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Research Article

Effectiveness of New Systemic Insecticides on Rice Leaffolder (*Cnaphalocrocis Medinalis* Guenée) and Influence on Beneficial Insect Fauna

Arshed Makhdoom Sabir^{1*}, Bilal Atta¹, Muhammad Dildar Gogi², Muhammad Asif Farooq³, Muhammad Ijaz¹, Muhammad Ahsin Ayub⁴, Amjed Khan¹, Amara Nasiba¹, Muhammad Junaid Nisar², Muhammad Usman Saleem¹

¹ Rice Research Institute, Kala Shah Kaku 39020, Pakistan.

² Integrated Pest Management Laboratory, Department of Entomology, University of Agriculture, Faisalabad 38040, Pakistan.

³ Institute of Plant Protection, Muhammad Nawaz Sharif-University of Agriculture, Multan 66000, Pakistan.

⁴ Rice Research Station, Bahawalnagar 62230, Pakistan.

ABSTRACT

The rice leaffolder (*Cnaphalocrocis medinalis* Guenée) is a prominent pest of rice crops, resulting in substantial yield reductions globally. This study aimed to examine the effectiveness of novel systemic insecticides against *C. medinalis* while examining their effects on beneficial insect populations, essential for formulating sustainable pest management methods in rice agriculture. Fourteen systemic insecticides were assessed for their effectiveness against *C. medinalis* and their effects on beneficial insect populations. Insecticides were administered at prescribed field rates utilizing calibrated apparatus, with monitoring performed pre-treatment and at 72 hours and one-week post-treatment to evaluate pest death and the survival of beneficial insects. The pre-treatment populations of *C. medinalis* varied from 9.80 to 11.87 larvae per square metre, while the control group had an average of 10.87 larvae per square meter. Monitoring after treatment at 72 hours and one week indicated substantial decreases in insect numbers. Milzon 0.30% G, forecast 0.69% G, and Sirma 0.45% G shown the highest efficacy, with mortality rates of 90.72%, 88.82%, and 89.67% at 72 hours, and 95.71%, 92.88%, and 93.94% after one week, respectively. Conversely, Rector Super 0.35% G and the control group had no efficacy, with mortality rates of 79.26% and 0.00%, respectively. The survival rates of beneficial insects were highest in the control group (148.42%), followed by Forecast 0.69% G (72.06%), Milzon 0.30% G (71.66%), and Sirma 0.45% G (69.53%). The lowest survival rates were recorded for Power Drop 5.12% G (67.59%) and Agral Plus 5.44% G (65.90%). The results underscore the necessity of choosing insecticides that efficiently manage *C. medinalis* while reducing adverse effects on beneficial insects. It has been shown that Milzon 0.30% G, forecast 0.69% G, and Sirma 0.45% G are viable solutions for integrated pest control in rice agriculture. These alternative methods efficiently bring ecological sustainability and pest control into harmony with one another. It is recommended to conduct further research for the determination of long-term impact of these insecticides as well as to incorporate these insecticides with other pest control methods.



Correspondence

Arshed Makhdoom Sabir
amsabir@yahoo.co.uk

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INTRODUCTION

Rice is a major food crop which is cultivated all over the world and is responsible for the provision of basic nutrients to more than half of the population (Alam et al., 2020; Salgotra and Chauhan, 2023). Despite of this fact, crop yield is critically affected by

wide range of biotic stresses, for example, insect pest infestations (Singh et al., 2020; Shah et al., 2022; Chintalapati et al., 2023). The rice leaffolder, *Cnaphalocrocis medinalis* Guenée, is the major insect of rice crop especially in Asia, which is responsible for the major yield reduction (Singh et al., 2022; Zhao et al., 2023). Larvae of *C. medinalis* folded and scratch the green rice leaves which ultimately reduce the photosynthesis surface area, leads to deteriorate grain quality and production (Chintalapati et al., 2019; Zhao et al., 2023). Severe infestation of *C. medinalis* causes up to 60% yield losses (Chintalapati et al., 2017; Zhao et al., 2023).

Historically, the main pest management technique has been the use of chemical pesticides to control *C. medinalis* because they cause the highest mortality among insect species and are easy to use (Kumar et al., 2021; Reddy et al., 2023). The use of pesticides without considering their potential side effects has created many problems, including the development of insecticide resistance, the resurgence of secondary pests, and negative impacts on natural enemies and pollinators (Dey, 2016; Schechtman et al., 2020; Kumar et al., 2023). The cause of these problems has been linked to the harmful effects on the environment from the overuse of pesticides. Integrated pest management (IPM), which is effective in ecological relationships, addresses the public health and environmental risks that may be associated with the use of pesticides (Ali et al., 2021; Ádám et al., 2024; Kohli and Mittal, 2024).

Presently, the effectiveness of various insecticides on *C. medinalis* under field conditions is highly debated. These outcomes unveiled the selectiveness, residual activity and influence of these insecticides on beneficial insect fauna (Soomro et al., 2020; Kumar et al., 2021; Zala and Sipai, 2021). Modern insecticides, which includes diamides, neonicotinoids, and insect growth regulators (IGRs), have been found to be efficacious against *C. medinalis*. In addition, these pesticides have been revealed to reduce the incidence of negative consequence on non-target species (Chintalapati et al., 2016; Rath, 2017; Sulagitti et al., 2017). The diamide insecticide, chlorantraniliprole, has been shown to be highly effective against *C. medinalis* larvae, although it shows only mild toxicity to arthropods that help treat the disease (Rani et al., 2020; Sabitha et al., 2022). Botanical and microbial pesticides, particularly those derived from *Bacillus thuringiensis* (*Bt*), are gaining interest as extra ecologically friendly options (Gurr et al., 2012; Ashfaq et al., 2019; Seni et al., 2025).

The efficacy of insecticides can differ widely depending on variables such as application time, dose rate, formulation, and weather conditions (Adetuyi et al., 2012; Nansen and Ridsdill-Smith, 2013). Most importantly, despite these advances, the effectiveness of insecticides can still vary widely. Field-based research is especially significant for the aim of presenting ideas that are applicable to an area and enhancing the utilisation of pesticides within the framework of IPM (Peshin and Zhang, 2014; Pecenkaa et al., 2021; Yarahmadi and Rajabpour, 2024). In order to accomplish sustainable pest management and minimise dependency on synthetic pesticides, it is essential to combine chemical control with cultural, biological, and mechanical approaches (Hasan et al., 2007; Jaiswal et al., 2022; Thapa and Juyal, 2022).

The goal of this research is to examine the effectiveness of a range of insecticides against *C. medinalis* in the setting of field circumstances. More specifically, the study will concentrate on the influence that these insecticides have on the populations of pests and the predominance of natural enemies. We anticipate that with the assistance of this study, we will be able to give current insights into the effectiveness of a wide variety of insecticidal choices. This, in turn, will eventually contribute to the creation of strategies that are both effective and ecologically sustainable for the control of *C. medinalis*.

MATERIALS AND METHODS

Study Site

The study was conducted in rice fields at Rice Research Institute, Kala Shah Kaku, Punjab, Pakistan. This specific area was chosen because it has stable infection rates with *C. medinalis* and is home to a variety of insect species that are beneficial to the ecosystem. This area provided the ideal environment for assessing whether or not systemic insecticides are effective against *C. medinalis*, while at the same time analyzing the effects that these chemicals have on beneficial insects that are not the species that are meant to be targeted by these pesticides. From the very beginning, regular agronomic practices were used in order to guarantee that the rice fields were developed in a way that was uniform throughout all of the experimental plots.

Insecticide Selection

A total of fourteen different systemic insecticides were chosen for the purpose of study, along with a control that was not treated (Table 1). The selection of these pesticides was based on their systemic activity, market availability, and prospective effectiveness against *C. medinalis*.

Table 1. Details of insecticides including active components, classification, dose, and mode of action used against *Cnaphalocrocis medinalis* in the study.

Insecticides	Active ingredient	Classification	Dose per acre	Mode of action
Ferterra 0.4% G	chlorantraniliprole	Diamide	4 kg	Activates ryanodine receptors, causing paralysis
Refree 0.3% G	fipronil	Phenylpyrazole	8 kg	Blocks GABA receptors, leading to hyperexcitation
Actara 25% WG	thiamethoxam	Neonicotinoid	24 g	Agonist of nicotinic receptors, disrupting nerves
Oshin 20% SG	dinotefuran	Neonicotinoid	100 g	Agonist of nicotinic receptors, overstimulating nerves
Proclaim 1.9% EC	emamectin benzoate	Avermectin	8 kg	Activates glutamate receptors, causing paralysis
Pilot 4 G	catrap hydrochloride	Carbamate	9 kg	Inhibits acetylcholinesterase, disrupting nerves
Milzon 0.30% G	emamectin benzoate + chlorantraniliprole	Diamide + Avermectin	7 kg	Combines glutamate and ryanodine receptor activation
Forecast 0.69% G	chlorantraniliprole + thiamethoxam	Diamide + Neonicotinoid	3.5 kg	Combines ryanodine and nicotinic receptor activation
Eclipse 0.8% G	emamectin benzoate + indoxacarb	Avermectin + Oxadiazine	4 kg	Combines glutamate activation and sodium channel blocking
Mytosis 36% WP	thiamethoxam + dinotefuran	Neonicotinoid	100 g	Dual nicotinic receptor agonism
Power Drop 5.12% G	chlorantraniliprole + monomehypo	Diamide	7 kg	Combines ryanodine activation and sodium channel modulation
Agral Plus 5.44% G	catrap hydrochloride + fipronil	Carbamate + Phenylpyrazole	7 kg	Combines acetylcholinesterase inhibition and GABA blocking
Rector Super 0.35% G	chlorantraniliprole + emamectin benzoate	Diamide + Avermectin	4 kg	Combines ryanodine and glutamate receptor activation
Sirma 0.45% G	fipronil + chlorantraniliprole	Phenylpyrazole + Diamide	8 kg	Combines GABA blocking and ryanodine receptor activation

Experimental Design

The experiment was planned using a Randomized Complete Block Design (RCBD) with three replications. Each treatment was randomly allocated to plots within blocks to reduce variability and ensure unbiased results. The plot dimensions were standardized for uniformity, and a buffer zone was established between plots to avert cross-contamination of treatments.

Insecticide Application Protocol

Insecticides were applied at prescribed field rates with a calibrated knapsack sprayer for liquid formulations and a granular applicator for solid formulations. Applications were conducted in the early morning to reduce spread and maximize insecticide absorption. The control plots were not subjected to pesticide treatment. All applications were executed by trained staff to guarantee consistency and precision.

Monitoring Protocols

Pre-treatment Population Assessment

Prior to the application of insecticides, baseline data on *C. medinalis* numbers and beneficial insect fauna were gathered. *C. medinalis* larvae were enumerated per square meter via a standardized visual counting sample technique. Beneficial insects were sampled by visual observations to determine their initial diversity and abundance.

Post-treatment Monitoring

Post-application monitoring was conducted at two intervals: 72 hours and one week following treatment. The comparative development of *C. medinalis* populations was documented to assess variations in larval density. The percent mortality of *C. medinalis* was determined by comparing larval counts before and after treatment. The survival rate of beneficial insect fauna was evaluated after one week to ascertain the effects of pesticides on non-target organisms.

Statistical Analysis

Mortality data for *C. medinalis* and the survival rates of beneficial insects were documented and analyzed with Statistix 8.1 software. The experiment was evaluated using RCBD ANOVA to ascertain the significance of treatment effects. The Least Significant Difference (LSD) test was utilized for mean separation to discern variations among treatments. All statistical analyses were conducted at a 5% significance threshold.

RESULTS

The research assessed the impact of several insecticides on the *C. medinalis* and the survival rate of beneficial insect species. The pre-treatment average populations of *C. medinalis* ranged from 9.80 to 11.87 among treatments, with the control group exhibiting an average of 10.87. The highest pre-treatment average was recorded for Refree 0.3% G (11.87), followed by Milzon 0.30% G (11.33), Eclipse 0.8% G (11.67), and Actara 25% WG (11.20). The minimum pre-treatment value was observed in Rector Super 0.35% G (9.80), indicating a marginally reduced initial pest infestation in that treatment group (Table 2).

Post-treatment relative progression in the average count after 72 hours indicated substantial decreases in the pest population for the majority of insecticides. The minimal progression values were noted for Milzon 0.30% G (0.25), Forecast 0.69% G (0.31), Eclipse 0.8% G (0.34), and Mytosis 36% WP (0.34), signifying swift suppression of the *C. medinalis* population. In contrast, the highest values were recorded with Rector Super 0.35% G (0.58) and Control (2.77), indicating negligible effectiveness in diminishing insect populations in both treatments. After one week, the minimal relative progression was noted in Milzon 0.30% G (0.08), succeeded by Sirma 0.45% G (0.12), Forecast 0.69% G (0.13), and Eclipse 0.8% G (0.17), underscoring their sustained effectiveness in controlling the insect population over time. The most significant progression values after one week were observed for Rector Super 0.35% G (0.37) and Control (1.85), further substantiating the ineffectiveness of these treatments (Table 2).

The percentage of mortality after 72 hours shown significant variability among different pesticides. The greatest mortality was recorded for Milzon 0.30% G (90.72%), followed closely by Forecast 0.69% G (88.82%) and Sirma 0.45% G (89.67%), demonstrating significant initial efficacy against the *C. medinalis*. Additional efficacious treatments comprised Agral Plus 5.44% G (87.22%), Eclipse 0.8% G (87.75%), and Actara 25% WG (82.99%). The lowest death rates were seen for Rector Super 0.35% G (79.26%) and Control (0.00%), signifying that these treatments were the least efficacious in eliminating *C. medinalis* within the initial three days. After one week, the highest fatality rates were observed in Milzon 0.30% G (95.71%), Forecast 0.69% G (92.88%), and Sirma 0.45% G (93.94%), indicating persistent lethal effects. Additional treatments with notable mortality rates comprised Eclipse 0.8% G (90.97%) and Mytosis 36% WP (91.59%). The lowest death rate was observed in Rector Super 0.35% G (80.00%) and Control (0.00%), underscoring their ineffectiveness poor managing the pest population over an extended period (Table 2).

The pre-treatment average counts of beneficial insect fauna varied from 9.80 to 11.87, with the Control group recording 10.33. The Control group exhibited the highest survival rate of beneficial insect fauna after one week, at 148.42%, indicating no detrimental impacts on non-target organisms. The insecticidal treatments with the highest survival rates were Forecast 0.69% G (72.06%), Milzon 0.30% G (71.66%), and Sirma 0.45% G (69.53%), suggesting a comparatively less effect on beneficial insects. Alternative treatments, including Ferterra 0.4% G (69.15%), Oshin 20% SG (74.05%), and Actara 25% WG (72.00%), shown satisfactory survival rates of beneficial fauna. The lowest survival rates were observed for Power Drop 5.12% G (67.59%) and Agral Plus 5.44% G (65.90%), indicating a more pronounced detrimental effect on non-target insect populations (Table 2).

The pesticides exhibited differing levels of effectiveness in managing *C. medinalis*, while also affecting beneficial insect populations variably. Milzon 0.30% G, forecast 0.69% G, and Sirma 0.45% G exhibited the highest mortality rates of *C. medinalis* while preserving moderate to high populations of beneficial insect fauna, suggesting their efficacy as pest management alternatives. In contrast, Rector Super 0.35% G and Power Drop 5.12% G exhibited comparatively lower mortality rates and a more significant decline in beneficial insect survival, rendering them less advantageous options. *C. medinalis* did not experience any mortality as a consequence of the treatment that served as the control. This treatment had the greatest survival rate of insect beneficial fauna. Selection of suitable pesticides that effectively control pests while protecting beneficial species is crucial as this emphasizes the need for such selection. Pesticide selection in rice IPM systems can be greatly improved with the help of these studies, which provide important information (Table 2).

Table 2. Impact of insecticides on *Cnaphalocrocis medinalis* and beneficial insect fauna under field conditions

Insecticides	Pre-treatment (Average number)	Post-treatment				Beneficial insect fauna/ 5 plants	
		Relative progression in average number after		Percent mortality after		Pretreatment (Average number)	Survival percentage after one week
		72 hours	Week	72 hours	Week		
Ferterra 0.4% G	11.73	0.53 bc	0.36 bc	80.75 gh	80.44 g	10.67	69.15 bc
Refree 0.3% G	11.87	0.39 defg	0.22 ef	85.97 cde	88.10 cd	10.40	70.47 bc
Actara 25% WG	11.20	0.47 bcd	0.29 cde	82.99 fg	84.30 ef	10.47	72.00 bc
Oshin 20% SG	11.20	0.43 cdef	0.25 de	84.31 def	86.27 de	10.13	74.05 bc
Proclaim 1.9% EC	10.67	0.45 cde	0.26 de	83.66 efg	85.70 de	10.47	76.17 b
Pilot 4 G	11.53	0.51 bc	0.33 bcd	81.64 fgh	81.96 fg	11.20	65.60 c
Milzon 0.30% G	11.33	0.25 h	0.08 h	90.72 a	95.71 a	10.73	71.66 bc
Forecast 0.69% G	11.27	0.31 gh	0.13 gh	88.82 abc	92.88 ab	10.60	69.06 bc
Eclipse 0.8% G	11.67	0.34 fgh	0.17 fg	87.75 bc	90.97 bc	10.13	74.35 bc
Mytosis 36% WP	10.93	0.34 fgh	0.15 fgh	87.74 bc	91.59 b	10.40	72.15 bc
Power Drop 5.12% G	10.73	0.44 cdef	0.25 e	83.96 ef	86.40 de	11.00	67.59 bc
Agral Plus 5.44% G	10.00	0.36 efgh	0.15 fgh	87.22 bcd	91.79 b	11.27	65.90 c
Rector Super 0.35% G	9.80	0.58 b	0.37 b	79.26 h	80.00 g	11.27	69.91 bc
Sirma 0.45% G	11.53	0.28 gh	0.12 gh	89.67 ab	93.94 ab	10.60	69.53 bc
Control	10.87	2.77 a	1.85 a	0.00 i	0.00 h	10.33	148.42 a
LSD	NS	0.12	0.08	2.94	3.21	NS	8.81

DISCUSSION

In addition to providing valuable information on the efficacy of several systemic insecticides against *C. medinalis*, the findings also shed light on the impact of these insecticides on beneficial insect populations. The specific formulation showed considerable mortality against *C. medinalis* while causing moderate adverse effects on non-target beneficial insects. The results showed significant differences in the effectiveness of the insecticides studied. Previous research has proven the necessity to combine some insecticides into IPM approaches to minimize the environmental destruction that happens (Heong et al., 2015; Bottrell and Schoenly, 2012). These outcomes are trustworthy with the present research. This research emphasizes the requirement to align the efficiency of insect pest management with ecological

conservation, specifically in rice ecosystems that are favorably responsive to ecological conflicts (Gurr et al., 2017). The research exclusively emphasizes the significance of confirming effective insect pest management.

Efficacy of Insecticides Against *C. medinalis*

After 72 hours and one week of insecticides application, Milzon 0.30% G, forecast 0.69% G and Sirma 0.45% G caused maximum mortality against *C. medinalis*. These findings are coherent with those of Su et al. (2017) and Aquino et al. (2022) have found that systemic insecticides, such as chlorantraniliprole and thiamethoxam, are extremely efficacious against lepidopteran insect pests, respectively. The quick mortality of *C. medinalis* population was due to the systemic actions of the tested insecticides which certified that the insecticide is distributed completely to the plant tissues and the residual efficiency is reserved for an extended time (Finlayson and MacCarthy, 1965; Sandanayake et al., 2021). According to the study of Jeschke et al. (2011), systemic insecticides are specifically successful against internal consuming insect pests such as *C. medinalis* due to their absorption by the plant and dispersed to several tissues in the plant. However, Rector Super 0.35% G was least efficacious, emphasizing the significance of choosing an insecticide that is efficient against specific insect pests. Differences in insecticide action, formulation, and application methods may explain the differences in effectiveness (Zhang et al., 2011).

Impact on Beneficial Insect Fauna

These findings highlight the probable harm that use of indiscriminate insecticide could do to non-target insect pests, which are fundamental for natural pest management (Gurr et al., 2017). Beneficial insects, including predators and parasitoids, facilitate the biological management of pests, hence diminishing dependence on chemical insecticides (Pretty and Bharucha, 2015). A substantial efficiency was observed in Milzon 0.30% G, forecast 0.69% G, and Sirma 0.45% G against *C. medinalis*, whereas simultaneously keeping higher survival rates of beneficial insect fauna (69.53% to 72.06%). This indicates that these insecticides may possess a more selective mechanism of action, reducing unintended harm to beneficial species. Lu et al. (2019) demonstrated similar results, showing that specific neonicotinoids and diamides possess less toxicity to natural enemies relative to broad-spectrum insecticides. The selective toxicity of these pesticides may be due to the presence of specific metabolic targets that are less common in beneficial insects (Nauen et al., 2003).

Nevertheless, minimum survival rate of beneficial insect fauna was observed in Power Drop 5.12% G (65.90%) and Agral Plus 5.44% G (67.59%), which means that these two insecticides have a more adverse impact on the ecosystem than their target. The results of current study are in line with the previous study of Desneux et al. (2007), where risk of exposure to broad spectrum insecticides was focused. These insecticides disturb the environmental equilibrium by adversely disturbing natural enemies and initiating secondary infections in other insect pests. Decreases in beneficial insect populations propose that primary pests might come back or that secondary pests could develop. The same happening has been showed in rice ecosystems which were treated with non-selective insecticides (Heong et al., 2015). In line with Wilson and Tisdell (2001), the influence of insecticides consumption is raising dependency on chemicals, leading to environmental and financial obstacles.

CONCLUSIONS

As per the findings of this study, systemic insecticides demonstrate varied changeability in their efficacy against *C. medinalis* and in their impact on beneficial insect fauna. With the continuous development of sustainable rice production systems, it is essential to find insecticides that can not only effectively control insect pests but also protecting beneficial insect fauna in rice crops. Keeping in mind the future prospects, research should be based on long-term field bioassays to investigate the persistence of these effects and study the risk of combination these insecticides with other IPM technologies, to increase environmental sustainability. Furthermore, prioritizing the development of novel pesticides with enhanced selectivity and diminished environmental impact is essential to tackle the issues of pest management in rice ecosystems.

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AUTHOR CONTRIBUTIONS

AMS and BA conceptualized the study and recorded the data. AMS, BA and MDG statistical analyzed the data. BA, MAF, MAA and THA wrote Introduction section of the manuscript. AMS, BA, MDG, MAA, AK and AN wrote methodology section of the manuscript. AMS, BA, AK, MJN and MUS wrote results and discussion section of the

manuscript. THA and MUS edited the format of the manuscript according to the format of this journal. The final manuscript was ultimately perused, scrutinized and approved for final submission by all the authors.

COMPETING OF INTEREST

No conflicts of interest have been disclosed by the authors.

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