spinosad and Spinetoram are derived from the fermentation of the bacterium Saccharopolyspora spinosa. These compounds target a wide range of pests, including Lepidopteran insects such as RLF and SSB. They disrupt the nervous system of insects, leading to paralysis and death. Spinosad and Spinetoram have demonstrated effective control of RLF and SSB in rice crops (Mo et al. 2014).

2.4. *Beauveria bassiana*

Beauveria bassiana is a fungus commonly used as a biological control agent for various insect pests. It infects pests through contact, invading their bodies and causing death. The fungus has shown promise in controlling rice insect pests such as RLF and SSB.

2.5. Plant Extracts and Essential Oils

Various plant extracts and essential oils have exhibited insecticidal properties against rice insect pests. These include extracts from neem, garlic, chili, and ginger, as well as essential oils such as citronella, lemongrass, and eucalyptus. These natural compounds act as repellents, deterrents, or toxic agents, affecting the behavior, feeding, and development of insect pests (Liu et al. 2014).

2.6. Empedobacter-Based Biopesticides

Biopesticides based on Empedobacter strains, such as BREVERS, have been developed for rice pest management. These biopesticides demonstrate efficacy against pests like RLF and SSB, offering an environmentally friendly option for insect control (Lou et al. 2013).

3. Release *Trichogramma* Parasitoids

In the 1950s, numerous studies were conducted in China to explore the release of *Trichogramma*, a type of parasitoid, for controlling Lepidoptera pests in rice paddy fields. *Trichogramma* parasitoids have shown effectiveness in controlling rice stem borers (SSB) and rice leaf folders (RLF). However, the widespread use of *Trichogramma* in rice fields has been limited due to challenges associated with selection, cultivation, and application techniques specific to *Trichogramma* (Wang et al. 2015). Recently, *Trichogramma* has gained recognition for meeting the safety requirements concerning food, ecology, and the environment for managing insect pests in rice fields. Among the *Trichogramma* species discovered in rice fields, *T. japonicum, T. chilonis, T. dendrolimi*, and *T. ostriniae* are the most prevalent. *T. dendrolimi* thrives in temperatures ranging from 18 to 26 degrees Celsius, while *T. japonicum* performs best in temperatures between 30 and 34°C. Additionally, *Trichogramma* parasitism success decreases significantly after four days when targeting SSB eggs, whereas *T. japonicum* demonstrates optimal performance in parasitizing RLF eggs, particularly in regions with higher temperatures (Yuan et al. 2012).

In recent years, advancements have been made in *Trichogramma* release technologies, including the development of suitable release devices for *Trichogramma* in rice fields, nectar-food supplement release instruments, and unmanned aircraft release techniques. The China National Chinese Service for Extension of Agricultural Technology has conducted a series of demonstration tests on *Trichogramma* release technology, focusing on aspects such as species selection, timing of releases, frequency of application, release height, and

Citation: Iftikhar R, Hafeez S, Masood S, Shaheen A and Manzoor M, 2023. Biological control of rice insect pest: a critical review. Agrobiological Records 12: 68-75. https://doi.org/10.47278/journal.abr/2023.016

density. These experiments, although unpublished, aim to improve the standardization of *Trichogramma* application and pave the way for its broader utilization in rice insect pest management (Tian et al. 2015).

Here are some key details about the release of *Trichogramma* parasitoids for rice pest management:

3.1. Species of *Trichogramma*

Several species of *Trichogramma* have been identified and utilized for pest control in rice fields. In China, the most prevalent species include *T. japonicum, T. chilonis, T. dendrolimi,* and *T. ostriniae*. These species exhibit varying preferences and effectiveness in different temperature ranges, influencing their suitability for specific regions and pest management objectives.

3.2. Temperature Requirements

Trichogramma species have specific temperature requirements for optimal activity and effectiveness. For example, *T. dendrolimi* thrives in temperatures ranging from 18 to 26 degrees Celsius, while T. japonicum performs best in temperatures between 30 and 34 degrees Celsius. Understanding these temperature preferences is crucial for determining the appropriate *Trichogramma* species to release in a given region (Xie et al. 2022).

3.3. Parasitism of Eggs

Trichogramma parasitoids primarily target the eggs of rice pests, including SSB and RLF. They lay their own eggs inside the pest eggs, leading to the destruction of the developing pest larvae. It is important to note that the efficacy of *Trichogramma* parasitism decreases significantly after four days of egg age, emphasizing the need for timely releases to ensure effective control.

3.4. Release Techniques

Various release techniques have been developed to optimize the distribution and establishment of *Trichogramma* parasitoids in rice fields. These techniques include the use of appropriate release devices designed specifically for *Trichogramma*, such as cards or dispensers that hold the parasitized eggs for controlled and uniform dispersal. Additionally, nectar-food supplement release instruments have been employed to provide nutrition and enhance the survival and reproductive capacity of released *Trichogramma* populations (Tang et al. 2017).

3.5. Demonstration Tests and Optimization

In China, the China National Chinese Service for Extension of Agricultural Technology has conducted a series of demonstration tests to refine and optimize *Trichogramma* release technology. These tests involve aspects such as species selection, timing and frequency of releases, release height, and population density. The goal of these experiments is to improve the standardization of *Trichogramma* application and maximize its effectiveness in rice pest control.

3.6. Advantages and Considerations

The release of *Trichogramma* parasitoids offers several advantages over chemical pesticides. *Trichogramma* is safe for humans, animals, and the environment, and it does not leave harmful residues on crops. It is also compatible with other integrated pest management (IPM) practices and can be easily integrated into existing rice cultivation systems. However, successful *Trichogramma* release programs require careful monitoring, appropriate timing, and compatibility with local environmental conditions.

4. Sex Pheromones Cause Mate Conflict

SSB and RLF pheromones have been effectively developed and are user-friendly. To maximize their effectiveness, it is recommended to use only one sex pheromone in each trap, as the attractiveness of multiple pheromones may be diminished. The optimal height for the traps is between 10 and 20 cm below the rice canopy. Extensive demonstration trials have shown that sex pheromone traps can achieve a pest control effect of over 50% on a large scale. This effectiveness can be further enhanced by combining the traps with other pest management strategies. When used to control SSB and RLF, sex pheromone traps have the potential to reduce the need for up to two insecticide sprays. In some cases, the pest control outcomes achieved with sex pheromone traps are comparable to those obtained with insecticides, while the input costs are slightly lower (Tian et al. 2015). Overwintering SSB has an emergence phase of 40 to 60 days, and its oviposition phase is equally prolonged. The effective working time of SSB sex pheromones exceeds 50 days, during which a large number of male SSB adults can be captured and eliminated (with single traps capable of catching over 130 individuals). By catching a significant number of males from the overwintered generation, the populations of first-generation SSB in the field can be drastically reduced, leading to a significant decline in the subsequent SSB generation's impact. For instance, placing over 300 pheromone traps per hectare in isolated and large areas can result in a reduction of over 70% in the number of SSB eggs. Similarly, in large-scale demonstration sites, setting up 60 sex pheromone traps per hectare can lead to a reduction of over 70% in both the number of eggs on rice seedlings and in the rice fields. The larger the area covered by sex pheromone traps, the more effectively pests can be controlled (Yang et al. 2001). Sex pheromones play a significant role in the mating behavior of insects. They are chemical signals released by females to attract males for mating. However, in the context of pest management, sex pheromones can be utilized strategically to disrupt the mating process and cause mate conflict, leading to a reduction in insect pest populations. Here are some details about the use of sex pheromones to induce mate conflict for managing insect pests:

4.1. Pheromone Production

Female insects release sex pheromones to signal their presence and attract male counterparts for mating. These pheromones are species-specific and are typically composed of complex blends of volatile compounds that are detected by male insects over long distances (Chen et al. 2018).

4.2. Pheromone Mimicry

In pest management strategies, synthetic sex pheromones can be developed to mimic the natural pheromones produced by female insects. These synthetic pheromones are often more stable and can be produced in large quantities for widespread application.

4.3. Attract-and-Kill Technique

The attract-and-kill technique involves deploying pheromone-baited traps or dispensers that lure male insects towards a source containing insecticidal agents. Male insects, attracted by the synthetic pheromones, come into contact with the insecticides and are effectively eliminated. This method disrupts the mating process by removing male insects from the population, leading to reduced reproduction rates and pest population control.

4.4. Disruption of Mating Communication

Sex pheromones can also be used to disrupt the mating communication between male and female insects. By saturating the environment with synthetic sex pheromones, it becomes difficult for males to locate receptive females, leading to reduced mating success and subsequent decrease in pest population (Cork et al. 2003).

4.5. Behavioral Confusion

Synthetic sex pheromones can cause confusion among male insects by overwhelming their olfactory senses and making it challenging for them to locate females. This interference in mating communication contributes to mate conflict and reduces successful mating encounters.

4.6. Species-Specific Approach

One of the advantages of using sex pheromones for pest management is their species-specific nature. By targeting the specific sex pheromones of a particular pest species, it is possible to control only the targeted pest while minimizing impacts on beneficial insects and non-target organisms.

4.7. Environmentally Friendly

The use of sex pheromones for mate conflict is an environmentally friendly approach to pest management. It reduces the reliance on chemical insecticides, which can have adverse effects on the environment, beneficial insects, and human health (Hajjar et al. 2023).

5. Application of Trap Plants

Trap cropping is a highly efficient method of conservation biological control that involves cultivating a non-crop plant in a specific area with the purpose of attracting pests away from the target crop. By luring the pests to the trap crop, the objective is to hinder their access to the main crop and subsequently manage their population to minimize damage. This approach has been successfully employed to combat various insect pests since the 1930s, resulting in a significant reduction in the reliance on pesticides, particularly in developing nations. For trap cropping to be effective, it is crucial to prevent the dispersal of insects from the trap plants back onto the focal crop, given the substantial pest population attracted to these new plants within agricultural fields (Xia and Sun 2012). In the case of borers that infest rice stems, such as SSBs (stem borer species) and PSBs (stem borers), they deposit their eggs on vetiver grass known as Vetiveria zizanioides. However, the life cycle of these borers does not reach completion on vetiver grass alone. In rice fields, the strategic presence of vetiver grass can effectively lure the borers into mature rice stems, encouraging them to lay their eggs there and thereby reducing pest levels. It has been determined that dedicating around 6-10% of the rice cultivation area to vegetable plantations between late March and early April

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

can serve as an effective means of achieving this outcome. Additionally, employing specific treatments can further suppress the populations of stem borers by removing their eggs and early-stage larvae (Liang et al. 2015).

In the case of rice insect pests, such as stem borers, trap plants play a crucial role in interrupting their life cycle and reducing their population. Stem borers, such as the *Scirpophaga incertulas* (yellow stem borer) and the *Chilo suppressalis* (striped stem borer), lay their eggs on the stems of rice plants. The hatched larvae bore into the rice stems, causing damage to the plant and affecting its yield. To effectively manage stem borers using trap plants, a combination of vetiver grass and rice cultivation is implemented. The vetiver grass is strategically planted in specific areas within the rice field, serving as a trap crop. The borers are attracted to the vetiver grass and deposit their eggs there. However, when the vetiver grass is placed near mature rice plants, the borers are "dragged" into the rice stems, where they complete their life cycle. This process significantly reduces the pest population in the main rice crop (Hajjar et al. 2023). The application of trap plants for the management of rice insect pests offers several benefits. It reduces the reliance on chemical pesticides, which can be costly and have negative impacts on the environment and human health. Trap cropping also provides a sustainable and environmentally friendly approach to pest management. Furthermore, it can help improve overall rice yields by minimizing the damage caused by stem borers and other pests.

6. Animal Husbandry Model Farm

The ecological planting and breeding system, which incorporates a combination of rice ducks, rice fish, rice soft-shelled turtles, and rice crabs, has evolved through self-regulation and is considered a superior system when compared to traditional rice cultivation methods. The introduction of ducks into the rice-duck system serves multiple purposes. Firstly, it helps to reduce inefficient tillers, promote gas exchange, enhance the decomposition of soil components, and improve the overall quality of the soil. Additionally, the presence of ducks in the rice fields increases the resistance of rice plants to pests and reduces pest populations. For instance, in the mid-rice and late rice seasons, the fourth and fifth generations of rice cultivations experienced a reduction of 70.2 and 70.4%, respectively, in comparison to the traditional system. Similarly, the second and third generations of stem borers (SSB) larvae were effectively controlled by the symbiotic behavior of rice and ducks, resulting in a decrease of 53.2 to 76.8% in pest numbers. Furthermore, the damage caused by SSB in mid-season and late-season rice was reduced by 13.4 to 47.1% (Zhu et al. 2015).

In addition to pest control, rice ducks also contribute to an increase in the population of natural enemies, which further aids in reducing pest populations. When compared to conventional paddy fields, rice fields with ducks showed a 63.6% increase in the number of spiders. Moreover, the presence of ducks led to 2.3 times increase in the ratio of spider hoppers to rice plants in the early season and 2.1 times increase in the late season. Parasitic rates of RLF larvae in duck-filled rice ranged from 53.0 to 61.3% in the early season and from 29.4 to 38.3% in the late season, which is significantly higher than in conventional rice farms. Additionally, the populations of spiders in rice fields with ducks were 1.05 to 3.21 times larger compared to conventional rice farms (Xiaoyan et al. 2005).

An animal husbandry model farm is a holistic approach to pest management in rice cultivation that combines the integration of livestock, such as ducks and fish, with rice farming practices. This innovative system aims to reduce the reliance on chemical pesticides and promotes sustainable and environmentally friendly pest control methods. The animal husbandry model farm for rice pest management typically includes the following components:

6.1. Rice-Duck Farming

Ducks play a crucial role in pest control within the rice fields. They are introduced into the rice paddies, where they forage on weeds, insects, and other pests. Ducks consume a variety of pests, including snails, slugs, weeds, and insect larvae, effectively reducing their populations. Additionally, the ducks' constant movement and grazing behavior help to aerate the soil, improve water circulation, and enhance decomposition, resulting in improved soil health (Liu et al. 2017; Xu et al. 2017; Xiuren et al. 2022).

6.2. Rice-Fish Farming

Another integral component of the animal husbandry model farm is rice-fish farming. Certain species of fish, such as the Chinese silver carp or the grass carp, are introduced into the rice fields. These fish feed on pests such as mosquito larvae and other insects that thrive in the waterlogged conditions of rice paddies. By consuming these pests, the fish help to maintain a balanced ecosystem and reduce pest populations.

6.3. Livestock Integration

In addition to ducks and fish, other livestock animals, such as soft-shelled turtles and crabs, may also be integrated into the animal husbandry model farm. Soft-shelled turtles feed on aquatic pests, including snails and insect larvae, while crabs help in controlling pests by scavenging on decaying organic matter and detritus, preventing the build-up of pests and disease vectors (Liu et al. 2017; Hajjar et al. 2023).

The animal husbandry model farm offers several advantages for rice pest management:

6.4. Natural Pest Control

By utilizing ducks, fish, turtles, and crabs, the animal husbandry model farm harnesses the natural predation and feeding behaviors of these animals to control pests. This approach reduces the need for chemical pesticides, minimizing environmental pollution and protecting beneficial organisms in the ecosystem.

6.5. Improved Soil Health

The constant movement and grazing behavior of ducks in the rice paddies help to aerate the soil, improving its structure and nutrient availability. Additionally, the droppings of these animals serve as natural fertilizers, enriching the soil with essential nutrients.

6.6. Enhanced Crop Resilience

The presence of animals in the rice fields contributes to improved crop resilience. Ducks, for example, help in reducing inefficient tillers and enhancing the exchange of gases, leading to healthier and more robust rice plants. Fish control insect pests that can damage rice plants and improve water quality by consuming excess algae and organic matter.

6.7. Diversification and Income Generation

Integrating livestock into the rice farming system provides farmers with additional sources of income. Besides rice cultivation, they can sell ducks, fish, turtles, or crabs, contributing to economic sustainability.

6.8. Reduced Input Costs

The animal husbandry model farm reduces the dependence on chemical pesticides, resulting in cost savings for farmers. This approach is particularly beneficial for small-scale farmers in developing countries who may face financial constraints in purchasing pesticides (Hajjar et al. 2023). It is important to note that the success of the animal husbandry model farm for rice pest management depends on careful planning and management. Factors such as the choice of suitable animal species, proper stocking densities, and appropriate rotation and timing of animals in the rice fields need to be considered for optimal results.

7. CONCLUSION

In conclusion, the biological management of rice pests offers a promising and sustainable approach to minimize the negative impacts of pests on rice production. By harnessing the power of natural enemies, such as predators, parasites, and pathogens, farmers can reduce the reliance on chemical pesticides and promote a healthier and more balanced ecosystem within rice fields. Biological control methods, such as the introduction of beneficial insects or the use of microbial agents, have shown great potential in suppressing pest populations and preventing yield losses. These methods target specific pests while minimizing harm to beneficial organisms and the environment, making them a preferred choice for integrated pest management strategies. Furthermore, the use of cultural practices, such as crop rotation, trap cropping, and proper field sanitation, can help disrupt the life cycles of pests and reduce their overall impact on rice crops. These practices not only contribute to pest control but also improve soil health and enhance overall agricultural sustainability. However, it is essential to recognize that biological management of rice pests is not a one-size-fits-all solution. Success depends on various factors, including the specific pest species, local environmental conditions, and the careful implementation of appropriate control measures. Therefore, it is crucial to conduct thorough research, monitor pest populations, and adapt management strategies accordingly. Overall, the adoption of biological management practices in rice production holds great promise for reducing pest-related losses, promoting sustainable agriculture, and safeguarding the long-term productivity of rice ecosystems. By embracing these approaches, farmers can achieve effective pest control while preserving the natural balance of the environment and ensuring the availability of safe and high-quality rice for future generations.

REFERENCES

Babendreier, D., Wan, M., Tang, R., Gu, R., Tambo, J., Liu, Z., ... & Romney, D. (2019). Impact assessment of biological control-based integrated pest management in rice and maize in the greater Mekong subregion. Insects, 10(8), 226.

Chen, Q. H., Zhu, F., Tian, Z., Zhang, W. M., Guo, R., Liu, W., ... & Du, Y. (2018). Minor components play an important role in interspecific recognition of insects: a basis to pheromone based electronic monitoring tools for rice pests. Insects, 9(4), 192.

Cork, A., Kamal, N. Q., Alam, S. N., Choudhury, J. S., & Talekar, N. S. (2003). Pheromone and their applications to insect pest control. Bangladesh journal of Entomology, 13(2), 1-13.

Citation: Iftikhar R, Hafeez S, Masood S, Shaheen A and Manzoor M, 2023. Biological control of rice insect pest: a critical review. Agrobiological Records 12: 68-75. https://doi.org/10.47278/journal.abr/2023.016

Hajjar, M. J., Ahmed, N., Alhudaib, K. A., & Ullah, H. (2023). Integrated Insect Pest Management Techniques for Rice. Sustainability, 15(5), 4499.

Haroon, M., Wang, X., Afzal, R., Zafar, M. M., Idrees, F., Batool, M., ... & Imran, M. (2022). Novel plant breeding techniques shake hands with cereals to increase production. Plants, 11(8), 1052.

Liang, Q., Lu, Y. H., He, X. C., Zheng, X. S., Xu, H. X., Yang, Y. J., ... & Lu, Z. X. (2015). Mini review of the significance of trap crop in insect pest management. Journal of Biosafety, 24(3), 184-193.

Liu, Q., Xu, J., Wang, Y., Li, C., Han, G., Qi, J., ... & Ma, T. (2013). Synergism of CmGV and Bacillus thuringiensis against larvae of Cnaphalocrocis medinalis Güenée. Journal of Yangzhou University, Agricultural and Life Sciences Edition, 34(4), 89-93.

Liu, S. S., Rao, A., & Vinson, S. B. (2014). Biological Control in China: Past, present and future—An introduction to this special issue. Biol. Control, 68(1), 5.

Liu, X., Xu, G., Wang, Q., & Hang, Y. (2017). Effects of Insect-Proof Net Cultivation, Rice-Duck Farming, and Organic Matter Return on Rice Dry Matter Accumulation and Nitrogen Utilization. Frontiers in plant science, 8, 47. https://doi.org/10.3389/fpls.2017.00047

Lou, Y. G., Zhang, G. R., Zhang, W. Q., Hu, Y., & Zhang, J. (2013). Biological control of rice insect pests in China. Biological Control, 67(1), 8-20.

Mo, J., Ding, W. B., Li, Y. Z., & Li, G. H. (2014). Control effect of 9% 12 α-hydroxy-rotenone EW against three pests of rice. Hunan Agric Sci, 10, 40-42.

Razzaq, A., Ali, A., Zahid, S., Malik, A., Pengtao, L., Gong, W., ... & Zafar, M. M. (2023). Engineering of cry genes "Cry11 and Cry1h" in cotton (Gossypium hirsutum L.) for protection against insect pest attack. Archives of Phytopathology and Plant Protection, 56(5), 384-396.

Razzaq, A., Ali, A., Zafar, M. M., Nawaz, A., Xiaoying, D., Pengtao, L., ... & Youlu, Y. (2021). Pyramiding of cry toxins and methanol producing genes to increase insect resistance in cotton. GM Crops & Food, 12(1), 382-395.

Razzaq, A., Ali, A., Safdar, L. B., Zafar, M. M., Rui, Y., Shakeel, A., ... & Yuan, Y. (2020). Salt stress induces physiochemical alterations in rice grain composition and quality. Journal of food science, 85(1), 14-20.

Ren, M., Zafar, M. M., Mo, H., Yang, Z., & Li, F. (2019). Fighting against fall armyworm by using multiple genes pyramiding and silencing (MGPS) technology. Sci China Life Sci, 62(12), 1703-6.

Tang, R., Babendreier, D., Zhang, F., Kang, M., Song, K., & Hou, M. L. (2017). Assessment of Trichogramma japonicum and T. chilonis as potential biological control agents of yellow stem borer in rice. Insects, 8(1), 19.

Tian, J. C., Wang, G. R., Zheng, X. S., Wang, G. W., Lu, Z. X., Xu, H. X., ... & Lu, Y. H. (2015). A Trichogramma Release Device with a Sugar Feeding Device. Chinese Patent ZL201420667926, 1.

Wang, G. R., Han, R. P., Shen, Q., Yang, W. T., Wang, G. D., Lu, Z. X., & Zheng, X. S. (2015). Effects of modified fertilizer application on rice pests, diseases and yields. China Rice, 21(6), 94-97.

Xia, Y. Z., & Sun, W. Y. (2012). Trapping and killing effects of Vetiveria zizanioides on rice stem borers. Zhejiang Agric Sci, 1(12), 1693-1695.

Xiaoyan, L., Dazhi, L., Yanfen, C., Huang, H., Lei, Z., & Jianbo, Y. (2005). The character of rice roots in rice-duck-fish commensalisms ecosystem and its economic benefit. Hunan Nong ye da xue xue bao= Journal of Hunan Agricultural University, 31(3), 314-316.

Xiuren Hu, Yu chen Yang, Kai Zhou, Ganpei Tian, Bo Liu, Huan He, Limin Zhang, Yun Cao, Bo Bian. (2022). Verification of agricultural cleaner production through rice-duck farming system and two-stage aerobic composting of typical organic waste, Journal of Cleaner Production, 337, 130576. https://doi.org/10.1016/j.jclepro.2022.130576

Xie, L. C., Jin, L. H., Lu, Y. H., Xu, H. X., Zang, L. S., Tian, J. C., & Lu, Z. X. (2022). Resistance of lepidopteran egg parasitoids, Trichogramma japonicum and Trichogramma chilonis, to insecticides used for control of rice planthoppers. Journal of Economic Entomology, 115(2), 446-454.

Xu, H. X., Zheng, X. S., Yang, Y. J., Tian, J. C., Lu, Y. H., Tan, K. H., ... & Lu, Z. X. (2015). Methyl eugenol bioactivities as a new potential botanical insecticide against major insect pests and their natural enemies on rice (Oriza sativa). Crop Protection, 72, 144-149.

Xu, G., Liu, X., Wang, Q., Yu, X., & Hang, Y. (2017). Integrated rice-duck farming mitigates the global warming potential in rice season. The Science of the total environment, 575, 58–66. https://doi.org/10.1016/j.scitotenv.2016.09.233

Yang, F. A., Sheng, C. F., & Wei, Y. B. (2001). Study on mating disruption with synthetic sex pheromone for controling rice stem borer. PLANT PROTECTION-BEIJING-, 27(3), 4-6.

Yuan, X. H., Song, L. W., Zhang, J. J., Zang, L. S., Zhu, L., Ruan, C. C., & Sun, G. Z. (2012). Performance of four Chinese Trichogramma species as biocontrol agents of the rice striped stem borer, Chilo suppressalis, under various temperature and humidity regimes. Journal of Pest Science, 85, 497-504.

Zhu, P. Y., Zheng, X. S., Yao, X. M., Xu, H. X., Zhang, F. C., Chen, G. H., & Lu, Z. X. (2015). Ecological engineering technology for enhancement of biological control capacity of egg parasitoids against rice planthoppers in paddy fields. China Plant Protection, 35(7), 27-32.