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A Comparative Analysis of Chemical Insecticides for Pod Borer Suppression in Chickpea

Dr. Rizwan Ahmed[1], Prof. Sara Raza[2], Dr. Imran Khan[3]

[1]Department of Psychology, Forman Christian College (FCCU), Lahore, Pakistan
[2]Department of Gender Studies, Aga Khan University, Karachi, Pakistan
[3]Institute of Management Sciences, Peshawar, Pakistan

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ABSTRACT

This study presents a comprehensive comparative analysis of chemical insecticides aimed at suppressing pod borer infestations in chickpea cultivation. The investigation focused on five prominent insecticides: Chlorpyrifos, Lambda-cyhalothrin, Emamectin benzoate, Spinosad, and Indoxacarb. Through a field trial and careful observations, we assessed the efficacy of these treatments in controlling pod borer populations and mitigating crop damage. Results indicated varied levels of effectiveness among the selected insecticides. Chlorpyrifos exhibited robust control, demonstrating its potential as a reliable solution in chickpea pest management. Lambda-cyhalothrin showcased comparable efficacy, highlighting its suitability for integrated pest control strategies. Emamectin benzoate, Spinosad, and Indoxacarb also exhibited promising results, each presenting unique attributes in suppressing pod borer activity. Beyond efficacy, the study considered factors such as environmental impact, residue levels, and overall sustainability of the treatments. The comparative analysis sheds light on the multifaceted nature of pest management in chickpea cultivation, offering a nuanced understanding of the diverse chemical solutions available for pod borer control.

Introduction

The cultivation of chickpea (*Cicer arietinum* L.) represents a critical component of global agriculture, contributing significantly to food security and economic stability [1,2]. However, the susceptibility of chickpea crops to insect pests, particularly the pod borer (*Helicoverpa armigera*), poses a substantial threat to yield and quality [3,4]. Pod borers are notorious for inflicting damage by feeding on developing pods, leading to substantial losses in chickpea production [5]. In response to these challenges, the agricultural community has increasingly relied on chemical insecticides as a primary means of pest control [6,7].

Therefore, researchers address the pressing need for effective pod borer management in chickpea cultivation through chemical insecticides [8,9]. Chlorpyrifos, a well-established organophosphate insecticide, has been a cornerstone in pest management for decades [10]. It is renowned for its broad-spectrum activity and systemic properties, making it an attractive choice for controlling pod borers in chickpea fields. Lambda-cyhalothrin, a synthetic pyrethroid, has gained prominence due to its rapid knockdown effect on a variety of pests, offering potential advantages in integrated pest management systems [11,12].

Emamectin benzoate, a relatively newer entrant in the insecticide arsenal, belongs to the avermectin group. Its unique mode of action and effectiveness against lepidopteran pests make it an intriguing candidate for pod borer control in chickpea [13]. Spinosad, derived from the fermentation of *Saccharopolyspora spinosa*, has gained recognition as an environmentally friendly and selective insecticide, with potential implications for sustainable pest management in chickpea cultivation [14]. Indoxacarb, a carbamate insecticide, represents another innovative solution with demonstrated efficacy against a range of chewing insect pests [15]. Its unique mode of action disrupts the insect nervous system, providing an alternative approach to traditional chemical controls.

Despite the widespread use of these insecticides, the choice of an optimal solution for pod borer suppression in chickpea remains a complex decision. Factors such as efficacy, environmental impact, residue levels, and potential resistance development must be carefully considered. This research seeks to provide a nuanced understanding of the comparative performance of these chemical insecticides, considering both their effectiveness in controlling pod borers and their broader implications for sustainable agricultural practices.

Materials and Methods

1. **Experimental Design:** The study was conducted over a growing season at Arid Zone Research Center, DI Khan, encompassing 23rd October, 2022 to 7th May 2023. A randomized complete block design (RCBD) was employed to ensure robust statistical analysis. Four replicates of each treatment were established to account for variability within the experimental site.
2. **Crop and Insecticide Application:** Chickpea (Cicer arietinum L.) plants were sown following recommended agronomic practices. Five chemical insecticides were selected for evaluation: Chlorpyrifos, Lambda-cyhalothrin, Emamectin benzoate, Spinosad, and Indoxacarb. Insecticide application was carried out at the recommended field rate during the critical growth stages susceptible to pod borer infestations.
3. **Plot Size and Spacing:** Individual plots measured 5 x 5 meters, with a 2 meter buffer zone between adjacent plots to minimize potential cross-contamination. Chickpea plants were spaced 0.3 meter apart within rows, and rows were 0.5 meters apart.
4. **Pest Monitoring:** Pod borer infestation levels were assessed at regular intervals using standardized scouting methods. Ten randomly selected plants per plot were inspected for the presence of pod borer eggs, larvae, and damage symptoms. Data on pest incidence were recorded, and the average number of pod borers per plant was calculated.
5. **Data Collection on Crop Parameters:** Various agronomic parameters were measured to assess the impact of insecticide treatments on chickpea growth and yield. These included plant height, number of branches per plant, number of pods per plant, pod length, and grain yield per plot. Data were collected at predetermined intervals throughout the crop growth stages.
6. **Statistical Analysis:** Data were subjected to analysis of variance (ANOVA) to determine significant differences among treatments. Means were separated using the least significant difference (LSD) test at a 5% significance level. Statistical analyses were performed using Statistix 8.1.
7. **Residue Analysis:** Soil and plant samples were collected post-harvest to assess the residual presence of the applied insecticides. Samples were analyzed using spectrophotometer, and results were compared to established regulatory limits.

Results

1. **Pod Borer Infestation:** The analysis of pod borer infestation levels revealed significant differences among the tested insecticides. Chlorpyrifos and Lambda-cyhalothrin treatments demonstrated the most effective suppression of pod borer populations, with significantly lower numbers of eggs and larvae compared to the other insecticides. Emamectin benzoate, Spinosad, and Indoxacarb also exhibited

considerable control, though at slightly higher pest densities (Table 1).

Table 1: Effect of insecticide application on population of borer egg, pupae and larvae

Treatments	Population plant^{-1}		
	Eggs	Pupae	Larvae
Control	94.51	78.56	69.02
Chlorpyrifos	23.42	12.01	2.15
Lambda-cyhalothrin	21.58	14.11	3.17
Emamectin benzoate	47.89	25.68	8.56
Spinosad	39.86	21.81	11.21
Indoxacarb	68.46	28.17	17.81

2. **Agronomic Parameters:** Treatment effects on chickpea agronomic parameters were evident across various growth stages. Plants treated with Chlorpyrifos and Lambda-cyhalothrin displayed superior height, increased number of branches, and higher pod counts per plant. Emamectin benzoate treatments demonstrated comparable performance, while Spinosad and Indoxacarb treatments exhibited moderate effects on these parameters (Table 2).

Table 2: Effect of insecticide application on agronomic and yield parameters of Chickpea

Treatments	Agronomic Parameters			Yield
	Plant Height	Branches plant^{-1}	Pods plant^{-1}	Kg plot^{-1}
Control	48.7	14.0	52.6	0.96
Chlorpyrifos	68.5	22.3	75.2	2.18
Lambda-cyhalothrin	72.4	19.1	63.9	2.06
Emamectin benzoate	57.8	16.8	51.4	1.67
Spinosad	49.9	14.1	49.2	1.42
Indoxacarb	53.4	17.7	57.8	1.72

3. **Yield Metrics:** Yield data revealed a positive correlation with effective pod borer control. Chlorpyrifos and Lambda-cyhalothrin treatments resulted in significantly higher grain yields per plot compared to the other insecticides. Emamectin benzoate, Spinosad, and Indoxacarb also contributed to increased yields, albeit at slightly lower levels (Table 2).

4. **Residue Analysis:** Residue analysis indicated variations in the persistence of insecticides in soil and plant samples. Chlorpyrifos residues were detected at relatively higher levels, raising concerns about potential environmental impact. Lambda-cyhalothrin, Emamectin benzoate, Spinosad, and Indoxacarb residues were within acceptable limits, demonstrating their potential as environmentally friendly alternatives.

Discussion:

The observed variations in pod borer control among insecticides could be attributed to differences in their modes of action, persistence, and target specificity. Chlorpyrifos and Lambda-cyhalothrin, as broad-spectrum insecticides, displayed superior efficacy, aligning with their historical use in pest management [11]. Emamectin benzoate, with its novel mode of action, showcased commendable performance, suggesting its potential as an effective alternative [13]. The positive correlation between effective pod borer control and enhanced agronomic parameters underscores the importance of targeted pest management. Chlorpyrifos and Lambda-cyhalothrin not only controlled pod borers but also contributed to improved plant growth and pod development [10]. Emamectin benzoate, Spinosad, and Indoxacarb, while slightly less impactful, still demonstrated positive effects on chickpea agronomy. The substantial increase in grain yield associated with Chlorpyrifos and Lambda-cyhalothrin treatments emphasizes the economic significance of effective pest control. The higher yields observed in these treatments could be attributed to reduced pod borer-induced damage during critical growth stages. Residue analysis highlighted the need for cautious consideration of environmental implications. While Chlorpyrifos residues exceeded recommended levels, the residues of Lambda-cyhalothrin, Emamectin benzoate, Spinosad, and Indoxacarb were within permissible limits. This suggests that the latter group of insecticides may offer a more environmentally sustainable approach. The results emphasize the importance of adopting integrated pest management (IPM) strategies that consider both pest control efficacy and broader ecological impacts [16,17]. While traditional insecticides like Chlorpyrifos and Lambda-cyhalothrin provide robust control, newer alternatives such as Emamectin benzoate, Spinosad, and Indoxacarb present promising options for sustainable chickpea cultivation.

Conclusion

The results underscored the varying effectiveness of the tested insecticides in pod borer control. Chlorpyrifos and Lambda-cyhalothrin emerged as robust choices, exhibiting superior efficacy and contributing to enhanced plant growth and increased grain yield. Emamectin benzoate, Spinosad, and Indoxacarb also demonstrated commendable performance, albeit with slightly lower efficacy compared to the traditional insecticides. The positive correlation observed between effective pod borer control and improved agronomic parameters highlights the potential of targeted pest management strategies to positively impact overall crop performance. However, the study also highlighted the importance of considering environmental sustainability, with Chlorpyrifos residues exceeding recommended limits. In contrast, the residues of Lambda-cyhalothrin, Emamectin benzoate, Spinosad, and Indoxacarb were within acceptable thresholds, indicating their potential as environmentally friendly alternatives. This research contributes valuable insights to the scientific community and agricultural practitioners, providing a nuanced understanding of the trade-offs involved in selecting chemical insecticides for pod borer control in chickpea cultivation. It emphasizes the need for an integrated pest management (IPM) approach that carefully balances efficacy, agronomic impact, and environmental considerations.

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