

Use some elements of integrated management to reduce field damage caused by the corn stem borer *Sesamia cretica* Led

Hassan Mohammed Khalaf¹, Ziad Shihab Ahmed², Abdullah Abdul Karim Hassan²

¹Ministry of Agriculture - Directorate of Agriculture, Salah al-Din

Email: hassanpro652@gmail.com

²Department of Plant Protection - College of Agriculture - Tikrit University, Iraq

Abstract

A field experiment was conducted in Kirkuk province /Al-Hawija District to evaluate the efficacy of two fungal isolates, *Aspergillus versicolor* isolate Has-3 and *Fusarium cf. incarnatum-equiseti* isolate Has-4, at a concentration of 108 spores/ml, the plant growth inhibitor Ethephon 480 SL, at two concentrations of 0.62 and 1.25 ml/liter of water, and half the concentration and the concentration recommended by the insecticide manufacturer, Belt 480 EC, at concentrations of 0.10 and 0.20 ml/liter, Denim Fit UV 45 WG at concentrations of 0.20 and 0.40 g/liter, and Movento 100 SC at concentrations of 0.37 and 0.75 ml/liter of water, in reducing field damage caused by the corn stem borer *S. critica* Led. This study was conducted using a split-plot design. The results of the study showed that increasing the concentrations of pesticides and the growth inhibitor ethephon reduced the percentage of growth tip death. Denim Fit pesticide at a concentration of 0.40 g/L excelled Belt and Movento pesticides. Half concentration of ethephon at 1.25 ml/L excelled a quarter concentration, while the effect of the two fungi used in the study was similar. The triple interaction treatment between ethephon at a concentration of 1.25 ml/L and the fungus *Fusarium cf. incarnatum-equiseti* isolate Has-4 and Denim Fit at a concentration of 0.40 g/L produced the best results. The percentage of growth tip death decreased to 2.83%, while it reached 21.98% in the control treatment. The average number of holes, the number of feeding tunnels, and the percentage of the excavated area of the stem also decreased to 2.44 holes/plant, 1.33 tunnels/plant, and 13.47%, while it reached 9.55 holes/plant, 4.89 tunnels/plant, and 38.46% in the control treatment for the aforementioned studied traits, respectively .

Keywords: Corn stem borer, entomopathogenic fungi, biological control, ethephon, *Sesamia cretica*, *Zea mays* L.

Introduction

Corn (*Zea mays* L.), a member of the Poaceae family, is considered an important and widely distributed strategic cereal crop worldwide and in the Arab world [13]. The cultivated area of corn in Iraq has reached 1.12 million hectares [9]. Corn can be affected by several pests, including the corn stem borer (*Sesamia cretica* Led.). One of the most important pests that cause serious damage to the quality and quantity of the crop, especially in the seedling stage, where infection sometimes leads to the loss of the entire plant. Losses in Iraq have

been estimated at 80% [1]. Many methods have been used to combat this pest, including chemical, biological, agricultural, and other pesticides. However, the intensive use of traditional chemical pesticides in large quantities has led to the emergence of genetic control in generations of insects against the action of these pesticides, in addition to their negative effects on the environment, public health, and beneficial organisms such as parasites, predators, bees, and flower pollinators [19]. Therefore, it has become

necessary to search for environmentally friendly products and control methods that are compatible with the modern trend in integrated pest management to obtain agricultural products free of pesticide residues. Therefore, the world has turned to the use of entomopathogenic fungi, which are considered one of the most important living organisms that parasitize insects, as they have the ability to, They are also characterized by their ability to form spores that resist and tolerate unfavorable environmental conditions [17]. These organisms contribute to biological control of insect pests, as they are considered an environmentally friendly method of control due to their low toxicity to non-target organisms. Many studies have indicated the importance of using fungi in controlling insect pests that belong to the order of Lepidoptera, which infect corn, especially stem borers, including the genus *Sesamia*. [14] The efficiency of some modern, safe, and environmentally friendly chemical pesticides can also be improved by mixing them with fungi that are pathogenic to insects, which achieves satisfactory results in controlling insect pests, as they reduce the rate of pesticide treatment, reduce the risks of

Materials and Methods

-1 Field Operations and Study Factors:

A 3-dunum corn field was established for the spring season of /4/82024 in the village of Tal Ali, affiliated with the Al-Hawija District, southwest of Kirkuk province. The land was plowed perpendicularly using a three-disc plow. Leveling operations were then carried out, and the field was divided into three sectors using a Randomized Complete Block Design (RCBD). Each sector contains 21 experimental units, with a total of 63 experimental units per replicate, and each experimental unit has three replicates. The area of each experimental unit is 21 m² with dimensions of (7 x 3). All recommended agricultural methods for growing the crop

environmental pollution, and delay the emergence of insect resistance. against the action of chemical pesticides [5], as it has recently appeared that many researchers have resorted to using some plant growth regulators (PGRs) that work to enhance the efficiency of growth and pre-harvest maturity in corn, such as Ethephon, which increases the concentration of ethylene directly or indirectly in plant tissues and increases the efficiency of the pollination and fertilization processes. It also plays an important role in sex expression and protein synthesis through its contribution to the production of some enzymes and the synthesis of RNA, which increases the plant's resistance to the action of the pest and thus affects the corn yield in quantity and quality [18]. Given the importance of corn crop and the quantitative and qualitative losses it is exposed to due to the corn stem borer *S. cretica*, and to reduce the damage caused by this pest, this study was conducted with the aim of reducing field damage resulting from infection with the corn stem borer *S. cretica* by using some chemical pesticides with fungal isolates and the growth inhibitor Ethephon.

were followed, including plowing, smoothing, irrigation, and weeding. Planting began on April 3, 2024, using a mechanical corn seeder mounted on an agricultural tractor. The seeder was calibrated to ensure a planting distance of 20 cm between plants and 75 cm between rows. NPK fertilizer was also added. (0-20-20) Russian origin was added to the soil with cultivation at a rate of 75 kg/acre, and the germination rate reached 97%. A 3 m isolation distance was left between the sectors and a 2 m distance between the experimental units. In addition to the weeding operations, the fertilization process was also carried out with urea fertilizer (N 46%) of Iraqi origin at a rate of 75 kg/ha, which was carried out 35 days after germination, where it was added using a weeder carried on the agricultural tractor [4].

The field was monitored daily until the first insect infection appeared. After the infection appeared in the field at a rate of 2-3%, the first treatment was carried out with the two fungal isolates *Aspergillus versicolor* isolate Has-3 and *Fusarium cf. incarnatum-equiseti* isolate Has-4 at a concentration of 108 spores/ml, the plant growth inhibitor Ethephon 480 SL at concentrations of 0.62 and 1.25 ml/liter of water, and the manufacturer's recommended concentrations, half the concentration of the insecticide Belt 480 EC at concentrations of 0.10 and 0.20 ml/liter, Denim Fit UV 45 WG at concentrations of 0.20 and 0.40 g/liter, and Movento 100 SC at concentrations of 0.37 and 0.75 ml/liter of water, according to the plan developed for the current study.

.2 Estimation of field damage resulting from infestation by the corn stem borer *S. cretica*:

.1-2 Percentage of shoot tip death in corn (*Zea mays* L.):

Plants showing symptoms of shoot tip death were counted 25 days after treatment. This can be distinguished by the appearance of stunted plants, dry shoot tips, and ease of removal. Plants affected by shoot tip death and the total number of plants in each treatment were counted. The method of Al-Jabouri and Al-Karbouli (2012)[3] was applied to calculate the percentage of seedling death:

Percentage of shoot tip death = (Number of dead plants)/(Total number of plants)100%

Results and Discussion

.1 Evaluation of the effectiveness of the growth inhibitor ethephon (ml/L), fungal species (108 CFU/ml), and pesticide type and concentration (ml or µg/L) on the percentage of shoot tip death of infected corn (*Zea mays* L.) plants 25 days after treatment.(%)

The results of the statistical analysis of the data in Table (1) indicated that the percentage

.2-2 Number of holes (hole/plant):

All leaves were removed from corn stems, and the number of holes made by the borer larvae per plant was counted [2.]

.3-2 Number of feeding tunnels (tunnel/plant):

After dissecting the stem, the larval feeding tunnels appeared, and the number of these tunnels was then calculated for each plant [2.]

.4-2 Percentage of excavated area of the stem : (%)

The length of each tunnel (cm) in infected plants was measured using a graduated ruler. The lengths of the tunnels were then summed according to the method of El-Hosary et al. (2012)[10] to calculate the percentage of excavated area per plant, using the following equation:

Percentage of excavated area per plant = (Total sum of lengths of infected plant entanglements)/(Length of infected plant)× 100%

.3 Statistical Analysis

The experiment was conducted using a split-plot design with three replicates, where treatments were distributed according to a randomized complete block design (RCBD). The results were statistically analyzed using SAS version 9. Means were compared using the least significant difference (LSD) test at a 5% probability level.[7]

of death of the growing tip of the seedlings of corn *Z. mays* when using the growth retardant ethephon alone at a concentration of 0.62 and 1.25 ml/liter of water decreased significantly, reaching 6.02% and 3.90% for both concentrations, respectively, with a clear significant difference from the control treatment, which reached 21.98%. The increase in pesticide concentrations also affected the studied trait when used alone, reaching 9.92, 7.80% for the pesticide Belt,

6.02, 5.67% for the pesticide Denim Fit, and (7.80, 5.67)% for the pesticide Movento (half concentration and recommended concentration), respectively. while, the fungi *Aspergillus versicolor* isolate Has-3 and *Fusarium cf. incarnatum-equiseti* isolate Has-4 had a clear effect in reducing the percentage of dead seedlings when sprayed alone, as it reached 4.25 and 4.96% for the two fungi, respectively. Referring to the results of Table (1), we find that the triple interaction between ethephon, pesticides and fungi had a clear effect on the percentage of death of the growing tip of the seedlings. The interaction treatment between ethephon at half the recommended concentration with the fungus *Fusarium cf. incarnatum-equiseti* isolate Has-4 and Denim Fit herbicide at the recommended concentration had the lowest percentage of 2.48 compared to the control treatment, which amounted to 21.98%. The results showed that the overall effect rate of ethephon had a

positive impact on the percentage of shoot tip death, reaching 4.39% and 3.95% for both concentrations E25 and E50, respectively, with a clear significant difference from the treatments without ethephon, which amounted to 5.64%. The pesticide treatments had no significant difference in their impact on the percentage of shoot tip death, which amounted to 4.13, 4.19 and 4.70% for Denim Fit, Movento and Belt herbicides, respectively. However, all of these treatments significantly excelled the control treatment, which amounted to 21.98%. The overall effect rate of the Has-4 fungus was 3.76%, which significantly reduced the percentage of shoot tip death compared to the fungus 3Has- which had a growth tip mortality rate of 4.32%, and the treatment with the two fungi provided good protection for corn seedlings compared to the treatments without the two fungi, which had a rate of 5.89%.

Table 1: Evaluation of the effectiveness of the growth inhibitor level ethephon (ml/L), fungus type (108 CFU/L), and pesticide type and concentration (ml or g/L) on the percentage of growth tip death (%) of corn *Z. mays* L. after 25 days of treatment.

Ethephon concentrations	Fungi type and pesticide concentrations	Percentage of growing tip death (%)			Ethephon effect average	Ethephon effect average and pesticide concentrations	Pesticide effect average
		0.0	<i>F. incarnatum-equiseti</i> isolate Has-4	<i>A. versicolor</i> isolate Has-3			
0.0	0.0	21.98	4.25	4.96	5.64	10.40	B
	B50	9.92	4.60	4.60		6.38	4.70
	B100	7.80	3.19	3.54		4.84	
	D50	6.02	3.19	3.54		4.25	
	D100	5.67	3.19	3.54		4.13	
	M50	7.80	4.25	3.90		5.31	
	M100	5.67	3.19	3.54		4.13	
E25	0.0	6.02	3.90	6.02	4.39	5.31	D
	B50	4.96	4.60	5.31		4.96	4.13
	B100	3.90	4.25	4.25		4.13	
	D50	4.25	4.60	5.31		4.72	
	D100	4.25	2.48	4.25		3.66	

	M50	3.90	3.54	4.60		4.01	
	M100	3.54	4.25	3.90		3.90	
E50	0.0	3.90	2.83	4.96	3.95	3.90	M
	B50	4.25	4.25	4.60		4.37	
	B100	3.54	3.54	3.54		3.54	4.19
	D50	4.60	3.90	5.31		4.60	
	D100	3.19	2.83	4.25		3.42	
	M50	5.31	4.96	3.90		4.72	
	M100	3.19	3.19	2.83		3.07	
L.S.D0.05		1.941			0.6253	1.1206	
Fungal effect average		5.89	3.76	4.32			
L.S.D0.05		0.3914					

B50* = Belt 0.10 ml/L // B100* = Belt 0.20 ml/L // D50* = Denim Fit 0.20 g/L// D100* = Denim Fit 0.40 g/L

// M50* = Movento 0.37 ml/L // M100* = 0.75 ml/L// E25* = Ethepon 0.62 ml/L // E50* = Ethepon 1.25 ml/L

.2

Evaluation of the effectiveness of the growth inhibitor ethephon (ml/L), fungal species (108 CFU/L), and pesticide species and concentration (ml or g/L) on the average number of holes produced by feeding larvae of the corn stem borer *S. cretica* in the infected corn plant *Z. mays* L. (hole/plant).

Through the results of the statistical analysis of Table (2), we find that most of the treatments used in the study played a prominent role in influencing the average number of holes in the infected corn plant. The results of the statistical analysis proved that the average effect of the two concentrations, a quarter and a half of the recommended concentration used of the growth inhibitor ethephon under study, had a significant effect on the average number of holes, as it reached 3.91 and 3.85 holes/plant for both concentrations, respectively, with a clear significant difference from the treatments without ethephon, which reached 4.46 holes/plant. Meanwhile, the average number

of holes decreased from 9.55 holes/plant in the comparison treatment to 3.34 and 3.48 holes/plant for the average use of Denim Vet and Movento pesticides, thus excelled the Belt pesticide, as the average number of holes in this treatment reached 4.62 holes/plant. We also find that the use of the two fungal isolates, *Fusarium cf. incarnatum-equiseti* isolate Has-4 and *Aspergillus versicolor* isolate Has-3 had a significant effect in reducing the average number of holes to 3.85 and 4.03 holes per plant for the two fungi, respectively. The results of the three-way interaction between ethephon concentrations, pesticide concentrations, and the two fungal isolates had a significant effect on the average number of holes, as the average number of holes decreased from 9.55 holes per plant in the control treatment to 2.44 holes per plant in the three-way interaction between ethephon at half the recommended concentration, *Fusarium cf. incarnatum-equiseti* isolate Has-4, and Denim Fit at the recommended concentration.

Table 2: Evaluation of the effectiveness of the growth inhibitor level of ethephon (ml/L), the type of fungus (108 CFU/ml), and the type and concentration of the pesticide (ml or g/L) on the average number of holes resulting from feeding of the larvae of the corn stem borer *S. cretica* in the infected corn plant *Z. mays* L. (hole/plant.)

Ethephon concentrations	Fungi Type and Concentrations of Pesticides	Number of holes (hole/plant)			Ethephon effect average	Ethephon effect average and pesticide concentrations	Pesticide effect average
		0.0	<i>F. incarnatum-equiseti</i> isolate Has-4	<i>A. versicolor</i> isolate Has-3			
0.0	0.0	9.55	5.11	5.22	4.46	6.62	B
	B50	5.67	5.22	5.22		5.37	4.62
	B100	5.00	4.66	4.89		4.85	
	D50	3.89	3.77	3.78		3.81	
	D100	3.44	3.11	3.44		3.33	
	M50	3.78	3.89	3.78		3.81	
	M100	3.55	3.22	3.55		3.44	
E25	0.0	5.11	4.89	5.11	3.91	5.03	D
	B50	4.89	4.88	4.89		4.48	3.34
	B100	4.44	4.33	4.44		4.40	
	D50	3.55	3.11	3.22		3.89	
	D100	2.99	2.78	3.00		2.92	
	M50	3.55	3.33	3.55		3.89	
	M100	3.22	2.66	3.22		3.25	
E50	0.0	5.00	4.55	4.66	3.85	4.74	M
	B50	4.77	4.22	4.44		4.48	3.48
	B100	4.33	4.00	4.11		4.14	
	D50	3.89	3.89	3.89		3.29	
	D100	3.11	2.44	3.00		2.85	
	M50	3.89	3.89	3.89		3.48	
	M100	3.44	2.89	3.44		3.03	
L.S.D0.05		0.5226			0.131	0.3017	
Fungal effect average		4.33	3.85	4.03			
L.S.D0.05		0.1232					

B50* = Belt 0.10 ml/L // B100* = Belt 0.20 ml/L // D50* = Denim Fit 0.20 g/L// D100* = Denim Fit 0.40 g/L //

M50* = Movento 0.37 ml/L // M100* = 0.75 ml/L//E25* = Ethephon 0.62 ml/L // E50* = Ethephon 1.25 ml/L

.3

Evaluation of the effectiveness of the growth inhibitor ethephon level (ml/L), fungus type (108 CFU/L), and pesticide type and concentration (ml or g/L) on the average number of feeding tunnels of the corn stem

borer *S. cretica* in the stems of infected corn *Z. mays* L. plants (tunnel/plant .)

From Table (3), we find that the triple interaction between ethephon, pesticides and

fungi had a clear effect on the average number of feeding tunnels of the corn stem borer *S. cretica* in the infected corn plant. The two interaction treatments between ethephon at half the recommended concentration with the fungi Has-3 and Has-4 and Denim Fit at the recommended concentration gave the lowest rate of 1.33 tunnels/plant, with a clear significant difference from the comparison treatment, which reached 4.89 tunnels/plant. The results of data analysis indicated that the average number of feeding tunnels of the corn stem borer on the corn plant decreased significantly after treatment with the growth retardant ethephon alone (a quarter and a half of the recommended concentration), reaching 2.67 and 2.55 tunnels/plant for both concentrations, respectively, while the fungi *Aspergillus versicolor* isolate Has-3 and

Fusarium cf. incarnatum-equiseti isolate Has-4 had a clear effect in reducing the average number of feeding tunnels when sprayed alone, as it reached 2.78 tunnels/plant for both fungi, while the results showed that the overall effect rate of ethephon had a good effect in reducing the average number of feeding tunnels, as it reached 2.11 and 1.96 tunnels/plant for both concentrations E25 and E50, respectively, with a significant difference from the treatments without ethephon, as it reached 2.43 tunnels/plant. The two pesticides Denim Fit and Movento also excelled significantly and slightly in their effect on this studied trait, as they gave the lowest rate of 1.80 and 1.93 tunnels/plant, thus excelled the treatment with Belt pesticide, as the average number of tunnels in it reached 2.39 tunnels/plant.

Table 3: Evaluation of the effectiveness of the growth inhibitor level of ethephon (ml/L), the type of fungus (108 CFU/ml), and the type and concentration of the pesticide (ml or g/L) on the average number of feeding tunnels of the corn stem borer *S. cretica* in the stems of the infected corn plant *Z. mays* L. (tunnel/plant.)

Ethephon concentrations	Fungi Type and Concentrations of Pesticides	Number of feeding tunnels (tunnel/plant)			Ethephon effect average	Ethephon effect average and pesticide concentrations	Pesticide effect average
		0.0	F. cf. incarnatum-equiseti isolate Has-4	A. versicolor isolate Has-3			
0.0	0.0	4.89	2.78	2.78	2.43	3.48	2.39
	B50	2.78	2.67	2.66		2.70	
	B100	2.66	2.55	2.55		2.59	
	D50	2.22	2.22	2.33		2.25	
	D100	1.89	2.00	1.78		1.66	
	M50	2.33	2.22	2.33		2.29	
	M100	1.89	1.77	1.78		1.89	
E25	0.0	2.67	2.55	2.66	2.11	2.63	1.80
	B50	2.67	2.44	2.44		2.51	
	B100	2.33	2.11	2.22		2.22	
	D50	2.11	1.78	2.22		2.03	
	D100	1.77	1.44	1.44		1.55	
	M50	2.22	2.11	2.22		2.18	

	M100	1.78	1.55	1.66		1.66	
E50	0.0	2.55	2.44	2.33	1.96	2.44	M
	B50	2.44	2.22	2.22		2.29	
	B100	2.11	2.00	2.11		2.07	
	D50	2.00	1.67	2.00		1.89	
	D100	1.67	1.33	1.33		1.44	
	M50	2.11	2.00	2.00		2.03	
	M100	1.66	1.44	1.55		1.55	
L.S.D0.05		0.4096			0.1303	0.2365	
Fungal effect average		2.32	2.06	2.12			
L.S.D0.05		0.0955					

B50* = Belt 0.10 ml/L // B100* = Belt 0.20 ml/L // D50* = Denim Fit 0.20 g/L// D100* = Denim Fit 0.40 g/L//

M50* = Movento 0.37 ml/L // M100* = 0.75 ml/L// E25* = Ethepon 0.62 ml/L // E50* = Ethepon 1.25 ml/L

4.Evaluation of the effectiveness of the growth inhibitor ethephon (ml/L), fungal species (108 CFU/ml), and pesticide type and concentration (ml or g/L) on the percentage of the excavated area of the stem of a corn (*Z. mays* L.) plant infested by the corn stem borer (*S. cretica*.(%) (

The results of the statistical analysis of the data and output in Table (4) indicated that the percentage of the excavated area of the corn stem infected by the feeding of the corn stem borer insect decreased significantly after treatment with the growth retardant ethephon alone at a quarter and a half of the recommended concentration, reaching 18.10 and 17.46% for both concentrations, respectively. The fungi Has-3 and Has-4 also had a clear effect in reducing the percentage when sprayed alone, reaching 18.57 and 18.36% for both fungi, respectively. The increase in pesticide concentrations also affected the studied trait when used alone, reaching 18.34 and 17.77% for the Belt pesticide, 17.38 and 17.01% for the Denim Fit pesticide, and 17.80 and 17.21% for the Movento pesticide (half the concentration and the recommended concentration), respectively. The results showed that all treatments reduced the percentage of the excavated area of the

plant stem. With a clear significant difference from the comparison treatment, which amounted to 38.46%, we also find that the triple interaction between ethephon, pesticides and fungi has a clear effect on the percentage of the excavated area of the infected corn stem. The interaction treatment between ethephon at half the recommended concentration with the fungus *Fusarium cf. incarnatum-equiseti* isolate Has-4 and Denim Fit pesticide at the recommended concentration had the lowest rate of 13.47% with a highly significant and clear difference from the comparison treatment which reached 38.46%. The results also showed that the overall effect rate of ethephon had a good effect in reducing the percentage of the excavated area as it reached 15.54 and 14.64% for both concentrations (E25 and E50) respectively with a clear significant difference from the treatments without ethephon as it reached 18.66%. The pesticide Denim Fit was slightly superior in its effect on the studied trait as it gave the lowest rate of 15.42% followed by Movento pesticide at a rate of 15.72% while the rate reached 16.17% when using Belt pesticide.

Table 4: Evaluation of the effectiveness of the growth inhibitor level ethephon (ml/L), fungus type (108 CFU/L), and pesticide type and concentration (ml or g/L) on the percentage of the excavated area of the stem of the corn plant *Z. mays* L. infected due to feeding by the corn stem borer *S. cretica*.(%)

Ethephon concentrations	Fungi Type and Concentrations of Pesticides	Percentage of excavated area (%)			Ethephon effect average	Ethephon effect average and pesticide concentrations	Pesticide effect average
		0.0	<i>F. incarnatum-equiseti</i> isolate Has-4	<i>A. versicolor</i> isolate Has-3			
0.0	0.0	38.46	18.36	18.57	18.66	25.13	B
	B50	18.34	18.18	18.24		18.25	16.17
	B100	17.77	17.68	17.67		17.70	
	D50	17.38	17.58	17.56		17.51	
	D100	17.01	16.97	17.10		17.02	
	M50	17.80	17.89	17.81		17.83	
	M100	17.21	17.17	17.15		17.18	
E25	0.0	18.10	15.93	16.47	15.54	16.83	D
	B50	16.10	15.50	16.34		15.98	15.42
	B100	15.48	15.50	15.88		15.62	
	D50	15.61	14.97	15.45		15.34	
	D100	14.65	13.88	14.45		14.33	
	M50	15.82	15.76	15.54		15.71	
	M100	15.13	14.77	15.06		14.99	
E50	0.0	17.46	15.19	15.23	14.64	15.96	M
	B50	15.00	15.53	14.62		15.05	15.72
	B100	14.56	14.52	14.20		14.43	
	D50	14.80	14.90	13.92		14.45	
	D100	14.10	13.47	13.93		13.83	
	M50	14.79	14.97	14.29		14.68	
	M100	14.25	13.66	14.20		14.03	
L.S.D0.05		0.4925			0.1099	0.2843	
Fungal effect average		17.13	15.82	15.89			
L.S.D0.05		0.127					

B50* = Belt 0.10 ml/L // B100* = Belt 0.20 ml/L // D50* = Denim Fit 0.20 g/L// D100* = Denim Fit 0.40 g/L//

M50* = Movento 0.37 ml/L // M100* = 0.75 ml/L// E25* = Ethephon 0.62 ml/L // E50* = Ethephon 1.25 ml/L

The purpose of estimating field damage caused by the corn stem borer *Sesamia cretica*, through precise indicators such as the percentage of shoot apex mortality, the

number of holes, the number of feeding tunnels, and the percentage of the excavated area of the stem, is to provide a comprehensive understanding of the severity of the infestation and its cumulative impact on the plant. This detailed estimation allows

determining the level of damage caused by the insect to plant tissues, which negatively affects the efficiency of internal water and nutrient transport, thus affecting vegetative growth, flowering, and grain formation. It also allows assessing the suitability of the cultivated variety and the agricultural practices followed, which contributes to directing integrated pest management programs towards more accurate and efficient procedures. Thus, this data contributes to supporting scientifically based decisions to reduce losses and achieve high productivity. The reason for the low percentage of shoot apex mortality, the number of holes, the number of feeding tunnels, and the percentage of the excavated area of the stem may be due to the role of the study treatments, including ethephon, which directly affects some aspects of the life of the corn stem borer, as this obstacle played an important role in preventing larval feeding. This directly reflects the achievement of good relative efficiency in eliminating the larvae of this pest, as ethephon stimulates plant defense mechanisms, such as increasing the accumulation of phenolic compounds and lignans, which enhance the rigidity of the cell wall and hinder its penetration. It also reduces the percentage of death of the growing tip by improving the sustainability of the growing tissues, and reduces the number of larvae on the infected plant by reducing the plant's attractiveness for laying eggs and increasing chemical defenses. This reduces the number of holes, which are an indicator of attempts to penetrate the tissues, and reduces the number of feeding tunnels, which indicates weak nutritional activity of the insect. The decrease in the percentage of the excavated area of the stem also shows a reduction in internal damage, which confirms that ethephon contributes significantly to enhancing the plant's resistance to the effects of infection by activating multiple defense mechanisms that reduce the plant's susceptibility to insect exploitation [8]. The results were somewhat similar to the results of the study by Ghanem et al. (2019) conducted at Sakha Agricultural

Research Station in Kafr El-Sheikh Governorate, Egypt, during the 2016 and 2017 cotton growing seasons. The results showed that treatment with the growth retardant ethephon at a concentration of 3 cm³/L gave the lowest infection rate of the cotton bollworm *Pectinophora gossypiella*, reaching 56.68 and 37.60% during the two study seasons, respectively. The infection rate of the spiny bollworm *E. insulana* reached 50.66 and 43.75% when using the growth retardant ethephon at a concentration of 1.5 cm³/L during the 2016 and 2017 growing seasons, respectively. Al-Rashad (2023) also indicated that the plant growth regulator gibberellins plays an important role in influencing the percentage of infection with spiny bollworm larvae in the field, by stimulating systemic resistance in parts of the cotton plant. The concentration of 250 contributed to mg/L reduced the infection rate from 27.45% and 20.79% in the control treatment to 15.44% and 14.53% after the second and third sprays, respectively. The growth regulator gibberellin also showed great importance in improving the effectiveness of insecticides, as the killing efficiency increased to 100% when used at a concentration of 250 mg/L with the pesticide balt at a concentration of 0.3 ml/L, five days after the second spray in laboratory experiments.

The results we obtained after implementing the current experiment, shown in the tables above, showed a significant decrease in the studied characteristics compared to the control treatment, as the treatment of plants with Denim Fit pesticide, at a concentration used in the study of 0.40 g/L, excelled. This is attributed to the fact that Denim Fit pesticide combines the power of two pesticides specialized in eliminating worms, namely emamectin benzoate and lufenuron. It is considered a broad-spectrum pesticide with high penetration that works by contact and through the digestive system, as it combines the power and effectiveness of two pesticides with two different modes of action that work

to eliminate all stages of the insect, such as larvae, prevent egg hatching, and stop egg laying in adult insects in a single spray. The active ingredient, emamectin benzoate, works to interrupt the nerve signals that give orders to move the muscles of the treated larvae, disrupting nerve conduction and causing irreversible paralysis, thus losing the ability to move and feed and dying quickly. As for lufenuron, which belongs to the group of insect growth inhibitors, it prevents the formation of chitin. We also do not underestimate the importance of the pesticides Belt (2023) to evaluate the toxicity of the active ingredient Lufenuron on the growth and development of the fall armyworm *Spodoptera frugiperda*. The results showed that Lufenuron exhibits high toxicity against *S. frugiperda*, with an LC₅₀ value of 0.99 mg/L. It was also shown that Lufenuron can reduce pupation and emergence rates, as the treated larvae died due to defects in the chitin synthesis and metamorphosis process. EL-Shennawy and Kandil (2017) also indicated that the use of pesticides (emamectin benzota 2.5% EC) and nomolt (Teflubenzuron 15% EC) at a concentration of 150 and 50 ml/200 liters of water, respectively, on the first-instar larvae of the harmful stage of the spiny bollworm *E. insulana* at the half-lethal concentration, the pesticide Emamectin was superior. Benzoate compared to Nomolt reduced the average larval weight to 91.1% and increased the rate of deformity and mortality, reaching 79% compared to 74% for Nomolt. Biochemical analyses revealed that the use of both pesticides on the first larval stage resulted in a decrease in carbohydrate, protein, and lipid levels. The concentration of the enzyme phenol oxidase, which is essential for melanin production and cuticle formation, also decreased. Conversely, the concentration of the enzyme chitinase increased when the enzyme was filtered and extracted. Insect pathogenic fungi are a component of integrated pest management systems, and they

have great potential as biological control agents against insects. It was found that the fungi *Aspergillus versicolor* isolate Has-3 and *Fusarium cf. incarnatum-equiseti* isolate Has-4 secrete a group of cuticle-degrading enzymes such as chitinase, lipase, and protease. These enzymes contribute to penetrating the insect's body wall, as the fungus stimulates the chitinase enzyme during the parasitism stage, causing hydrolysis of chitin to reach the hemocoel, which begins the parasitism stage inside the insect, at which point the fungi begin to attack the insect's internal systems. Moreover, the fungi secrete mycotoxins such as Isarolides, Tenillin, Nidolotoxin, and Aflatoxin. The slight superiority of the *F. incarnatum* fungus is mainly due to its great potential as a biological control agent against harmful insects, its specialization, rapid spread, and high reproductive rate [20]. The current study is consistent with what Yunus (2019) reported in his results on the effect of selected fungi on the corn stalk borer *S. cretica*, as the treatment of the fungus *Fusarium cocophilum* was superior in terms of mortality. 45% compared to the *Beauveria bassiana* treatment, where the mortality rate was 43.7%, with significant differences from the rest of the fungi. As for the concentrations of fungal suspensions that gave the best mortality rate, they were 28.9 and 39.3% in the two concentration treatments of 1 x 5101 10 spores/ml, respectively. As for the time period, the best mortality rate was after 14 days of treatment, and the mortality rate was 54.1%. In a study on the pathogenicity of fungi isolated from the environment against the aphid *Brevicoryne brassicae*, the *Aspergillus versicolor* strain was the most virulent fungus, as it caused a mortality rate of 85.9% in the *B. brassicae* insect community after 24 hours. This study proved that the *A. versicolor* fungus isolated from the environment is a promising candidate for biological control of agricultural pests [16.]

Conclusions:

We conclude from the current study that treatment with the plant growth retardant ethephon at a concentration of 1.25 ml/L, the fungus *Fusarium* cf. *incarnatum-equiseti* isolate Has-4, and the chemical pesticides used (Belt, Denim Fit, and Movento) at the recommended concentrations were highly effective in reducing the percentage of shoot

tip death and reducing field damage such as the number of holes, feeding tunnels, and burrows. This, in turn, reduced the percentage of burrowed area in the stem resulting from infestation by the larvae of the corn stem borer *Sesamia cretica*, which resulted in increased yield and quality.

References

- [1] Al-Ameri, N. M. N. 2011. The effect of chemical control of the *Sesamia cretica* Led corn stalk borer. On the growth and productivity of the corn crop *Zea mays* L. in Qadisiyah governorate. *Euphrates Journal of Agriculture Science*, 3(1): 123-130.
- [2] Al-Asibi, M. R. Sh. 2023. A study of the sensitivity of some corn cultivars to infestation by the corn stem borer *Sesamia cretica* Led. (Lepidoptera: Noctuidae). Master's thesis, College of Agriculture, University of Mosul.
- [3] Al-Jubouri, Ab, F. A., and Al-Karbouli, H. H. 2012. Estimation of Damage Caused by Corn Stem Borer Infestation on Plants, Yield Components, and Chemical Content of Seeds of Some Local Varieties of Cereal White Sorghum. *Iraqi Journal of Agricultural Sciences*, 43(3), 78.
- [4] Al-Muhairi, A. S. A. 2016. Effect of some agricultural and chemical processes on the corn stem borer *Sesamia cretica* Led. (Lepidoptera: Noctuidae). PhD thesis, College of Agriculture, University of Mosul.
- [5] Al-Rafai, Ot. H. A. 2018. The Use of Some Vegetable Oils, Actara and Cruiser Pesticides, and the Bacterial Biopreparation Thuricide and Their Integration in Controlling the Corn Stem Borer *Sesamia cretica* (Lepidoptera: Phalaenidae) on Corn, Master's Thesis, College of Agriculture, Tikrit University.
- [6] Al-Rashad, Ab. K. R. 2023. Integration of Gibberellic Acid with Some Chemical Pesticides in Controlling the Spiny Bollworm, *Earias insulana* (Boisd) (Lepidoptera: Noctuidae). Master's Thesis, College of Agriculture, Tikrit University.
- [7] Al-Rawi, Kh. M., and Khalaf Allah, A. A. M. 2000. Design and Analysis of Agricultural Experiments, Second Edition, Dar Al-Kutub for Printing and Publishing, University of Mosul.
- [8] Al-Sandoq, Dh. L. 2016. Induction of Systemic Resistance in Plants and Its Complex Relationship with the Pathogen, Scientific Article, Scientific Forum for Agricultural and Palm Scientists and Researchers. <https://agri-palm.com>.
- [9] Central Statistical Organization (CSO), 2023. Annual Statistical Abstract, Ministry of Planning, Iraq.
- [10] EL-Hosary, A.A.; EL-Badawy, M.EL.M.; Saafan, T.A.E., and Ismail. M.R.M. 2012. Genetic analysis of agronomic characters and resistance to borer for genotypes in corn. 13th international Conf. Agron., Fac. of Agric., Benha Univ., Egypt, 35-48.
- [11] El-Shennawy, R. M. and Kandil, M. A. 2017. Potency of Nano-Particle Compound and Two Traditional Insecticides Against the

Spiny Bollworm ‘*Earias insulana* In Relation to Some Biological and Biochemical Aspects. Egyptian Academic Journal of Biological Sciences. A ‘Entomology, ‘10(6) ‘179-189.

[12] Ghanem, A.A.; Abdul Badie, A. H.; Al-Muzayen, G. A., and Abdul Khaliq, A. A. 2019. Evaluation of Ethephon Application on Bollworms, *Pectinophora gossypiella* (Saund.) and *Earias insulana* (Bois.) Infestation and Boll Opening in Cotton Fields. Journal of Plant Protection and Pathology, 10(8), 401-402.

[13] Konan, K. M.; Kouassi, K. I.; Bonny, B. S.; Doubi, B. T. S.; Zoro, B. I. A., and Dogbo, D. O. 2023. The efficiency of cassava–Bambara groundnut intercropping according to the sowing date of cassava. South African Journal of Plant and Soil, 1-9.

[14] Leyden, P. 2014. Efficacy of *Bacillus thuringiensis* spvay applications for control of lepidoptera pests. Master thesis. potchcfstoom campus of North west Lniversity. Africa south .49 pp.

[15] Lv, H.; Ling, S.; Guo, Z.; Zheng, C.; Ma, H.; Li, J., and Ma, K. 2023. Effects of lufenuron treatments on the growth and development of *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 263, 109499.

[16] Pacheco, J. C.; Poltronieri, A. S.; Porsani, M. V.; Zawadneak, M. A. C., and Pimentel, I. C. 2017. Entomopathogenic

potential of fungi isolated from intertidal environments against the cabbage aphid *Brevicoryne brassicae* (Hemiptera: aphididae). Biocontrol Science and Technology, 27(4), 496-509.

[17] Saleh, Y. A.; Janan, M. K., and Thamer S. J. 2011. Isolation and Identification of Fungi Associated with the Black Bean Aphid and the Possibility of Using Some of Them in Biological Control of the Insect, University of Kufa Journal of Biological Sciences, 1(3.(

[18] Shafeek, M.R.; Helmy, Y.I.; Ahmed, A.A. and Ghoname, A.A. 2016. Effect of foliar application of growth regulators (GA3 and Etherel) on growth, sex expression and yield of summer squash plant (*Cucurbita pepo* L.) under plastic house condition. International Journal of Chem. Tech. Research. 9(6): 70-76.

[19] Tengey, T. K.; Alidu, S. M.; Moro, A.; Nboyine, J., and Affram, E. I. 2023. Resistance to *Callosobruchus maculatus* among cowpea (*Vigna unguiculata* (L.) Walp) genotypes. Journal of Crop Improvement, 37(3), 309-322.

[20] Thambugala, K.M.; Daranagama, D.A.; Phillips, A.J.L.; Kannangara, S.D., and Promputtha, I. 2020 .Fungi vs. Fungi in Biocontrol: An Overview of Fungal Antagonists Applied Against Fungal Plant Pathogens. Front. Cell. Infect. Microbiol. 2020, 10, 604923. [Google Scholar] [CrossRef.]