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Laboratory and field evaluation of selected insecticides against Locusts and Grasshoppers: Towards sustainable pest management in Egyptian agriculture

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Abstract
Locusts and grasshoppers infestations pose significant threats to agricultural productivity and food security, particularly in regions like Egypt, where sustainable pest management strategies are urgently needed. This study evaluated the efficacy of three insecticides spinosad, alpha-cypermethrin, and cypermethrin, as potential alternatives to chlorpyrifos, which has been banned for locusts control in Egypt since December 2023. Laboratory trial was conducted to assess mortality rates of the desert locust *Schistocerca gregaria* (Forsskål, 1775) (*Orthoptera, Acrididae*), while field trial was conducted to assess mortality rates of the desert locust *S. gregaria*, the african migratory locust *Locusta migratoria* Fairmaire & L.J. Reiche, 1849 (*Orthoptera, Acrididae*), and the grasshopper lamenting grasshopper *Eyprepocnemis plorans* Charpentier, 1825 (*Orthoptera, Acrididae*). In laboratory conditions, alpha-cypermethrin and cypermethrin demonstrated superior efficacy, achieving 99.63% and 96.30% mortality, respectively, after 48 hours, while spinosad reached only 74.07% on *S. gregaria*. Field trials in 2022 and 2023 corroborated these findings, with pyrethroids consistently achieving 96–100% mortality across all species, compared to spinosad's moderate efficacy (62.96 - 74.07%). Statistical analyses confirmed significant differences between spinosad and the pyrethroids, with no notable variation in susceptibility among the target species.
The study highlights alpha-cypermethrin and cypermethrin as highly effective, fast-acting alternatives to chlorpyrifos, aligning with their neurotoxic mode of action and lower environmental persistence. In contrast, spinosad's slower lethality limits its utility during acute outbreaks, despite its favorable safety profile. These findings underscore the importance of selecting context-appropriate insecticides for integrated pest management (IPM) programs, balancing efficacy, speed of action, and environmental impact. The results provide critical insights for policymakers and agricultural stakeholders in Egypt and similar regions, advocating for pyrethroid-based strategies to mitigate locust-driven crop losses while adhering to sustainable practices.

Keywords: *Schistocerca gregaria, Locusta Migratoria, Eyprepocnemis Plorans,* alpha-cypermethrin, cypermethrin, spinosad, insecticide efficacy, sustainable agriculture

Introduction

One of the most damaging invasive plant pests is locust. Under specific environmental circumstances (such as particularly heavy rainfall), they can alter their behavior and appearance. Also they shift from solitary individuals to a collective mass of insects known as swarms. In the deserts of North Africa, the Middle East, and Southwest Asia, solitarious locusts (Desert Locust) are found in small numbers during periods of calm or recessions. This desert region, referred to by the FAO as the "recession area", spans over 30 countries and covers about 16 million km² in size. In extreme situations, swarms have the potential to infiltrate a landmass that is almost 20% of the Earth's surface (FAO, 2015).

According to a preliminary assessment by the Pakistani government, the financial losses resulting from desert locusts in 2020 and 2021 were estimated to be between 3.4 billion and 10.21 milliards US dollars. Food insecurity affects about 3 million people in Pakistan, with the situation in Balochistan being especially dire. Due to crop losses, around 34,000 people will require emergency assistance for food security and livelihood support. Moreover, Crop losses might have an indirect impact on a much larger population, which would raise the price of important commodities. Also, farmers suffer large losses as a result of the severe economic effects, which lead to government relief initiatives to lessen the financial burden (FAO 2020).

In order to prevent locust infestations and grasshopper outbreaks, chemical treatment has been the primary way of control (Rachadi, 2010) [28]. Since the 1940s, chemical pesticides and their application methods for controlling locusts and grasshoppers have undergone multiple changes. Sodium arsenite baits were initially employed, but they were later superseded by the newly discovered organochlorine compounds as dusting agents or baits. However, because of labor challenges and a slow rate of application, liquid pesticides were sprayed as the ideal way to treat large areas quickly (Duranton *et al*., 1987) [10].

In Egypt, organic phosphorus compounds are thought to be the main ingredients used to fight grasshoppers and locusts. The sole substance authorized by the Egyptian Ministry of Agriculture's Agricultural Pesticides Committee for the control of locusts in recent years is chlorpyrifos, whether in the form of ultra-fine particles or emulsifiable concentrates. The Agricultural Pesticides Committee has banned its use on termites, cotton, and locusts from December 31, 2023, therefore It is necessary to look for substitute pesticides that are equally effective for use during swarms or outbreaks.

Dobson (2000) [8] mentioned that chemical pesticides from the groups organophosphates, carbamates, pyrethroids, phenyl pyrazole, and benzoylurea were used in locust control operations during that period. Broad range insecticides are among them (Arthurs, 2008) [5]. The Pesticide Referee Group (PRG) (an independent advisory body of the FAO) suggests many pesticides particularly for the management of locusts. PRG states that *Metarhizium acridum* (Driver & Milner) should be used first, followed by insect growth inhibitors, while neurotoxic pesticides should considered only as a last resort. Thus, the current study aims to assess the effects of a selected licensed insecticides, such as chlorpyrifos substitutes in Egypt, against locusts and grasshoppers in both lab and field conditions.

Materials and Methods

Insect Rearing

The laboratory bioassay conducted against newly emerged fifth-instar nymphs of *S. gregaria* utilized specimens obtained from a laboratory stock colony maintained by the Locust and Grasshoppers Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki. The insects were reared under densely breeding conditions as outlined by Robert *et al*. (2002) [29]. Fresh and clean leaves of berseem (*Medicago sativa*) were introduced during winter to maintain the survival and growth of the desert locust (*S. gregaria*), whereas leaves of the leguminous plant *Sesbania aegyptiaca* were utilized as food during summer. The locusts were reared under controlled conditions at a temperature of 30 ± 2°C and a relative humidity of 30–50%.

Tested Insecticides

In this study, three water-based insecticides registered in Egypt according to the Agricultural Pesticides Committee were applied at their recommended concentrations. Trade names, active ingredients, and rates of application as follows:

1- Tracer® 24% Sc (spinosad 24% SC) at a rate of 100 ml/feddan.

2- Super Alpha® 10% EC (Alpha-cypermethrin H) at a rate of 250 ml/feddan.

3- Cyperco® 20% EC (cypermethrin) at a rate of 300 ml/feddan.

Laboratory Trials

This study was carried out at the Locust and Grasshopper Research Department. Ninety individuals fifth-instar nymphs of the *S. gregaria* were divided into three replicates for treatment. Other thirty nymphs were used as control group. The application Insecticides technique involved a dipping food technique. The food (leaves of berseem or leguminous plant) was immersed in the insecticidal solution for 30 seconds, and then left to air till dry completely; away from direct sunlight. The insects were starved for 12 hours and then offered the treated food. Daily mortality was recorded and corrected according to Abbott's formula (1925) [1].

Field Trials

Insects and Site of the Study

The present study was conducted in the El Farafra Oasis, southwestern Egypt, during the 2022 and 2023 agricultural seasons. The investigation was conducted on several orthopteran species belonging to the family Acrididae, including *S. gregaria*, *L. migratoria*, E. plorans, and multiple grasshopper species. The experimental area was cultivated with *Zea mays*, heavily infested with locusts and grasshoppers. The population was mixed with adults and nymphs of *S. gregaria* (17.4%), *L. migratoria* (35.8%), and *E. plorans* (46.8%). The average number was 28 insects/m^2 (ranging between 26 - 30 insects/m^2).

Insecticides Technique

Spray Equipment and Calibration

The three previously selected insecticides were applied at their standard recommended rates against *S. gregaria*, *L. migratoria*, and *E. plorans*. A motorized knapsack mist blower equipped with a standard No. 3 spray nozzle for low-volume (LV) treatment upwind was used in the present investigation. Spray solution flow rates and swath width were determined according to Dobson (2001) [9] and Cressman & Dobson (2001) [7, 9] procedures.

Application Criteria

In the present study, the application criteria for water-based formulations applied via the LV spray technique were as follows: a flow rate of 1.25 L/min, a track spacing of 5 m, an application speed of 2.4 km/hr, a spray volume of 67.5 L/feddan, a spray height of 0.5 m, a wind speed of 2-3 m/sec, and a temperature range of 18-25°C.

Experimental Design

The experimental zone was divided into plots, with three replicates for each of three pesticides and a control treatment. Each replicate was 1050 m² (50 m x 21 m). The plots were distributed in a completely randomized pattern and separated by a broad swath of 50 m² (5 m x 10 m). The aforementioned LV upwind spray technique was applied for three water-based insecticides.

For mortality assessment, ninety insects of each species were randomly collected by using a sweeping net two hours after treatment from each treated plot. The collected insects were placed in 3 cages (as replicates); which were placed under field conditions in a shaded area. The insects were fed daily on plants from the relevant treated plots. Daily mortality was recorded and corrected according to Schneider-Orelli's formula (Püntener, 1981). [17].

Statistical Analysis

All data were subjected to one-way analysis of variance (ANOVA) at $p < 0.05$ according to (Gomez & Gomez, 1984) [16]. To differentiate between means, Duncan's LSD test at the P = 0.05 probability was used.

Results

Laboratory Trials

The corrected mortality rates for the fifth-instar nymphs of the desert locust treated with three insecticides: spinosad, alpha-cypermethrin, and cypermethrin at two time intervals (24 and 48 hours post-treatment) are presented in Table 1. Based on the data after 24 hours, spinosad induced the lowest mortality rate (60.0%), which was significantly lower than both alpha-cypermethrin (93.33%) and cypermethrin (90.0%). A similar pattern was observed after 48-hours, where spinosad mortality increased significantly to 74.07%, but remained statistically lower than alpha-cypermethrin (99.63%) and cypermethrin (96.30%). Statistical analysis also revealed that there is no significant differences were observed between mortality rates induced by alpha-cypermethrin and cypermethrin at both time intervals.

Furthermore, the mortality rate of spinosad showed a significant increase over time, indicating a relatively slower action. In contrast, both alpha-cypermethrin and cypermethrin demonstrated a rapid knockdown efficacy, achieving consistently high mortality rates within the first 24 hours and consistently high levels throughout the observation period.

Table 1: The corrected mortality percentage (mean ± SE) of the selected insecticides on the fifth nymphal instar of the desert locust in laboratory

Hours**	Spinosad*	Alpha-cypermethrin*	Cypermethrin*
24	60.0 ± 3.34^{bB}	93.33 ± 3.33^{aA}	90.0 ± 0^{aA}
48	74.07 ± 2.18^{bA}	99.63 ± 0.34^{aB}	96.30 ± 0.43^{aB}
F Value	12.463	3.536	213.609

Values followed by same letter are not significantly differ ($p < 0.05$).
* Small letters indicate significant difference between rows (within insecticides).
**capital letters indicate siginficant difference between columns (within hours).

Field trials

Field Mortality of Insecticides in 2022-2023

Field experiments conducted during the 2022-2023 seasons revealed significant differences in mortality rates among the three tested insecticides (spinosad, Alpha-cypermethrin, and Cypermethrin) on the three-insect species *S. gregaria*, *L. migratoria*, and *E. plorans*, as shown in Table 2. Mortality percentages increased over time, with higher values recorded at 48 hours post-treatment compared to 24 hours. Spinosad induced moderate mortality in both seasons across all tested species. Specifically, In the 2022 season, mortality rates for *S. gregaria*, *L. migratoria*, and *E. plorans* were (53.33%, 56.67% and 50.00%), respectively aftert 24 hours, and for 48 hours (67.86%, 71.34%, and 64.29%), resp ectively. A similar trend was observed in the 2023 season, where the corresponding values were (63.33%, 63.33%, and 56.67%), respectively aftert 24 hours, and for 48 hours were (70.37%, 74.07% and 62.96%), respectively. In contrast, both alpha-cypermethrin and cypermethrin demonstrated high and rapid efficacy across all species and seasons. For alpha-cypermethrin, in the 2022 season mortality rates after 24 hours for *S. gregaria*, *L. migratoria*, and *E. plorans* were (96.7%, 96.67% and 93.33%) respectively, and for 48 hours were (100%, 100% and 96.67%), respectively. In the 2023 season, where the values after 24 hours were (90.00%, 90.00% and 90.00%), respectively. While after 48 hours the corresponding values were (100%, 100%, and 92.59%), respectively. Cypermethrin also showed the similar trend in all tested insect species: in the 2022 season mortality rates after 24 hours for *S. gregaria*, *L. migratoria*, and *E. plorans* were (93.33%, 96.67% and 90.0%) respectively, and for 48 hours were (100%, 100%, and 96.4%), respectively. In the 2023 season, where the values after 24 hours were (95.0%$, 95.0%, and 93.2%), respectively. While after 48 hours the corresponding values were (100%, 100% and 96.3%), respectively.

Statistical analysis (Table 2) confirmed significant differences in efficacy among insecticidal treatments. Spinosad was significantly less effective than both Alpha-cypermethrin and Cypermethrin, which did not differ significantly from each other. However, when comparing the overall mortality responses across the three insect species, no differences were detected over time, suggesting a similar susceptibility pattern among *S. gregaria*, *L. migratoria*, and *E. plorans* to the tested insecticides. Overall, the field results across both seasons confirmed the robustness of this pattern: spinosad showed moderate and delayed action, while alpha-cypermethrin and cypermethrin exhibited rapid and almost complete mortality across all species.

Comparison Between the Two Field Seasons (2022 vs. 2023)

When comparing results between the two seasons, Cypermethrin consistently showed the highest and most stable mortality rates across all species and time points, with slightly improved efficacy in 2023. Alpha-cypermethrin also maintained high efficacy in both years, although minor variations were observed. Spinosad remained the least effective compound, though a slight improvement in its mortality percentages was observed in 2023.

Overall, statistical analysis across seasons indicates that Cypermethrin and Alpha-cypermethrin are significantly more effective than spinosad in controlling all three locust species. The lack of significant differences among insect species within each season suggests a consistent response across target pests, enhancing the reliability of the findings.

Table 2: The corrected mortality percentage (mean ± SE) of the selected insecticides on *S. gregaria*, *L. migratoria*, and *E. plorans* during the 2022–2023 field seasons

Season	Active ingredient**	Mortality Percentages							
		After 24 hrs				After 48 hrs			
		*S. gregaria**	*L. migratoria**	*E. plorans**	F value	*S. gregaria**	*L. migratoria**	*E. plorans**	F Value
2022	Spinosad	53.33 ± 1.9^{abB}	56.67 ± 1.93^{aB}	50 ± 1.71^{bB}	278.11	67.86 ±1.19^{abB}	71.34 ± 2.4^{aB}	64.29 ± 1.16^{bB}	315.34
	Alpha-cypermethrin	96.7 ± 1.91^{aA}	96.67 ± 1.73^{aA}	93.33 ± 3.33^{aA}	515.37	100 ± 0^{aA}	100 ± 0^{aA}	96.67 ± 1.93^{aA}	574.61
	Cypermethrin	93.33 ± 3.85^{aA}	96.67 ± 1.93^{aA}	90.0 ± 3.34^{aA}	294.93	100 ± 0^{aA}	100 ± 0^{aA}	96.4 ± 1.6^{bA}	3.35
	F Value	78.85	153.64	69.35		729.45	149.08	137.19	
2023	Spinosad	63.33 ± 3.34^{aB}	63.33 ± 1.92^{aB}	56.67 ± 1.9^{aB}	203.34	70.37 ± 2.91^{aB}	74.07 ± 1.09^{aB}	62.96 ± 0.74^{bB}	257.52
	Alpha-cypermethrin	90.0 ± 00^{aA}	90.0 ± 3.34^{aA}	90.0 ± 3.335^{aA}	364.14	100 ± 00^{aA}	100 ± 00^{aA}	92.59 ± 1.79^{bA}	538.19
	Cypermethrin	95.0 ± 2.31^{aA}	95.0 ± 1.16^{aA}	93.2 ± 1.18^{aA}	1.11	100 ± 00^{aA}	100 ± 00^{aA}	96.3 ± 2.03^{aA}	518.17
	F Value	52.74	53.84	75.74		103.59	563.89	127.49	

Values followed by the same small letter at each column, or by the same capital letter at each row are not significantly different at $P = 0.05$.
* Small letters indicate significant differences between rows
**Capital letters indicate siginficant differences between columns

Discussion

The present study demonstrated marked differences in the efficacy of spinosad, alpha-cypermethrin, and cypermethrin against the three insect species (*S. gregaria*, *L. migratoria*, and *E. plorans*) under both laboratory and field conditions. Overall, both alpha-cypermethrin and cypermethrin exhibited rapid insecticidal activity and consistently high mortality rates across all tested species. In contrast, spinosad was moderately effective, characterized by delayed action and lower mortality rate. These findings are not consistent with Hosny *et al*. (2010) [19] who reported 75% and 100% mortality in *S. gregaria* at 24 and 48 hours post-treatment, respectively, under laboratory conditions. Also Their field trials using spinosad at a concentration of 50 ml/100 L against grasshoppers resulted in a mortality of 83.3% and 100% after same intervals, respectively. Similarly, Ali *et al*. (2017) [4] reported that spinosad (Tracer® 24% SC) applied at 65 ml/100 L water under Egyptian field conditions caused mortality rates of 64 and 89%, and in lab. the mortality were 75 and 100% in *S. gregaria* within 24 and 48 hours post-treatment, respectively. Likewise, field studies of Soliman *et al*. (2019) [32] showed that spinosad at dose rate of 15.12 g. a. i. /ha resulted in 98, 99 and 100% mortality to mixed populations of hoppers and adults of *S. gregaria* within two days of field application. In addition; in lab., the corrected mortality rates after 3 days of treatment with 30, 60, 120 and 180 ppm of spinosad were (34.48% and 62.1%,), (55.2% and 79.3%), (86.2% and 100%) and (100% and 100 %) for the 5th nymphal instar and adults of *S. gregaria*, respectively. The result also disagrees with the finding by Kamel (2018) [20] who indicated that spinosad (under laboratory conditions) caused 100% mortality to the 4th instar hoppers of *S. gregaria* after 48 hours of treatment using feeding technique, as well as a high rate of mortality in the hoppers after 48hrs of field treatment. Our results partially overlap with those of Ebrahim *et al*. (2024) [11] reported mortality rates of 71% in adults and 67% in hopper instars of *S. gregaria* at 96h post-treatment. Furthermore, they assessed the proportional impact of contact toxicity versus stomach poisoning induced by spinosad on *S. gregaria*. Their findings indicated that contact toxicity was more effective than stomach poisoning on both adult locusts and hoppers. Meanwhile, adults demonstrated more susceptible greater susceptibility than hoppers to both modes of action. Additionally, they evaluated the residual levels of spinosad on treated plants, and the data demonstrated a rapid decline in spinosad concentrations on plants from 4.582 mg/kg one hour after application to 0.098 mg/kg by day 6 post treatment.

The high performance of alpha-cypermethrin and cypermethrin recorded in our trials is consistent with earlier studies.

Abdel-Ghaffar *et al*. (2019) [2] investigated the efficacy of cypermethrin (10% EC) applied at nymphal instars and adults of various grasshopper species under field conditions in Egypt. Mortality percentages were assessed at 24, 48, and 72 hours post-treatment using full doses, half doses, and quarter doses. Notably, the half doses resulted in mortality percentages similar to those of the full dose. The mortality percentages for grasshopper nymphs and adults after 24 hours were 87.60% and 94.80%, after 48 hours were 98.80% and 89.60%, and after 72 hours were 95.60% and 99.20%, respectively with a full dose. For the half dose, the percentages were 80.40% and 87.20% after 24 hours, 95.20% and 81.20% after 48 hours, 88.40%, and 96.40% after 72 hours, respectively. With a quarter dose, the percentages were 76.00% and 81.20% after 24 hours, 90.80% and 77.60% after 48 hours, 83.60%, and 91.20% after 72 hours, respectively, which is in agreement with the results of this research.

Similarly, in Uzbekistan Sanjar *et al*. (2022) [31] conducted field experiments to determine the efficacy of alpha-cypermethrin in two pesticides (ALPAC 100 EC and Alpha 10% s.k.) against nymphs of Moroccan and Italian locusts. ALPAC 100 EC caused the same results of mortality rates in both nymphs of Moroccan and Italian locusts were 94.8% and 98.9% at 3 and 24 hours after treatment, respectively. And it was noted that within 1 hour after treatment, the nymphs stopped feeding and moving. Meanwhile, the highest mortality rates (96.2 and 97.4%) respectively, were observed 24 hours after treatment both young and old nymphs of Italian locust with Alpha 10% s.k at a dose of 0.1-0.15 L/ha.

Overall, both the present and previous studies indicate that spinosad can effectively control *S. gregaria*, but, its delayed action compared to pyrethroids limits its role as a sole agent during acute outbreaks. stand-alone option in emergency control of locust outbreaks. Spinosad is a bioinsecticide consisting of spinosyn A and D, secondary metabolites of the soil bacterium *Saccharopolyspora spinosa* (Thompson *et al*., 2000) [33]. It is a neurotoxin that has both contact and stomach activity, and its primary mode of action is through altering the function of GABA-gated chloride channels leading to prolonged neuronal excitation and eventual mortality (Salgado, 1998 [30] and Thompson *et al*., 2000) [33]. This mechanism explains its relatively slower insecticidal activity. On the other hand, spinosad is environmentally favorable and relatively safe to non-target organisms (Biondi *et al*., 2012 [6], NPIC, 2014 and WHO, 2019). These characteristics make it a valuable for sustainable Integrated Pest Management (IPM) programs, this supports its role as a sustainable alternative in non-emergency contexts.

In addition to biopesticides like spinosad, which offer environmentally safer alternatives but comparatively lower efficacy, chemical insecticides such as pyrethroids have been extensively investigated. For instance, the grasshopper Zonocerus *variegatus* treated with varying cypermethrin doses showed behavioral modifications. These alterations included numbness, abrupt death, ovipositor opening, exhaustion, muscular spasms, and hyperactivity (Agwu *et al*., 2016) [3]. Abdel-Ghaffar *et al*. (2019) [2] attributed cypermethrin's superior control efficacy against grasshopper nymphal instars and adults to its higher octanol/water partition coefficient (Log Kow = 6.54), which increases lipophilicity and enhances increases the insecticide's deposition on the insect's body surface. Consistently, a study by Hinks *et al*. (1989) [18] reported that cypermethrin is a lipophilic, highly hydrophobic molecule whose distribution within the insect is probably significantly impacted by the hemolymph's carrying capacity, rate of circulation, and rate of partitioning into the internal organs.

However, the high efficacy of broad-spectrum chemical insecticides like cypermethrin and organophosphates such as chlorpyrifos, their use raises serious health and environmental concerns. Chlorpyrifos formulations, in particular, exhibit unpredictable behavior and and carriage serious risks to farmers' health, particularly through inadvertent acute pesticide poisoning, which mostly affects farmers in Bangladesh, India, Vietnam, and Laos (Watts, 2023) [36]. According to several additional studies, farmers are harmed by chlorpyrifos, and the harm is exacerbated when personal protective equipment is not used (Phung *et al*., 2012 [27]; Venugopal *et al*., 2021 [35]; Marasinghe, *et al*., 2014 [24] and Liem *et al*., 2021) [23].

The efficacy of insecticides in controlling locusts and grasshoppers is a critical aspect of sustainable pest management, particularly in regions like Egypt, where these pests pose significant threats to agricultural productivity and food security. Building on the comparative efficacy of spinosad and pyrethroids, the identification of suitable substitutes for hazardous insecticides like chlorpyrifos is essential for sustainable locust management. The primary chemical substitutes for chlorpyrifos fall into following groups: avermectins, spinosyns, neonicotinoids, diamide insecticides, and pyrethroids (ECHA, 2024) [12]. However, the selection of any alternative must be preceded by severe assessment of its health and environmental risks in compliance with the International Code of Conduct on Pesticide Management and the standards for highly hazardous pesticides (HHP), to ensure a genuinely safer option (PAN, 2021) [26]. Among these, pyrethroids such as alpha-cypermethrin and cypermethrin stand out for their outstanding performance. Their mode of action (interfering with sodium channel function in the insect nervous system) induces rapid paralysis and death (Elliot *et al*., 1978) [13]. The high efficacy of pyrethroids against african migratory locust (*L. migratoria*) and the desert locust (*S. gregaria*) as demonstrated in this study, underscores their value in rapid response strategies. Moreover, their effectiveness against the grasshopper *E. plorans* suggests broad applicability for controlling mixed pest populations in Egyptian agriculture (FAO, 2020). The use of fast-acting pyrethroids can help minimize such losses by swiftly reducing pest populations before they reach critical levels. Additionally, their lower environmental persistence compared to chlorpyrifos reduces the risk of long-term ecological harm (Zhang *et al*., 2011) [39].

Spinosad and spinetoram are categorized as slightly dangerous and unlikely to produce acute hazard, respectively, in accordance with WHO's Recommended Classification of Pesticides by Hazard (WHO, 2019). 110. Lepidoptera, Diptera, and some members of numerous other insect groups, including grasshoppers, leafhoppers, spider mites, and cockroaches, are among the many pests that spinosyns are effective against with broad-spectrum activity (Kirst, 2010) [21]. The larvae of sawflies, some beetles, psyllids, fleas, red fire ants, and several Orthoptera are additional target insects (US EPA, 2009). Compared to other broad-spectrum pesticides like chlorpyrifos, the spinosyns are less toxic and provide less of a risk to aquatic, mammalian, and avian species. They are specifically designed to target insects. (NPIC, 2014; National Pesticide Information Center).

Pyrethroids are particularly effective against locust swarms due to their fast-acting nature, which is crucial for mitigating large-scale infestations. Their rapid degradation in the environment also reduces residual toxicity, making them a safer alternative to organophosphates like chlorpyrifos (WHO, 2020). The current findings align with previous studies highlighting pyrethroids as the preferred choice for emergency locust control (Latchininsky *et al*., 2011) [22].

Conclusion

This study highlights alpha-cypermethrin and cypermethrin as highly effective and rapid alternatives to chlorpyrifos for locust and grasshopper control in Egypt. In addition, their relatively favorable safety profiles make them indispensable tools for managing outbreaks of both local and migratory pest species. Future research should explore synergies between pyrethroids and biopesticides like *Metarhizium acridum* to enhance sustainable pest management strategies. Based on field trial findings, it was proposed that these insecticides be added to Egypt's list of pesticides approved for use against locusts.

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