Control the pink corn borer, *Sesamia cretica* by alternative chemical insecticides as well as population density measure

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Abstract

Maize, scientifically known as *Zea mays* L., holds significant agricultural value worldwide, serving as a staple food source and industrial cereal. It is grown across diverse environmental settings to meet varying demands. Corn is susceptible to infestation by a range of insect pests, with the stem-boring lepidopterans posing a particularly severe threat and leading to substantial reductions in crop yield. The biodetrimental effects of different treatments (plant extracts and bio-agents) on the pink corn borer, *Sesamia cretica* was investigated. Based on the findings, it can be concluded that the compounds tested had a significant impact on the management of the pink corn borer, *S. cretica*. The outcomes indicate that treating corn hybrids with biological substances could be highly beneficial as part of an integrated pest management (IPM) strategy for corn crops in Egypt, aiming to prevent environmental contamination and potential risks to humans and animals, all while striving to enhance maize yield both in terms of quantity and quality through the implementation of a comprehensive pest control program targeting insects that infest maize fields.

Key words: Integrated Pest Management - Maize - Alternative chemical pesticides- yield

Introduction

Maize, scientifically known as *Zea mays* L. and belonging to the Graminae family, is a significant crop in numerous developing nations for both consumption and industrial use. It is classified among cereals that can thrive in diverse environmental conditions, although crop yields are influenced by various natural, physical, and soil nutrient factors. The economic value of maize has notably risen due to its utilization as a staple food for humans and livestock, as well as a key raw material in the production of bio-based products like oil, alcohol, and starch. In

Egypt, maize ranks as the second most crucial cereal crop after wheat on a global scale, with approximately 3 million Feddans of maize cultivation in 2024 yielding around 210 million tons. During the same year, the average grain yield per Feddan was recorded at 30.4 Ardabs/Feddan, with an Ardab equating to 140 Kg and a Feddan covering 4200 m².[1-4]. Multiple authors, including [5-7], have researched to investigate and estimate the impact of corn insect pests on yield losses. In recent years, nanotechnology has emerged as a highly promising and innovative method for pest control, utilizing nanoparticles (NPs) with dimensions typically around 100 nm or smaller [8]. The assessment of nanotechnology's effectiveness in insect control is primarily focused on the unique characteristics of NPs, such as their high surface-to-volume ratio, enhanced chemical reactivity, and ability to penetrate living cells [9]. Various nano-particle materials have been tested in laboratory settings for their efficacy against different insect species, with silver nanoparticles (Ag NPs) being synthesized by fungi, bacteria, algae, and plant extracts [10-15]. Fungi like certain species of Verticillium are particularly known for their ability to produce Ag NPs **[16- 23].**

The main goal of paper is to "increase maize yield quantity and quality" by design and using integrated pest management programme for controlling insect pests infested maize in field.

Material and Methods

1. **Effect of different treatments on population density of pests.**

A portion of land measuring approximately one feddan was selected in Giza Governorate, where maize plants, *Zea mays* L. were naturally infested with pests. This area was then divided into experimental plots of equal size, measuring 6x7m each. The experiment followed a randomized complete block design, with each treatment replicated in 5 plots over two consecutive planting dates - the first in 2021 and the second in 2022. Maize plants were systematically treated using a knapsack sprayer equipped with a single nozzle, applying either natural plant extracts or chemical substances for pest control; control plots, on the other hand, were sprayed with water only. Before these applications and at intervals of 3, 7, and 10 days following treatment, a total of 50 plants per treatment (10 per replicate) were randomly sampled for post-treatment assessments. These samples were securely stored in muslin bags until laboratory analysis was conducted, involving the counting of larvae and holes on both treated and untreated maize plants. To conduct statistical analysis, the percentage reduction in pest population was determined using a specific equation [24] as follows:

Reduction (%) = (1- Ta x Cb/ Tb x Ca) x 100, where:

Ta = No. of larvae in treated plots after treatment.

Tb = No. of larvae in treated plots before treatment.

Ca = No. of larvae in un-treated plots after treatment.

Cb = No. of larvae in un-treated plots before treatment.

2. **Effect of different treatments on maize yield**

To assess the impact of various previously mentioned applications on the yield of maize crops, the harvested grain was subjected to drying in the field and then separated from the ears. The maize grain was collected, and the average weight per plot ($6x7m^2$) was documented. Five sets of averages were obtained from each treatment, including the untreated control, over the course of two consecutive planting dates (March 2021 and March 2022).

Data were statistically analyzed by ANOVA using the Instat V2.03 computer programme test and mean values were separated by the least significant differences (LSD) procedure [25] at probability = 5%.

Results

Effect of different treatments on population density of pests.

The efficiencies of the maize hybrids, TWC 310 (three way cross 310), SC 2031 (single cross hybrid 2031) and SC 2030 (hi-tech single cross 2030) treated with NeemAzal T/S (0.5%) and Chlorophan (Chlorpyrifos) 48% E.C. (0.005%), *Pulicaria incisa* and Ag NPs from *B. bassiana* were assessed against the pink corn borer population density under field conditions at El-Ayat region in Giza Governorate throughout the first and second plantation dates, 2021 & 2022.

1. **First date, March 2021.**

According to the data presented in Table 1, the average number of larvae per plant on mature plants before any treatments varied between 2.8±0.2 and 8.7±1.1 larvae on SC 2031, indicating a noticeable discrepancy in insect infestation distribution. After three days of application, the treatments suppressed the levels of infestation to varying degrees in comparison to the untreated control group. NeemAzal-T/S (0.5%) on TWC310 and Chlorophan (0.005%) on TWC310 notably reduced the infestation rate to 66.2% and 69.2%, respectively, although they did not reach the efficacy level of Chlorophan (0.005%) on SC2031 (80.4%).

Seven days post-treatment, all tested treatments; Ag NPs from *B. bassiana* on SC2031 and Chlorophan (0.005%) on SC2030, became more efficient, where the reduction of the infestation reached 83.6 and 86.9 %, respectively.

Ten days after spraying treatments Ag NPs from *B. bassiana* on SC2031 and Chlorophan (0.005%) on SC2030 caused 96.2 and 97.6% reduction in infestation, respectively. There was no significant difference between Chlorpyrifos and NeemAzal-T/S (0.5%) treatments on SC2031 which resulted in 1.1±0.2 and 1.0±0.3b larva/plant compared with 5.4±0.6 larva /plant in untreated control, ten days after spraying treatments. The experiment in the first planting date (March 2021) there were notable discrepancies in the average reduction percentages between various treatments and an untreated control group. The effectiveness of *Pulicaria incisa* extract in reducing pest on TWC310 was significantly lower at 66.4%, compared to other treatments tested. Chlorophan at a concentration of 0.005% showed the highest reduction percentages at 83.3% on SC2030, followed by Ag NPs derived from *B. bassiana* on SC2031 with 82.5%, and Chlorophan (0.005%) on SC2031 at 81.2%.

Differences between untreated control and treatments were significant, on the other hand, differences between NeemAzal-T/S (0.5%), Ag NPs from *B. bassiana* and Chlorophan (0.005%) were insignificant.

Table 1. Efficacy of the tested materials against larval stage of the pink corn borer on tested maize hybrids at El-Ayat region, Giza Governorate, first date (March 2021).

Maize hybrid	Treatment	Mean number of larva / plant and % reduction in infestation after spraying								
		Before treat.	After treat. 3 days		After treat. 7 days		After treat. 10 days		Average	
		Mean No.	Mean No.	% R.	Mean No.	% R.	Mean no.	% R.	Mean no.	% R.
TWC310	*Pulicaria incisa*	5.2±0.6b	3.3±0.4a	59.4	2.3±0.2b	73.6	1.3±0.2b	87.0	2.3±0.6a	66.4
	Ag NPs from *B. bassiana*	5.7±0.0a	3.5±0.3a	60.7	2.2±0.3b	76.9	1.4±0.3b	87.3	2.4±0.5a	68.0
	NeemAzal-T/S	5.3±0.5a	2.8±0.4b	66.2	1.5±0.1b	83.1	0.7±0.04b	93.1	1.7±0.6a	75.6
	Chlorophan	5.2±0.3a	2.5±0.3b	69.2	1.4±0.1b	83.9	0.4±0.1b	96.0	1.4±0.6b	79.5
SC2031	*Pulicaria incisa*	6.5±0.6b	3.4±0.4a	66.5	2.8±0.1b	74.3	0.8±0.04b	93.6	2.3±0.7a	73.1
	Ag NPs from *B. bassiana*	8.7±1.1b	3.2±0.3a	76.5	2.4±0.1b	83.6	0.4±0.04b	97.6	2.0±0.6a	82.5
	NeemAzal-T/S	5.3±0.4a	2.5±0.3b	69.8	2.0±0.2b	77.5	1.1±0.2b	89.2	1.9±0.5a	72.8
	Chlorophan	8.5±0.7b	2.6±0.3b	80.4	2.6±0.3b	81.8	1.0±0.3b	93.9	2.1±0.4a	81.2
SC2030	*Pulicaria incisa*	4.7±0.4a	3.2±0.2a	56.4	1.9±0.1b	75.9	0.7±0.03b	92.3	1.9±0.3a	69.3
	Ag NPs from *B. bassiana*	3.5±0.4a	1.6±0.3b	70.7	1.5±0.2b	74.5	0.4±0.3b	94.1	1.2±0.4b	73.9
	NeemAzal-T/S	7.2±0.6b	4.2±0.4a	62.7	2.2±0.4b	81.8	1.0±0.4b	92.7	2.5±0.6a	73.6
	Chlorophan	4.1±0.2a	1.4±0.2b	78.1	0.9±0.1b	86.9	0.3±0.04b	96.2	0.9±0.3b	83.3
	Untreated	2.8±0.2a	4.4±0.3a	--	4.7±0.3a	--	5.4±0.6a	--	3.7±0.8a	--
LSD 0.05		2.9	1.3	--	1.5	--	1.2	--	2.2	--

% R* = Percentage reduction in larval infestation.

Values within a column indicated by the same letter are statistically indistinguishable at a 5% significance level

Second date, (March 2022).

The results presented in Table 2 indicate that the distribution of insect infestations was determined to be natural. Before any treatments, the average number of larvae found on mature plants varied from 5.3±0.7 to 7.0±0.6 larvae per plant, with the highest numbers observed in plants treated with Chlorophan SC2030 and the lowest in the untreated control group. After 3 days of treatments, the mean number of larvae and holes of pink corn borer ranged from 2.0±0.3 to 2.6±0.3 larvae/plant on Chlorophan TWC310 and *Pulicaria incisa* SC2030, respectively, compared with 5.2±0.1 larvae/plant on untreated control SC2030. While it ranged from 0.9±0.1 larva/plant on Chlorophan SC2030 to 5.4±0.5 larva/plant on the untreated control after 7 days of treatment. After 10 days of treatment with the compounds, the mean number of larvae was reduced from 5.7±0.7 larvae/plant on untreated control SC2030 to the minimum 0.4±0.1 larvae/plant on Chlorophan TWC310. The mean of *S. cretica* larvae showed a marked variation, ranging from 1.2±0.3 larvae per plant on Chlorophan SC2030 to 5.0±0.5 larvae per plant on the untreated control group. After 3 days of treatments the reduction percentage of larvae and holes of pink corn borer ranged from 55.1 and 69.4% on *Pulicaria incisa* SC2030and Chlorophan SC2030, respectively. While it reached from 64.8% on NeemAzal-T/S TWC310 to 87.4% on Chlorophan SC2030 after 7 days of treatments. After 10 days of treatment with the compounds, the reduction percentage was increased from 81.1% on *Pulicaria incisa* SC2030 to 94.2% on Chlorophan TWC310.

The *S. cretica* larvae exhibited varying levels of reduction percentage, ranging significantly from 65.9% on *Pulicaria incisa* SC2030 to 81.8% on Chlorophan SC2030.

The treatments resulted in the most substantial decrease in the number of *S. cretica* egg-masses and larvae, as well as a significant reduction in the number of plants with damaged leaves and wilting tops.

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Table 2. Efficacy of the tested materials against larval stage of the pink corn borer on tested maize hybrids at El-Ayat region, Giza Governorate, second date (March 2022).

Maize hybrid	Treatment	Mean number of larva / plant and % reduction in infestation after spraying								
		Before treat.	After treat. 3 days		After treat. 7 days		After treat. 10 days		Average	
		Mean No.	Mean No.	%R.	Mean No.	%R.	Mean no.	%R.	Mean no.	%R.
TWC310	*Pulicaria incisa*	6.2±0.5a	2.0±0.2b	67.1	1.9±0.2b	69.9	0.9±0.2b	86.5	1.6±0.4b	72.6
	Ag NPs from *B. bassiana*	5.6±0.7a	2.1±0.3b	61.8	2.0±0.3b	64.9	0.7±0.3b	88.4	1.6±0.5b	69.7
	NeemAzal-T/S	5.3±0.7a	2.2±0.1b	57.7	1.9±0.1b	64.8	0.7±0.2b	87.7	1.6±0.6b	68.0
	Chlorophan	6.4±0.3a	2.0±0.3b	68.1	1.6±0.1b	75.5	0.4±0.1b	94.2	1.3±0.3b	78.5
SC2031	*Pulicaria incisa*	5.7±0.8a	2.3±0.4b	58.8	2.0±0.1b	65.6	1.1±0.4b	82.1	1.8±0.7b	66.5
	Ag NPs from *B. bassiana*	6.8±0.6a	2.2±0.4b	67.0	1.7±0.1b	75.5	0.6±0.2b	91.8	1.5±0.4b	76.6
	NeemAzal-T/S	6.1±0.3a	2.4±0.1b	59.9	2.0±0.2b	67.8	0.8±0.2b	87.8	1.7±0.5b	70.5
	Chlorophan	6.0±0.6a	2.1±0.4b	64.3	1.2±0.3b	80.4	0.6±0.1b	90.7	1.3±0.2b	77.0
SC2030	*Pulicaria incisa*	5.9±0.4a	2.6±0.3b	55.1	1.9±0.1b	68.4	1.2±0.3b	81.1	1.9±0.3b	65.9
	Ag NPs from *B. bassiana*	6.9±0.8a	2.2±0.3b	67.5	1.5±0.2b	78.7	0.6±0.3b	91.9	1.4±0.5b	78.5
	NeemAzal-T/S	6.4±0.5a	2.2±0.4b	64.9	1.4±0.4b	78.5	0.9±0.2b	86.9	1.5±0.6b	75.2
	Chlorophan	7.0±0.6a	2.1±0.3b	69.4	0.9±0.1b	87.4	0.5±0.1b	93.4	1.2±0.3b	81.8
	Untreated	5.3±0.7a	5.2±0.1a	--	5.4±0.5a	--	5.7±0.7a	--	5.0±0.5a	
LSD 0.05		2.8	1.1		1.7		1.8		2.6	

% R* = Percentage reduction in larval infestation.

In a column, values corresponding to the same letter are not deemed to be statistically significant at a 5% significance level.

Effect of different treatments on maize yield

1. First date, March 2021

The findings outlined in Table (3) reveal that during the initial date of plantation in March 2021, various treatments exhibited positive impacts on maize productivity. Compared to the control group, the enhancement rate ranged from 1.04 to 1.13 for NeemAzal-T/S TWC310 and Chlorophan TWC310, respectively. The average yield recorded in the control group was 3010 kg per feddan, whereas it was 3390, 3320, and 3310 kg per feddan in the Chlorophan TWC310, *Pulicaria incisa* SC 2031, and Ag NPs from *B. bassiana* TWC310 treatment groups, respectively. The discrepancy in yield outcomes following the application of treatments was found to be statistically significant when compared to the untreated control group SC2030.

2. Second date, March 2022

The findings presented in Table (4) demonstrate that in the second date plantation (March 2022 plantation), the various treatments had a beneficial impact on maize yield. The increase in yield compared to the control group ranged from 1.04 to 1.18 for *Pulicaria incisa* SC 2031 and Chlorophan TWC310, respectively. The average yield obtained in the control group was 2930 kg per feddan, whereas the yields produced after the application of *Pulicaria incisa* SC 2031 and Chlorophan TWC310 treatments were 3050 to 3450 kg per feddan, respectively. The difference in yield means following the application of treatments were statistically significant when compared to the control group.

Based on the findings, it can be inferred that the examined compounds significantly contributed to managing the pink corn borer, *S. cretica*. The study's conclusions indicate that applying biological agents to corn hybrids would be a beneficial strategy for integrated pest management in Egypt, promoting environmental sustainability and minimizing risks to humans and animals.

Table 3. Efficacy of different treatments against *S. cretica* on maize grain yield, at El-Ayat region, Giza Governorate, March 2021.

Maize hybrid	Treatments	Infestation % after treated	Yield kg/plot	Yield kg/ feddan	Yield ardeb/ feddan	Increase yield rate
TWC310	***Pulicaria incisa***	15.0	32.4± 0.9a	3240	23.1	1.07
	Ag NPs from *B. bassiana*	14.0	33.1± 0.6b	3310	23.6	1.09
	NeemAzal-T/S	17.0	31.2± 0.4a	3120	22.3	1.04
	Chlorophan	12.0	33.9± 0.7b	3390	24.2	1.13
SC 2031	***Pulicaria incisa***	14.0	33.2± 1.3b	3320	23.7	1.10
	Ag NPs from *B. bassiana*	16.0	31.5± 1.3a	3150	22.5	1.05
	NeemAzal-T/S	16.0	32.5± 0.6a	3250	23.2	1.08
	Chlorophan	10.0	33.4± 1.3b	3340	23.9	1.11
SC2030	***Pulicaria incisa***	15.0	32.4± 1.3a	3240	23.1	1.07
	Ag NPs from *B. bassiana*	14.0	33.2± 1.3b	3320	23.7	1.10
	NeemAzal-T/S	18.0	32.0± 0.8a	3200	22.9	1.07
	Chlorophan	11.0	32.3± 0.5a	3230	23.1	1.09
	Untreated	22.5	30.1± 0.5a	3010	21.5	1.00
LSD 0.05			2.6	-	-	-

*** Untreated SC2030 = control**

****Ardab = 140 kg.**

***** Increase yield rate= yield test/yield control**

Table 4. Efficacy of different treatments against *S. cretica* on maize grain yield, at El-Ayat region, Giza Governorate, March 2022.

Hybrids	Treatments	Infestation % after treated	Yield kg/plot	Yield kg/ feddan	Yield ardeb/ feddan	Increase yield rate
TWC310	***Pulicaria incisa***	17.0	31.5±0.6b	3150	22.5	1.08
	Ag NPs from *B. bassiana*	14.0	31.8±0.3b	3180	22.7	1.09
	NeemAzal-T/S	17.0	32.4±0.6b	3240	23.1	1.11
	Chlorophan	12.0	34.5±0.5b	3450	24.6	1.18
SC 2031	***Pulicaria incisa***	15.0	30.5±0.4a	3050	21.8	1.04
	Ag NPs from *B. bassiana*	13.0	30.8±0.3a	3080	22.0	1.05
	NeemAzal-T/S	18.0	31.4±0.4a	3140	22.4	1.07
	Chlorophan	13.0	33.5±0.6b	3350	23.9	1.14
SC2030	***Pulicaria incisa***	17.0	32.5±0.6b	3250	23.2	1.11
	Ag NPs from *B. bassiana*	14.0	32.8±0.3b	3280	23.4	1.12
	NeemAzal-T/S	16.0	33.4±0.4b	3340	23.9	1.14
	Chlorophan	14.0	34.2±0.6b	3420	24.4	1.17
	Untreated	25.0	29.3±0.5a	2930	20.9	1.00
LSD 0.05			2.1	-	-	-

*** Untreated SC2030 = control**

****Ardab = 140 kg.**

*****Increase yield rate = yield test/yield control**

****** Values within a given column denoted by the same letter are not considered statistically significant at the 5% confidence level**

Discussion

Effect of different treatments on population density of pests.

The efficiencies of the maize hybrids, TWC 310 (three-way cross 310), SC 2031 (single cross hybrid 2031) and SC 2030 (hi-tech single cross 2030) treated with NeemAzal T/S (0.5%) and Chlorophan (Chlorpyrifos) 48% E.C. (0.005%), *Pulicaria incisa* and Ag NPs from *B. bassiana* were assessed against the pink corn borer population density under field conditions at El-Ayat region in Giza Governorate throughout the first and second plantation dates, 2021 & 2022. Three days following the application of the sprays, the treatments exhibited varying degrees of suppression in infestation levels when compared to the untreated control group. Seven days post-treatment, all tested treatments; Ag NPs from *B. bassiana* on SC2031 and Chlorophan (0.005%) on SC2030, became more efficient, where the reduction of the infestation reached 83.6 and 86.9 %, respectively. The experiment in the first planting date (March 2021) showed highly significant differences in the average reduction percentage between treatments and untreated control. Differences between untreated control and treatments were significant, on the other hand, differences between NeemAzal-T/S (0.5%), Ag NPs from *B. bassiana* and Chlorophan (0.005%) were insignificant.

The outcomes of the current study align well with previous research conducted [26] focusing on the toxicity of various insecticides to *Ostrinia nubilalis* eggs and neonate larvae. Ismail specifically evaluated the efficacy of lemon grass, *Andropogon citratus*, *Bacillus thuringiensis* var. kurstaki, and other insecticides against larvae of the pink stalk borer, *S. cretica*. The results from field experiments suggest that both *B. thuringiensis* and *A. citratus* show promise of inclusion in integrated pest management (IPM) programs aimed at controlling *S. cretica* [27]. The impact of various insecticides, including chemical (methomyl), microbial (Bt.), petroleum oil (Sisi 6), and inorganic salt (barium nitrate), on *S. cretica* was examined in a field study. Results showed that methomyl demonstrated the highest efficacy in reducing the infestation of maize plants by *S. cretica*, with Agrein, Sisi 6, and barium nitrate following in effectiveness [28]. It has been noted that the pink stem borer, *Sesamia inferens*, and the stem borer, *Chilo suppressalis*, which are significant insect pests of sugarcane, have also begun infesting Japonica rice fields in northern regions and Indica rice fields. In the efforts to control *C. suppressalis*, it was observed that cartap and permethrin were more efficient insecticides compared to chlorpyrifos and carbofuran in combating *S. inferens*. Resistance levels in the field strain of *S.*

inferens were found to be lower than three-fold for cartap, chlorpyrifos, and carbofuran, three to nine-fold for permethrin, and up to 17-fold for spinosad when compared to the susceptible strain in Hsinchu [29]. The effectiveness of various volatile plant oils against the corn borer, *S. cretica* Led., was assessed in a field study. It was observed that Cinnamon oil at a concentration of 5% resulted in the greatest reduction in egg masses, larvae, and damage to the plants [30]. The effectiveness of various integrated pest management (IPM) programs involving microbial (Btk and baculovirus) and chemical control techniques, either alone or in combination, was examined in relation to combating *O. nubilalis* and *H. armigera*. Evaluations were conducted by quantifying larval populations, visually inspecting plants externally and internally, and assessing the resulting damage. It was found that the efficacy of microbial control agents was comparable to that of traditional chemical pesticides. These findings align with previous research indicating that azadirachtin, a key active compound in neem seeds and leaves, exhibits greater antifeedant properties compared to its effects on egg-laying behavior in certain insects like Heliothis armigera [31, 32]. The efficacy of utilizing petroleum ether extracts from Clove (*Syzygium aromaticum*) and Garlic (*Allium sativum*), along with the insecticide pyriban 48% E.C., in treating maize crosses against *S. cretica* was examined. Prior to treatment, there was no significant difference in the levels of damage observed among the tested crosses. Their susceptibility to *S. cretica* infestation was nearly identical [33]. The insecticide and garlic extracts demonstrated superior effectiveness in reducing pest infestation when compared to untreated plants (control). The efficacy of water and acetone extracts from radish *Raphanus raphanistrum* L. and turnip Brassica rape, both individually and in combination with various biopesticides (Protecto–Biosect) and an insect growth regulator (Runner), against *Sesamia cretica* during the early summer season of 2009. The highest reduction in the number of *S. cretica* egg-masses, larvae, and plants with perforated leaves and dead hearts was achieved by the aforementioned treatments [34]. Yacoub [35] investigated the efficacy of two biopesticides along with mixtures of lemongrass and Pigeon berry extracts in managing the pink stem borer *Sesamia cretica* Led. in maize fields at the start of the 2010 summer planting season. Ullah et al. [36] evaluated the effectiveness of indigenous EPF against *S. frugiperda* and demonstrated their efficacy in pest control through laboratory and field experiments.

Effect of different treatments on maize yield

The findings showed that the various treatments applied in the March 2021 and March 2022 date plantations led to a notable increase in maize yield. There was a significant difference in yield between the treated plots and the untreated control SC2030.

Sabra, et al. [37] discovered that the decrease in maize yield due to European corn borer resulted in a loss of 0.38 and 0.31 kg/100 plants during the 2003 and 2004 growing seasons, respectively, compared to the estimated loss of 0.35 and 0.29 kg/100 plants through the provided formula. The discrepancy between the actual and predicted yield loss was minimal. MoyinJesu [38] observed notable improvements ($P < 0.05$) in various growth and yield parameters of maize (such as leaf area, plant height, stem girth, grain yield, cob weight, and shelling percentage) as well as in watermelon (vine length, stem girth, branch number, fruit weight, population, and fruit diameter) when grown as a sole crop or in an intercropping system compared to the control group. Overall, the values of growth and yield parameters were marginally higher in the sole crop than in the intercropped setting. The application of modified neem leaf extract led to an increase in plant height and stem girth of maize when grown as a sole crop by 11.78% and 27.43%, respectively, compared to standard neem leaf extract. A similar trend of improvement was observed in maize grown in an intercropped system where modified neem leaf extract resulted in an increase in plant height and stem girth by 11.5% and 24.48%, respectively, compared to standard neem leaf extract. Al-Eryan, et al. [39] conducted an evaluation of yield losses in three varieties of maize (white, yellow, and sugary corn) caused by stem borers *Sesamia critica* and *Ostrinia nubilalis* in field conditions with insecticide treatment. Both conventional and analytical methods were employed to determine the most accurate assessment method. The findings of their study revealed that the grain weight per ear of intact maize was significantly influenced by the type of corn, but not by the application of insecticide. White corn exhibited the highest grain weight per ear at 154.33 gm, while sugary corn had the lowest at 36 gm per ear. The average grain weight per ear decreased notably in the presence of stem borers *S. criticae* and *O. nubilalis*, with white corn showing higher susceptibility. Application of insecticides reduced yield losses by 44.26% and 60.87% in white corn, and by 8% and 41.27% in yellow corn due to *S. critica* and *O. nubilalis*, respectively. Losses in yield due to plant absence were found to be 3.75%, 4.8%, and 10.53% for white, yellow, and sugary corn, respectively.

Based on the findings, it can be concluded that the examined compounds significantly contributed to the management of the pink corn borer, *S. cretica*. The study results indicate that incorporating biological agents into treatments of corn hybrids would be highly beneficial in Egyptian corn integrated pest management (IPM) strategies, as it can effectively mitigate environmental pollution and potential harm to humans and animals.

Conclusion

The effectiveness of maize hybrids, which include TWC 310, SC 2031, and SC 2030, that were treated with NeemAzal T/S (0.5%) and Chlorophan (Chlorpyrifos) 48% E.C. (0.005%), as well as *Pulicaria incisa* and Ag NPs from *B. bassiana*, was evaluated in controlling the pink corn borer population density in field conditions. The planting date in March 2021 resulted in significant variations in the percentage of reduction observed between the treated hybrids and the untreated control. While there were notable differences in reduction percentages between the untreated control and the various treatments, the disparities between NeemAzal-T/S (0.5%), Ag NPs from *B. bassiana*, and Chlorophan (0.005%) were deemed insignificant. Furthermore, the treatments mentioned also displayed the highest reduction percentages in the number of *S. cretica* egg-masses, larvae, as well as in plants exhibiting perforated leaves and dead hearts.

The various treatments exhibited favorable outcomes in increasing maize production. The improvements in yield compared to the control group were in the range of 1.04 to 1.13 for NeemAzal-T/S TWC310 and Chlorophan TWC310, respectively. Similarly, the enhancements ranged from 1.04 to 1.18 for *Pulicaria incisa* SC 2031 and Chlorophan TWC310, during the subsequent period. Based on the findings, it can be concluded that the tested substances played a significant role in managing the pink corn borer, *S. cretica*. The findings of this research indicate that treating corn hybrids with natural agents could be highly beneficial in the context of corn Integrated Pest Management (IPM) in Egypt, aiming to prevent environmental pollution and harm to humans or animals. Furthermore, these actions are essential to achieve the primary objective of the project, which is to enhance both the quantity and quality of maize yield through the implementation of an integrated pest management strategy for controlling insect pests infesting maize fields.

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