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Efficacy of some chemicals and bioinsecticides against cotton mealybug *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) as a new recorded pest of sugar beet in Egypt

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Abstract

The purpose of this study was to evaluate the effectiveness of chemical and bioinsecticides against the cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), which was recently found infesting sugar beet (*Beta vulgaris* L.) in Egypt. Lambda-cyhalothrin, mineral oil, sulfoxaflor, and Biossiana® are some of the chemical and bioinsecticides that are commonly used. Field trials were conducted over two consecutive growing seasons (2022–2023) in Kafr El-Sheikh Governorate using a randomized complete block design. Results demonstrated that lambda-cyhalothrin and sulfoxaflor achieved the highest population reductions (99.92% and 99.31%, respectively), with rapid knockdown effects attributed to their neurotoxic modes of action. Mineral oil showed delayed but significant efficacy (98.4% reduction by day 10), consistent with its physical mode of action. The biofungicide Biossiana® exhibited progressive control (96.1–99.31% reduction), with its performance linked to wax degradation and cuticular penetration. The study demonstrated that the efficacy of control measures against *P. solenopsis* was substantially influenced by the pest's distinctive morphological adaptations, most notably its protective wax coating and cryptic feeding behavior. These biological traits underscore the importance of adopting integrated pest management strategies that combine chemical and biological control methods. To optimize management outcomes, applications should be timed to coincide with vulnerable life stages, while treatment combinations should be employed to counteract the pest's wax-mediated resistance mechanisms. Furthermore, regular rotation of control agents is essential to maintain long-term effectiveness. This research aimed to provide crucial insights for developing sustainable management approaches against this recent pest infested sugar beet, offering solutions that balance effective control with environmental conservation.

Introduction

Sugar beet (*Beta vulgaris* L.) is a crop of global importance, primarily cultivated for sugar production. In Egypt, it holds significant economic value, particularly in

regions like Kafr El-Sheikh Governorate, where optimal climate and fertile soils favor its cultivation (FAO, 2021 and Fergani *et al.*, 2023). However, sugar beet productivity is frequently compromised by

biotic stressors, including insect pests such as aphids, leaf miners, and root maggots (Dewar and Cooke, 2006). Among these, the presence of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), commonly known as the cotton mealybug. This pest is traditionally associated with cotton and other broadleaf crops (Hodgson *et al.*, 2008) but has recently emerged as a potential threat to sugar beet, possibly due to shifting agricultural practices or climatic conditions. *P. solenopsis* is a small, soft-bodied insect (2–5 mm in length) covered with a white, waxy secretion that forms filamentous extensions around its body margins (Hodgson *et al.*, 2008). This wax coating serves as a protective barrier against desiccation and pesticide penetration, complicating chemical control efforts (Wang *et al.*, 2019). The pest's piercing-sucking mouthparts enable it to feed on phloem sap, leading to leaf yellowing, stunted growth, and honeydew excretion, which promotes sooty mold growth (Tanwar *et al.*, 2012). The mealybug's cryptic behavior, often hiding in leaf axils or soil crevices, further reduces exposure to contact insecticides (Fand *et al.*, 2015). These morphological and behavioral traits underscore the need for targeted control strategies. The management of insect pests in sugar beet typically relies on integrated pest management (IPM) strategies, which include the judicious use of chemical insecticides (Dewar, 2017). In this study, we evaluated the efficacy of three insecticides and a bio-fungicide against *P. solenopsis* in a sugar beet field. The insecticides tested were lambda-cyhalothrin, a pyrethroid insecticide known for its broad-spectrum activity (IRAC, 2023); mineral oil, which acts as a physical insecticide by suffocating pests (University of California Statewide IPM Program, 2023) and sulfoxaflor, a sulfoximine insecticide effective against sap-feeding insects (EPA, 2023). Additionally, a biofungicide (Biossiana®) was included to

assess its potential role in pest management, given its ability to enhance plant health and resilience.

The study was conducted over two consecutive growing seasons (2022 and 2023) in Kafr Askar, Kafr El-Sheikh Governorate, Egypt, using the local sugar beet variety "Halawa." The experimental design aimed to determine the effectiveness of these treatments in reducing *P. solenopsis* populations and to provide insights into their potential integration into sugar beet pest management programs.

1. Tested insecticides:

1.1. Lambda-cyhalothrin (Ogef® 10% WP): applied at a rate of 25 gm per 100 liters of water.

1.2. Mineral oil (Royal oil® 82%): Applied at a rate of 2L per 100 liters of water.

1.3. Sulfoxaflor (Closer® 24% SC): Applied at a rate of 250 cm³ per 200 liters of water.

1.4. Biofungicide (Biossiana® 1x10⁸CFU/gm): Applied at a rate of 500gm per 200 liters of water.

2. Field studies:

This study was carried out over two consecutive sugar beet growing seasons (2022 and 2023) in Kafr Askar, agricultural land (Ali Saad Mohamed), located in Kafr El-Sheikh Governorate, Egypt. A completely randomized block design (CRBD) was employed, using the local sugar beet variety "Halawa," which was planted on September 15th, 2022, and September 17th, 2023. The total experimental area covered 168 m² for each treatment and untreated area, subdivided into four equal plots of 42 m² each, representing approximately 1/100 feddan per treatment, with two unsprayed plant rows placed between them to prevent cross-contamination.

Insecticide applications were conducted once per season, on December 13th, 2022, and December 14th, 2023. A 20-liter motorized backpack sprayer was used to apply aqueous insecticide solutions at the recommended field rates as specified by the

Agricultural Pesticide Committee (<http://www.apc.gov.eg/ar/APCReleases.aspx>). Control plots received only water. Standard agronomic practices were consistently followed across all treatments.

To assess cotton mealybug populations, ten plants were randomly selected from each plot for sampling. Observations were recorded at five time points: a few hours before insecticide application, and at one,

$$\text{Reduction \%} = \left\{ 1 - \frac{n \text{ in Co before treatment} \times n \text{ in T after treatment}}{n \text{ in Co after treatment} \times n \text{ in T before treatment}} \right\} \times 100.$$

n: Insect population, **C:** control, **T:** treated.

Data on insect populations were statistically analyzed using one-way analysis of variance (ANOVA) to identify significant differences among treatments. The statistical analysis was conducted using SPSS software (2004).

Results and discussion

The study evaluated the efficacy of three insecticides (Lambda-cyhalothrin, mineral oil, and sulfoxaflor) and a biofungicide (Biossiana®) in reducing the population of *P. solenopsis* (cotton mealybug) in sugar beet fields over two consecutive growing seasons (2022 and 2023). The results are presented in Tables (1 and 2), which show the percentage reduction in mealybug populations at different time intervals after treatment application.

Effect of tested chemical and bioinsecticides on cotton mealybug infestation levels:

1. In the 2022 season:

The data obtained in Table 1 showed that lambda-cyhalothrin demonstrated the highest efficacy, with a total reduction of 99.92% in mealybug population by the 10th day. Also, significant population reduction was observed as early as one day post-treatment (38.12%), increasing to 90.49% by the 10th day. This treatment consistently outperformed others, showing the fastest and most sustained reduction in pest populations. The treatment with mineral oil achieved a total reduction of 98.4% by the 10th day. Although, the initial reduction was slower (24.61% at 1 day), but it showed significant efficacy by

three, seven-, and ten-days post-application. Initially, a fungicide was applied, followed by washing the backpack sprayer with clean water before proceeding with other pesticide applications, ensuring the sprayer was cleaned between each use.

The percentage reduction in mealybug population density was determined using the Henderson and Tilton (1955) formula:

the 7th day (69.68%) and 10th day (86.87%). On the other hand, sulfoxaflor treatment resulted in a total reduction reached 99.18% by the 10th day. Similar to lambda-cyhalothrin, it showed rapid action, with a 36.47% reduction at 1 day and 89.33% by the 10th day. Its efficacy was statistically comparable to lambda-cyhalothrin, making it a strong alternative for pest management. The treatment with the biofungicide (Biossiana®) achieved a total reduction of 96.1% by the 10th day. While, the initial reduction was slower (19.63% at 1 day), but it showed significant efficacy by the 7th day (68.52%) and 10th day (70.79%). The efficacy of biofungicide according to its mode of action likely contributed to its slower initial impact compared to chemical treatments.

2. In the 2023 season:

Consistent with the 2022 results, lambda-cyhalothrin showed total reduction of 90.71% by the 10th day. While rapid action was achieved (32.77% in 1 day) and sustained efficacy (90.71% by the 10th day). While mineral oil showed a total reduction of 98.05% by the 10th day. The initial reduction was slower (20.71% in 1 day), but it showed significant efficacy by the 10th day (87.76%). in case of Sulfoxaflor treatment rapid action (31.98% at 1 day) and sustained efficacy (90.28% by the 10th day) were observed, similar to the 2022 season. While the total reduction of 99.31% by the 10th day. The biofungicide (Biossiana®) achieved a total reduction of 99.31% by the 10th day.

Although the initial reduction was slower (15.29% in 1 day), but it showed significant efficacy by the 10th day (82.61%). The overperformance was improved compared to the 2022 season, possibly due to environmental or application factors.

The management of *P. solenopsis* (Cotton mealybug) infestations in sugar beet cultivation presents a unique challenge, as this pest is not traditionally associated with sugar beet crops. The increasing occurrence of *P. solenopsis* in non-host crops, such as sugar beet, may be attributed to changing agricultural practices, environmental conditions, or the pest's adaptive capabilities (Hodgson *et al.*, 2008 and FAO, 2021). Effective pest management strategies are essential to mitigate the potential economic losses caused by this invasive pest. This study evaluated the efficacy of three insecticides, lambda-cyhalothrin, mineral oil, and sulfoxaflor and a biofungicide (Biossiana®) in controlling *P. solenopsis* populations in sugar beet fields over two consecutive growing seasons (2022 and 2023). The results provide valuable insights into the performance of these treatments and their potential integration into integrated pest management (IPM) programs.

The results obtained through both seasons suggested that lambda cyhalothrin and Sulfoxaflor were the most effective treatments, with rapid and sustained reductions in mealybug populations. Their broad-spectrum activity and mode of action (Neurotoxicity and disruption of insect nervous systems) likely contributed to their high efficacy (IRAC, 2023 and EPA, 2023). On the other hand, the superior performance of lambda-cyhalothrin (99.92% reduction) and sulfoxaflor (99.31% reduction) can be attributed to their ability to overcome the pest's wax defences through different mechanisms. Lambda-cyhalothrin's lipophilic properties enable penetration of the wax layer (IRAC, 2023); while sulfoxaflor's systemic activity allows it to

reach concealed feeding sites (EPA, 2023). Also, the mineral oil, while effective, its time-dependent efficacy (98.4% reduction by day 10) reflects the progressive nature of its physical mode of action. Exhibited a slower initial impact due to its physical mode of action, which involves suffocating pests by blocking their spiracles. Despite this delayed onset, it achieved a comparable total reduction in pest populations by the 10th day, demonstrating its potential as a viable option for integrated pest management (IPM) programs. This aligns with findings from the International Organization for Biological and Integrated Control (IOBC), which highlights the role of mineral oils as a sustainable tool in pest management due to their low environmental impact and effectiveness against a wide range of pests (IOBC, 2022). The biofungicide Biossiana® exhibited notable effectiveness against *P. solenopsis* infestations, achieving population reductions comparable to sulfoxaflor during the 2023 growing season. This biological control agent interacted with mealybug physiology through three distinct phases, initial spore adhesion to the insect's cuticle, breakdown of protective wax layers via fungal enzymatic activity, and gradual fungal colonization of vulnerable body surfaces. These sequential mechanisms account for the treatment's initially slower but ultimately robust efficacy, with recorded pest reductions ranging from 96.1% to 99.31% (Meyer and Hoy, 2008). The product's dual mode of action, combining direct pathogenicity with plant health enhancement (Dewar, 2017), contributes to its sustained pest suppression capabilities, making it particularly valuable for integrated pest management systems. This aligns with findings from Meyer and Hoy (2008), who reported that bio-fungicides like *B. bassiana* effectively reduce mealybug populations by infecting and killing the pests through fungal spores. Their study highlighted the potential of bio-fungicides as a sustainable alternative to

chemical insecticides, particularly when integrated into IPM programs. The results of the current study further support the use of bio-fungicides like Biossiana® in managing non-traditional pests such as *P. solenopsis*, offering an environmentally friendly option for pest control in sugar beet cultivation. This highlights the potential of bio-fungicides as part of IPM strategies, especially in reducing reliance on chemical insecticides (FAO, 2021). The results were consistent throughout both seasons, with minor variations in efficacy. This suggests that the treatments are reliable under similar environmental and agronomic conditions (Fergani *et al.*, 2023). The present study confirms that lambda-cyhalothrin and sulfoxaflor are highly effective against *P. solenopsis* in sugar beet cultivation. However, the use of mineral oil and Biossiana® provides alternative

options for reducing chemical inputs and promoting sustainable pest management practices (Dewar and Cooke, 2006). So, integrating these treatments into IPM programs could help manage non-traditional pests like *P. solenopsis* while minimizing environmental impact (Hodgson *et al.*, 2008).

The study demonstrates that lambda-cyhalothrin, sulfoxaflor, and mineral oil are highly effective in reducing *P. solenopsis* populations in sugar beet fields, with Biossiana® showing promising results as a biofungicide. These findings provide valuable insights for integrating chemical and bioinsecticides treatments into IPM strategies, ensuring sustainable and effective pest management in sugar beet cultivation.

Table (1) : Reduction percentage of cotton mealybug in sugar beet field after treatment with tested insecticides (2022 season).

Treatment	Before Treatment (Mean $\pm$ SE)	1 Day	3 Day	7 Days	10 Days	Total Reduction
Lambda-cyhalothrin	18 $\pm$ 0.4	12.75 $\pm$ 0.25 38.12% ^a	10.50 $\pm$ 0.29 53.82% ^a	7.25 $\pm$ 0.25 70.28% ^a	2.50 $\pm$ 0.29 90.49% ^a	99.92% ^a
Mineral oil	18.25 $\pm$ 0.85	15.75 $\pm$ 0.25 24.61%	12.25 $\pm$ 0.25 46.86% ^b	7.50 $\pm$ 0.50 69.68% ^a	3.50 $\pm$ 0.29 86.87%	98.4% ^a
Sulfoxaflor	19.25 $\pm$ 0.25	14 $\pm$ 0.41 36.47% ^a	11 $\pm$ 0.41 54.76% ^a	7.00 $\pm$ 0.71 73.17%	3 $\pm$ 0.41 89.33% ^a	99.18% ^a
Biossiana	18.75 $\pm$ 0.85	17.25 $\pm$ 0.48 19.63%	12.50 $\pm$ 0.29 47.22% ^b	8 $\pm$ 0.71 68.52% ^a	5 $\pm$ 0.41 70.79%	96.1%
Untreated Area	19 $\pm$ 0.91	21.75 $\pm$ 0.25	24 $\pm$ 0.41	25.75 $\pm$ 0.48	27.75 $\pm$ 0.25	

-In a column, means followed by the same letters are non-significantly different, $P \geq 0.05$

Table (2) : Reduction percentage of mealybug in sugar beet field after treatment with tested insecticides (2023 season).

Treatment	Before Treatment (Mean $\pm$ SE)	1 Day	3 Day	7 Days	10 Days	Total Reduction
Lambda-cyhalothrin	20.75 $\pm$ 0.25	15.50 $\pm$ 0.29 32.77% ^a	12.75 $\pm$ 0.25 50.23%	8 $\pm$ 0.41 72.36% ^a	3 $\pm$ 0.41 90.71% ^a	90.71%
Mineral oil	21 $\pm$ 0.91	18.50 $\pm$ 0.50 20.71%	15.25 $\pm$ 2.59 41.18% ^a	10 $\pm$ 0.41 65.87% ^b	4 $\pm$ 0.41 87.76%	98.05% ^a
Sulfoxaflor	21.50 $\pm$ 0.29	16.25 $\pm$ 0.48 31.98% ^a	10.75 $\pm$ 0.25 59.5%	7.75 $\pm$ 0.85 74.16% ^a	3.25 $\pm$ 0.63 90.28% ^a	99.31% ^a
Biossiana	21.25 $\pm$ 1.11	20 $\pm$ 1 15.29%	15 $\pm$ 0.41 42.82% ^a	11.25 $\pm$ 0.25 62.05% ^b	5.75 $\pm$ 0.25 82.61%	99.31% ^a
Untreated Area	20.25 $\pm$ 0.25	22.50 $\pm$ 0.29	25 $\pm$ 0.41	28.25 $\pm$ 0.25	31.50 $\pm$ 0.29	

-In a column, means followed by the same letters are non-significantly different, $P \geq 0.05$

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