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COMPARISON OF BIOLOGICAL AND CHEMICAL METHODS FOR MANAGING FALL ARMY WORM IN *ZEA MAYS*

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Abstract

The present study evaluated the efficacy of botanical extracts (*Chenopodium ambrosioides* and *Citrullus indica*) and synthetic insecticides (Cypermethrin and Lambda-cyhalothrin) against *Trogoderma granarium* larvae in field conditions. The experiment measured larval mortality before and after treatment application at intervals of 1, 3, 7, and 14 days. Results revealed significant differences among treatments ($p < 0.05$). Lambda-cyhalothrin exhibited the highest efficacy, achieving 100% mortality within 7 days and a mean mortality of 0.60 across intervals. Cypermethrin followed closely, with a mean mortality of 1.26. Among botanical treatments, *C. ambrosioides* demonstrated better performance (mean mortality of 3.09) than *C. indica* (2.80), though both showed reduced efficacy compared to control. The untreated control group showed minimal mortality, with a mean of 4.85. These findings highlight the potential of botanical extracts as alternative pest control agents, though synthetic insecticides remain more effective under field conditions. The study underscores the importance of integrating eco-friendly botanicals into pest management programs to reduce reliance on synthetic chemicals and promote sustainable agricultural practices.

Keywords: Botanical extracts, Eco-friendly pest control, Larval mortality, synthetic insecticides, *Trogoderma granarium*

Introduction

The fall armyworm (*Spodoptera frugiperda*), an invasive and highly destructive pest, has become a significant challenge to maize (*Zea mays*) production globally. Since its first detection in the Americas, this pest has spread rapidly to Africa, Asia, and recently, South Asia, including Pakistan (Fatima et al., 2021; Sharanabasappa et al., 2018). In Pakistan, maize is a critical staple crop and a vital source of income for smallholder farmers. However, the fall armyworm poses a substantial threat to the country's agricultural productivity, with reports of severe yield losses in maize fields across Punjab, Sindh, and Khyber Pakhtunkhwa (Abbas et al., 2022). Traditionally, synthetic insecticides such as pyrethroids and organophosphates have been employed for fall armyworm control due to their rapid action and effectiveness (Hussain et al., 2021). However, overreliance on chemical pesticides has resulted in several challenges, including the emergence of insecticide resistance, environmental contamination, and negative impacts on non-target organisms (Sparks and Nauen, 2015; Fatima et al., 2021). For instance, resistance to synthetic insecticides has been reported in fall armyworm populations in several parts of Asia, emphasizing the urgent need for alternative management strategies (Gutierrez-Moreno et al., 2019). Biological control methods provide an eco-friendly and sustainable approach to pest management. In Pakistan, natural enemies such as parasitoids, predators, and microbial agents like *Bacillus thuringiensis* (Bt) have shown potential in controlling fall armyworm populations (Abbas et al., 2022). Additionally, botanical pesticides derived from indigenous plants, such as *Azadirachta indica* (neem), are being explored for their effectiveness in reducing pest populations while minimizing environmental risks (Fatima et al., 2021). Recent studies have highlighted the importance of integrating biological and chemical control methods under an integrated pest management (IPM) framework to achieve sustainable pest control (Abrahams et al., 2017). This study evaluates the efficacy of biological and chemical control methods for managing fall armyworm infestations in maize (*Zea mays*) in Pakistan. By assessing their impacts on larval mortality, crop yield, and environmental safety, the research provides insights into developing region-specific IPM strategies to mitigate the threat posed by fall armyworm. The findings aim to contribute to sustainable pest management practices in Pakistan's agricultural systems while addressing the challenges of food security.

Material and Methods

The study was conducted in a maize field located in Cereal Crop Research Institute, Nowshera during 2024. The experiment followed a randomized complete block design (RCBD) with five treatments and three replications. The treatments included two botanical extracts (Chenopodium ambrosioides and Citrullus indica), two synthetic insecticides (Cypermethrin and Lambda-cyhalothrin), and an untreated control.

Plant and Insect Material

Zea mays (maize) was grown under standard agronomic practices, including proper spacing, irrigation, and fertilization. Fall Armyworm (Spodoptera frugiperda) larvae were identified in the field before treatment application. The infestation level was assessed by visually inspecting randomly selected plants for larval presence and feeding damage.

Preparation of Botanical Extracts

Fresh leaves of C. ambrosioides and fruits of C. indica were collected, washed, and shade-dried for seven days. The dried plant material was ground into a fine powder using an electric grinder. Aqueous extracts were prepared by soaking 50 g of powdered material in 500 mL of distilled water for 24 hours. The solution was filtered using muslin cloth and diluted to obtain the desired concentration (5% w/v) before application.

Insecticide Application

Commercial formulations of Cypermethrin (25% EC) and Lambda-cyhalothrin (5% EC) were used according to manufacturer-recommended dosages. The treatments were applied using a knapsack sprayer in the early morning hours to minimize environmental degradation.

Data Collection and Assessment

Larval mortality was recorded at 1, 3, 7, and 14 days post-treatment. A total of 10 plants per plot were randomly selected, and the number of live larvae was counted. The mean mortality was calculated for each treatment and time interval.

Statistical Analysis

Data were analyzed using analysis of variance (ANOVA) in SPSS software, and significant

differences among treatments were determined at $p < 0.05$. Means were separated using Tukey's Honest Significant Difference (HSD) test.

Environmental and Safety Considerations

All treatments were applied following recommended safety guidelines to minimize environmental impact and ensure researcher safety. Protective gear was worn during application, and untreated buffer zones were maintained to prevent cross-contamination between treatments. This methodological approach ensured reliable and reproducible data collection to assess the comparative efficacy of botanical and synthetic insecticides against Fall Armyworm in maize fields.

Results and Discussion

The data presented in the Table 1 highlights the comparative efficacy of botanical extracts (*Chenopodium ambrosioides* and *Citrullus indica*) and synthetic insecticides (Cypermethrin and Lambda-cyhalothrin) against target pests, measured at intervals of 1, 3, 7, and 14 days after spraying. Significant differences ($p < 0.05$) were observed among treatments in terms of pest reduction over time, as indicated by the LSD values. Prior to spraying, the initial pest population showed minor variations, with the highest pre-treatment count recorded for *Lambda-cyhalothrin* (8.58) and the lowest for the control group (5.66). After one day of treatment, a rapid reduction in pest population was observed across all treatments. Among the synthetic insecticides, *Lambda-cyhalothrin* achieved the most significant reduction, with a mean population of 1.73, followed by Cypermethrin (2.70). The botanical treatments showed moderate efficacy, with *C. ambrosioides* and *C. indica* reducing the population to 4.15 and 3.70, respectively, while the control group exhibited no significant reduction (4.70). By the third day, *Lambda-cyhalothrin* and Cypermethrin continued to outperform botanical treatments, reducing pest counts to 0.70 and 1.70, respectively. Among the botanicals, *C. indica* and *C. ambrosioides* demonstrated comparable efficacy, with pest counts of 3.17 and 3.29, respectively. The control group showed a slight increase in pest population (4.90), likely due to the absence of treatment effects. At seven days post-treatment, *Lambda-cyhalothrin* eradicated the pest population entirely (0.00), while Cypermethrin resulted in a near-total reduction (0.66). The botanicals continued to show moderate effectiveness, with *C. ambrosioides* and *C. indica* reducing pest populations to 2.76 and 2.66, respectively. Conversely, the control group recorded an increase in pest population (5.16). After 14 days, *Lambda-cyhalothrin* and Cypermethrin maintained their superior performance, achieving complete pest eradication (0.00 for both). The botanical treatments exhibited slower but continued pest reduction, with *C. ambrosioides* and *C. indica* recording mean populations of 2.16 and 1.66, respectively. The control group remained ineffective, with a final mean population of 4.66. Across all time intervals, the overall mean efficacy ranked as follows: *Lambda-cyhalothrin* (0.60) > Cypermethrin (1.26) > *C. indica* (2.80) > *C. ambrosioides* (3.09) > Control (4.85). The results demonstrate the superior efficacy of synthetic insecticides (*Lambda-cyhalothrin* and Cypermethrin) over botanical treatments in managing pest populations.

Lambda-cyhalothrin consistently outperformed all other treatments, achieving complete pest eradication by the seventh day and maintaining this efficacy through 14 days. These findings align with previous studies reporting the rapid action and high potency of pyrethroid-based insecticides against various pest species (Sparks and Nauen, 2015). Cypermethrin also demonstrated significant pest suppression, albeit slightly less effective than *Lambda-cyhalothrin*. The synthetic insecticides' rapid mode of action and residual effects make them highly effective for short-term pest management strategies. Botanical treatments (*C. ambrosioides* and *C. indica*) showed moderate efficacy, with slower pest reduction compared to synthetic insecticides. *C. indica* outperformed *C. ambrosioides* across all time intervals, suggesting differences in their phytochemical compositions and bioactive compounds. The effectiveness of these botanical extracts can be attributed to secondary metabolites such as alkaloids, terpenoids, and phenolics, which are known to exhibit insecticidal and repellent properties (Isman, 2006). However, the slower action and lower potency of botanical treatments compared to synthetic insecticides underscore their limitations for achieving immediate pest control in high-pressure scenarios. The control group exhibited increasing pest populations throughout the study period, confirming the absence of natural mortality or external suppression factors. This emphasizes the need for intervention strategies to manage pest infestations effectively. From a sustainability perspective, botanical treatments offer a safer alternative to synthetic insecticides, particularly in agro-ecological systems where environmental and health risks from chemical pesticides are a concern. While synthetic insecticides remain indispensable for rapid pest suppression, integrating botanical extracts into pest management programs could help reduce pesticide resistance and environmental contamination (Abbas et al., 2022; Regnault-Roger et al., 2012). Further research is required to enhance the efficacy of botanical formulations, optimize their application methods, and explore their compatibility with integrated pest management (IPM) strategies.

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Table 1: Efficacy of different treatments against the fall army worm under field condition during 2023.

Treatments	Before Spraying	After Spraying				
		1	3	7	14	Mean
C. ambrosioides	6.57 c	4.15 b	3.29 b	2.76 b	2.16 b	3.09 b
C. indica	7.56 b	3.70 c	3.17 c	2.66 b	1.66 c	2.80 c
Cypermethrine	7.53 b	2.70 d	1.70 d	0.66 c	0.00 d	1.26 d
Lambda cyalothrine	8.58 a	1.73 e	0.70 e	0.00 d	0.00 d	0.60 e
Control	5.66 d	4.70 a	4.90 a	5.16 a	4.66 a	4.85 a
LSD $_{(0.05)}$	0.16	0.80	0.60	0.25	0.31	0.10

Mean in columns followed by the same letters are non-significant at 5% level of probability

Conclusion and Recommendations

This study highlights the superior efficacy of synthetic insecticides, particularly *Lambda-cyhalothrin*, in rapidly suppressing pest populations, achieving complete eradication by the seventh day, while botanical extracts (*C. ambrosioides* and *C. indica*) demonstrated moderate but sustainable pest control potential. To enhance pest management strategies, integrating botanical extracts with synthetic insecticides in an IPM framework is recommended to balance immediate pest suppression with environmental sustainability. Further research is needed to optimize botanical formulations, validate their field efficacy, and promote their adoption as eco-friendly alternatives to synthetic chemicals.

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