

Laboratory and Field Assessment of Methyl Jasmonate Combined with Insecticides for the Management of Maize Stem Borer *Sesamia cretica* Led.

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Abstract

This study was conducted through two complementary approaches—laboratory and field experiments—to evaluate the efficacy of the plant growth regulator methyl jasmonate (MeJA) in combination with two insecticides, Coragen and Karate Zeon, against the maize stem borer *Sesamia cretica*.

1. Laboratory Study

The laboratory phase was carried out at the Central Laboratory for Postgraduate Studies, College of Agriculture, University of Tikrit, For the period from 1/10/2024 to 1/11/2025 using MeJA at three concentrations (0.0, 60, and 120 μ Mol) and two insecticides, Coragen (20 and 40 ml/100 L) and Karate Zeon (15 and 30 ml/100 L).

Results demonstrated a marked increase in corrected mortality of third-instar larvae across treatments. The highest mortality rate (100%) was achieved under triple interactions combining MeJA (60 or 120 μ Mol) with either insecticide at the recommended or half-recommended concentration, following 9 days of exposure. When applied alone, MeJA at 120 μ Mol raised mortality to 54.67%, compared with 41.07% in the control. Regarding larval weight, the combination of 120 μ M MeJA and Coragen (recommended rate) produced a substantial reduction to 0.5 g/10 larvae after 9 days, compared with 1.95 g/10 larvae in the untreated control—reflecting a strong inhibitory effect on larval feeding and growth.

2. Field Study

Field experiments conducted in the Samarra District during the autumn season of 2024–2025 confirmed the laboratory findings. Both maize cultivars, Nevada and TG630, showed a clear response to the treatments, although Nevada tended to perform slightly better overall. Treatments with MeJA at 60 and 120 μ Mol significantly reduced the number of insect stages per tunnel to 0.50 and 0.30 larvae/tunnel, respectively, compared with 1.50 larvae/tunnel in the control. Among the insecticides, Coragen at the recommended rate achieved the lowest infestation level (0.11 insects/tunnel). The triple interactions once again proved most effective, with complete elimination of larvae (0.0 insects/tunnel) in several combined treatments.

Overall Findings

The integration of MeJA with selective insecticides, especially Coragen, exhibited a powerful synergistic effect, significantly enhancing larval mortality, suppressing infestation, and improving plant protection under both laboratory and field conditions. These results underscore the promising potential of combining plant growth regulators such as MeJA with environmentally safer insecticides as a sustainable and effective strategy within integrated pest management (IPM) programs for controlling *S. cretica* in maize.

Keywords: *Zea mays*, *Sesamia cretica*, Methyl jasmonate, Coragen, Karate Zeon, Integrated pest management.

1. Introduction

Yellow corn is considered *Zea mays* L. is one of the strategic crops in the Arab world, the world, and Iraq(1). Yellow corn, like other economic crops, is exposed to many pests, the most important of which is the corn stalk borer. *Sesamia cretica*, commonly known as pink corn stalk borer or large sugarcane borer (2). This insect is considered one of the most important corn stalk borer insects in the Middle East, as it infects a wide range of grass grain crops, but its food preference is concentrated on yellow corn, sorghum and sugar cane, causing production losses ranging from 16 to 78% in different regions of the world and according to environmental conditions and the stage of plant growth, where the loss is greater, the loss is greater when the plant is infected during the early growth stages, causing significant damage to young plants such as the death of the growing apex or what is known as the dead heart (3),(4). The corn borer *S. cretica* has five overlapping generations per year, and the average generation period may be 42.41 days on sugarcane and 54.57 days on yellow corn(5). Due to the economic importance of maize, the world has moved towards implementing various strategies to protect it from pests, especially the infestation of the corn stalk borer *S. cretica*, the use of chemical pesticides is one of the main methods for controlling this insect. Still, the excessive use of traditional pesticides with a wide spectrum, such as organophosphates, carbamates, organochlorines pesticides, has led to the

emergence of resistance in the generations following the pest, in addition to affecting non-target organisms such as predators, intruders, bees, and other organisms(6)(7). To reduce the hazards of conventional pesticides, modern selective compounds such as anthranilic diamides like Coragen are increasingly used within IPM programs due to their lower impact on non-target organisms and the environment when applied at recommended doses, alongside alternatives like natural compounds and plant growth regulators or their analogs(8)(9). The use of tolerant or relatively resistant cultivars is one of the adopted strategies for pest management, as maize cultivars vary in their adaptability under infestation with the corn stem borer *S. cretica*. (10). Due to the ecological problems associated with excessive pesticide use, attention has shifted toward plant growth regulators as a safer alternative in crop protection. Jasmonates, including Jasmonic Acid (JA), Methyl Jasmonate (MeJA), and their derivatives, are widely recognized for their role in enhancing plant resistance against pests by regulating responses to biotic and abiotic stresses(11). Studies have shown that among the physiological and morphological changes of the effect of the external application of the MeJA growth regulator, which is one of the defensive responses of the plant, is the increase in the density of leaf bristles, the density of stomata, the thickness and composition of the leaf epidermis, in addition to the production of biomass, where

they vary according to the different concentrations used(12) . Methyl Jasmonate (MeJA) is an important plant growth regulator involved in the regulation of various physiological and morphological processes. Several studies have reported that MeJA enhances plant defense systems and stimulates the biosynthesis of secondary metabolites such as phenolics, carotenoids, and anthocyanins(13).

This study aimed to evaluate the synergistic effect of MeJA combined with two insecticides against the maize stem borer under laboratory and field conditions.

2. Materials and Methods

2.1. Laboratory Study

The laboratory experiment was conducted at the Central Laboratory for Postgraduate Studies and the Laboratory of the Department of Plant Protection, College of Agriculture, University of Tikrit, during the period from October 1, 2024, to November 1, 2024.

2.1.2. Rearing of the Maize Stem Borer, *Sesamia cretica* Led., under Laboratory Conditions.

Due to the urgent need for larvae of the maize stem borer *S. cretica* Led. for conducting laboratory tests, second-instar larvae were collected from infested stems of maize plants (*Zea mays* L.) in several fields located in Samarra District, Salah al-Din Governorate. The larvae were transferred into transparent plastic containers (900 ml capacity) at a rate of 10 larvae per container. Each container was provided with natural food consisting of cut maize stems (3–4 cm in length). The container openings were tightly covered with muslin cloth to allow aeration and prevent larval escape, and the cloth was secured with rubber bands. The containers were then placed in an incubator at 25 ± 2 °C and $60 \pm 5\%$ relative humidity, with daily

monitoring until the larvae reached the third instar. The stem pieces were replaced periodically to provide fresh food and to remove waste(14).

2.1.3. Evaluation of the Efficacy of Treatments against *S. cretica* Larvae under Laboratory Conditions.

The efficiency of the growth regulator methyl jasmonate (MeJA) at three concentrations (0.0, 60, and 120 μ M), in combination with the insecticides Coragen 20% SC (20 and 40 ml/100 L) and Karate Zeon 10% EC (15 and 30 ml/100 L), was evaluated under exposure periods of 1, 3, 5, 7, and 9 days after treatment. The corrected mortality percentage and the average change in larval weight of *S. cretica* were assessed. Treatments were applied according to factorial combinations of the tested factors.

2.1.4. Corrected Mortality Percentage of Third-Instar Larvae of *Sesamia cretica* Led.

To determine the efficacy of each tested substance (methyl jasmonate and the insecticides Coragen and Karate Zeon at different concentrations), third-instar larvae of the maize stem borer were exposed to maize stem pieces sprayed with the respective treatment solutions. Ten larvae were placed in each container, and the number of dead larvae was recorded after 1, 3, 5, 7, and 9 days post-treatment. Corrected mortality of *S. cretica* larvae was calculated according to Abbott's formula :(15)

Corrected Mortality (%)

$$= \frac{\text{Total larvae at the beginning} - \text{Dead larvae}}{\text{Number of dead larvae in treatment} - \text{Dead larvae}} \times 100\%$$

2.1.5. Larval Weight Change of Third-Instar *S. cretica*

To calculate the change in larval weight, ten third-instar larvae were weighed prior to being

placed in 900 ml plastic containers containing maize stem pieces treated with the tested substances (either individually or in combinations, according to the studied concentrations). Larval weights (g/10 larvae) were recorded at intervals of 1, 3, 5, 7, and 9 days after treatment(16) .

2.2. Field Study

2.2.1. Field Operations

The yellow corn field was established with an area of 1500 m² (50 × 30 m) in November 2024, where the plants were produced by the Turkish company Rayal, specialized in the agricultural field, and three concentrations of methyl jasmonic acid (0.0, 60 and 120) micromolar and each of (SC20% Coragen with a concentration of 40-20 ml/100 liters and Karate Zeon 10%EC 30-15 ml/100 liters) in addition to the interference coefficients between the factors, with a total of 15 treatments representing the different treatments, including the comparison treatment without any addition. Each experimental unit measured 8 m² (4 × 2 m) and contained 60 plants(17).

2.3. Number of *S. cretica* larvae (larvae/plant).

The number of larvae per infested plant was determined following the method described by (3). Infested maize plants were carefully uprooted from the soil, leaves were removed, and the stems were longitudinally dissected using a sharp scalpel. The larvae present inside each plant were then counted.

2.4. Statistical Analysis

2.4.1. Statistical Analysis of the Laboratory Experiment

The laboratory experiment was conducted using a Completely Randomized Design (CRD). Data were analyzed using the GenStat statistical software. Differences among treatment means were compared using the

Least Significant Difference (LSD) test at the 5% probability level(18) .

2.4.2. Statistical analysis of field experiments:

The field experiment was conducted as a factorial study using a split-split-plot design with three replications, where maize varieties (Nevada and TG630) were the main factor, MeJA concentrations the sub-factor, and pesticide types and concentrations the sub-sub-factor. Data were analyzed using ANOVA in GenStat version 12, and the least significant difference (LSD) at a probability level of 5% was calculated to evaluate the effects of all factors and their interactions(18).

3. Results and Discussion:

3.1. Laboratory Study:

3.1.1. Effects of MeJA and Insecticides on Third-Instar *Sesamia cretica* Mortality.

Corrected mortality percentage is considered one of the most reliable indicators used in laboratory research to evaluate the efficacy of chemical insecticides, growth regulators, and biotic factors against insect pests, as it precisely reflects the mortality attributable to treatments. The present study revealed that corrected mortality varied depending on the applied treatments, as presented in Table (1). Statistical analysis demonstrated that the main factors exerted differential effects on corrected mortality (%) of *S. cretica* third-instar larvae.

The mean effect of methyl jasmonate (MeJA) concentrations showed a significant impact depending on the applied levels, as corrected mortality increased from 41.07% in the control (0.0 μMol) to 54.67% with MeJA at 120 μMol, which was significantly higher than both 0.0 and 60 μMol concentrations. Similarly, the mean effect of insecticides and their concentrations was significant, as

Coragen at the recommended concentration significantly surpassed all other treatments with a corrected mortality of 62%, compared with only 22.84% in the untreated control.

The effect of exposure periods also revealed significant variation. As shown in Table (1), the highest corrected mortality was recorded on the ninth day of exposure (89.06%), which was significantly superior to all other exposure times, whereas the lowest mortality was observed after the first day (8.67%).

Moreover, the interaction between MeJA concentrations (0.0, 60, and 120 µMol), the two insecticides (Coragen and Karate Zeon), and the longest exposure time (9 days) resulted in the maximum corrected mortality of 100%. In comparison, the untreated control at the same exposure period recorded only 10%. Meanwhile, MeJA alone at 60 µMol after 9 days resulted in 59.26% mortality, whereas 120 µMol alone at the same period yielded 66.67% mortality without insecticidal treatments.

Table (1). Effects of MeJA Concentrations, Insecticide Rates, and Their Interactions on Corrected Mortality of Third-Instar *Sesamia cretica* Larvae under laboratory conditions.

Corrected mortality (%) of third-instar larvae of the maize stem borer							
MeJA Concentrations	Type and concentration of pesticide	Exposure Duration Effect					
		1Day	3Day	5Day	7Day	9Day	
0.0 µM	No pesticide	0	0	0	0	10	
	K. Z.30ml	10	20	40	70	100	
	K. Z.15 ml	0	10	36.67	76.67	100	
	Cor. 40ml	20	30	60	83.33	100	
	Cor.20ml	10	30	46.67	73.33	100	
60µM	No pesticide	0	10	33.33	53.33	59.26	
	K. Z.30ml	0	20	60	76.67	100	
	K. Z.15 ml	0	13.33	46.67	80	100	
	Cor. 40ml	10	43.33	63.33	86.67	100	
	Cor.20ml	0	13.33	53.33	83.33	100	
120µM	No pesticide	0	10	40	60	66.67	
	K. Z.30ml	20	40	60	80	100	
	K. Z.15ml	10	30	50	70	100	
	Cor. 40ml	30	50	70	83.33	100	
	Cor.20ml	20	40	60	76.67	100	
L.S.D 0.05		9.848					
Impact of exposure periods		8.67	24	48	70.22	89.06	influence

L.S.D 0.05		2.543					MeJA	MeJA Effect With pesticide type and concentrations		
MeJA Impact During Exposure Periods	0.0	8.00	18.00	36.67	60.67	82.00	41.07	0.0	60	120
	60	2.00	20.00	51.33	.0076	91.85	48.24			
	120	.0016	.0034	.0056	.0074	93.33	54.67			
L.S.D 0.05		4.404					1.97			
Effect of Pesticide Type and Concentrations with Exposure Periods							Pesticide Effect	0.0	60	120
K.Z	30	10	26.67	53.33	75.56	100	53.11	48.00	51.33	60.00
	15	3.33	17.78	44.44	75.56	100	48.22	44.67	48.00	52.00
Cor.	40	20	41.11	64.44	84.44	100	62	58.67	60.67	66.67
	20	10	27.78	53.33	77.78	100	53.78	52.00	50.00	59.33
Control	0.0	0	6.67	24.44	37.78	45.31	22.84	2.00	31.19	35.33
0.05 L.S.D		5.686					2.543	4.404		

3.1.2. Effects of MeJA and Insecticide Treatments on Weight Change of Third-Instar *Sesamia cretica* Larvae

The study of larval weight change is considered an important physiological indicator for evaluating the impact of factors involved in insect pest management, including chemical insecticides and plant-based insect growth regulators, as it reflects their influence on feeding efficiency and food conversion. The results of statistical analysis, as shown in Table (2), indicated that the treatments tested in this study exhibited significant variation in larval weight change. Triple interactions among MeJA concentrations, insecticide types and rates, and exposure periods played a crucial role in reducing larval weight. For instance, the average weight of larvae decreased from 1.95 g/10 larvae in the triple interaction involving 0.0 μMol MeJA without insecticides after 9 days of exposure, to as low as 0.5 g/10 larvae in the triple interaction of 120 μMol MeJA combined with Coragen at the recommended concentration on the ninth day of exposure, representing the lowest recorded weight among all treatments.

Regarding the main factors of the experiment, Table (2) and the corresponding statistical analysis results revealed clear differences. For MeJA concentrations, 120 μM significantly outperformed the other concentrations by yielding the lowest larval weight (1.07 g/10 larvae), compared with the highest weight (1.32 g/10 larvae) at 0.0 μMol . Similarly, for insecticides, Coragen at the recommended concentration significantly reduced larval weight to 1.11 g/10 larvae, compared with the highest larval weight (1.33 g/10 larvae) recorded in the untreated control.

Exposure periods also showed a notable effect on larval weight reduction. The lowest weight was recorded after 9 days of exposure (0.99 g/10 larvae), whereas the highest weight was observed at the beginning of treatment (1.47 g/10 larvae). This indicated a total reduction of 0.48 g over the 9-day exposure period.

Table (2) Effects of MeJA Concentrations and Insecticides on Larval Weight Change of Sesamia cretica under labrotary condition.

Weight change rate (g/10 larvae) of third-in-life corn stalk borer larvae								
MeJA Concentrations	Type and concentration of pesticide	Exposure Duration Effect						
		Da y0	Da y1	Da y3	Da y5	Da y7	Da y9	
0.0 μM	No pesticide	1.36	1.38	1.44	1.50	1.70	1.95	
	K. Z.30ml	1.50	1.34	1.21	1.20	1.17	1.14	
	K. Z.15 ml	1.45	1.30	1.17	1.14	1.09	1.02	
	Cor. 40ml	1.52	1.44	1.39	1.28	1.19	1.11	
	Cor.20ml	1.53	1.47	1.35	1.24	1.14	1.01	
60μM	No pesticide	1.51	1.45	1.38	1.21	1.18	1.13	
	K. Z.30ml	1.40	1.43	1.29	1.17	1.13	0.99	
	K. Z.15 ml	1.52	1.43	1.39	1.26	1.23	1.09	
	Cor. 40ml	1.53	1.43	1.25	1.06	0.92	0.81	
	Cor.20ml	1.4	1.35	1.11	0.97	0.88	0.8	
120μM	No pesticide	1.46	1.33	1.17	1.03	0.95	0.87	
	K. Z.30ml	1.40	1.35	0.93	0.82	1.17	0.63	
	K. Z.15ml	1.51	1.28	1.25	1.16	1.11	1.03	
	Cor. 40ml	1.38	1.07	0.88	0.64	0.58	0.5	
	Cor.20ml	1.48	1.34	1.17	1.11	1.01	0.83	
L.S.D 0.05		0.0153						
Impact of exposure periods		1.47	1.36	1.23	1.21	1.07	0.99	influen ceMeJ A
L.S.D0.05		0.004						
Effect MeJA During exposure	0.0	1.47	1.39	1.31	1.27	1.26	1.24	1.32
	60	1.4	1.4	1.2	1.1	1.0	0.9	1.23
								MeJA Impact Rate With

periods		9	2	8	3	7	6		pesticide types and concentrations			
	120	1.4 5	1.2 7	1.0 8	0.9 5	0.8 7	0.7 7	1.07				
L.S.D 0.05		0.0068						0.0028				
Effect of Pesticide Type and Concentrations with Exposure Periods									Pesticid e Impact	0.0	60	120
K.Z	30ml	1.4 6	1.3 7	1.1 4	1.0 6	1.0 1	0.9 2	1.16	1.2 6	1.2 5	0.9 8	
	15ml	1.4 9	4 1.3	1.2 7	1.1 9	1.1 4	1.0 5	1.25	1.2 0	1.3 2	1.2 2	
Cor.	40ml	1.4 7	1.3 1	1.1 7	0.9 9	0.9 0	0.8 0	1.11	1.3 2	1.1 7	0.8 4	
	20ml	1.4 7	1.3 9	1.2 1	1.1 1	1.0 1	0.8 8	1.18	1.2 9	1.0 9	1.1 6	
Control	0.0	1.4 4	1.3 9	1.3 3	1.2 5	1.2 8	1.3 2	1.33	1.5 6	1.3 1	1.1 4	
L.S.D 0.05		0.0088						0.0036	0.0062			

3.2. Field Study

3.2.1. Effects of Maize Cultivar, MeJA, and Insecticide Interactions on the Number of *S. cretica* Stages per Tunnel.

The presence of the lowest possible number of insect stages within an individual plant is considered one of the key indicators of the success of management practices, as it is directly associated with the percentage and severity of infestation and their responsiveness to different management strategies. Results of the present study revealed significant variation among treatments in reducing the number of insect stages per feeding tunnel inside maize stems.

As shown in Table (3), the effect of cultivars alone was not significant, recording averages of 0.76 and 0.78 insects/tunnel for Nevada and TG630, respectively. Regarding MeJA concentrations, statistical analysis indicated significant differences among treatments, with 120 and 60µMol MeJA recording significantly lower values of 0.30

and 0.50 insects/tunnel compared with 1.50 insects/tunnel at 0.0µMol. For insecticides, results varied, with the lowest number of insects per tunnel (0.11 insects/tunnel) recorded under Coragen at the recommended rate. This treatment was significantly superior to the untreated control, which recorded the highest number of 2.67 insects/tunnel, but did not differ significantly from other insecticide concentrations.

Triple interactions among cultivars, MeJA concentrations, and insecticide types/rates showed a highly significant effect. The lowest value of 0.0 insects/tunnel was achieved in several triple combinations, including both cultivars (Nevada and TG630) combined with 60 or 120 µMol MeJA and either the recommended or half-recommended rates of Coragen and Karate Zeon. These treatments were significantly superior to some other triple combinations, such as Nevada with 0.0 or 60 µMol MeJA without insecticides, and TG630 with 0.0, 60, or 120 µMol MeJA without insecticides, which recorded higher

averages of 4.00, 2.00, 4.00, 3.00, and 2.00 insects/tunnel, respectively.

Table (3): Effects of Cultivar, MeJA, and Insecticide Interactions on Larval Density per Tunnel of *S. cretica* in Maize.

Number of insects in the tunnel (insect/tunnel)									
Cultivars	MeJA Concentrations	Type and concentrations of pesticides					Impact of Cultivars With MeJA Concentrations	Impact of Cultivars	
		Control	Coragen		Karate Zeon				
			0.0	20 ml/100L	40 ml/100L	15 ml/100L			30 ml/100L
Nevada	0.0	4.00	1.00	0.67	1.00	1.67	1.67		
	60	2.00	0	0	0	0	0.40		
	120	1.00	0	0	0	0	0.20		
TG630	0.0	4.00	1.33	0	1.33	0	1.33		
	60	3.00	0	0	0	0	0.60		
	120	2.00	0	0	0	0	0.40		
L.S.D 0.05		1.1748					0.367		
Pesticide Impact		2.67	0.389	0.11	0.39	0.28	Effect of MeJA Concentrations		
L.S.D 0.05		0.5143							
Effect of MeJA with pesticides	0.0	4.00	1.17	0.33	1.16	0.83	1.50		
	60	2.50	0	0	0	0	0.50		
	120	1.50	0	0	0	0	0.30		
L.S.D 0.05		0.845					0.311		
Effect of the Cultivars with pesticides	Nevada	2.33	0.33	0.22	0.33	0.55		0.76	
	TG630	3.00	0.44	0	0.44	0		0.78	
L.S.D 0.05		0.656						0.115	

4. Conclusion

The present laboratory investigation confirmed that both methyl jasmonate (MeJA) and the insecticides Coragen and Karate Zeon significantly affected the corrected mortality and larval weight of the maize stem borer, *Sesamia cretica*. The application of MeJA at 120 μ Mol enhanced larval mortality and reduced larval biomass compared with the untreated control, suggesting that jasmonates may play a role in insect defense through physiological and biochemical regulation(19). Similar findings were reported by(20). who demonstrated that exogenous application of MeJA in maize activated defensive pathways that suppressed lepidopteran larval growth.

Among the insecticides, Coragen at the recommended rate achieved the highest corrected mortality and larval weight reduction, consistent with previous reports on the efficacy of chlorantraniliprole-based insecticides against lepidopteran stem borers (21). These results are further supported by(22). Who found Coragen (particularly in nano-form) highly effective against *S. cretica*, significantly reducing tunnel numbers and larval feeding activity.

Extended exposure periods markedly increased the effectiveness of the treatments, with the ninth day of exposure producing the highest corrected mortality and the lowest larval weights, this agrees with(23). The exposure period up to the ninth day also contributed to enhancing efficacy due to the

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cumulative effect of both the defensive compounds and the insecticide on the insect's vital functions, increasing mortality rates to 89.06%. When MeJA was combined with the insecticide and a prolonged exposure period, some treatments achieved 100% mortality and reduced larval weight to 0.5 g/10 larvae. These results are comparable to those of(24). who found that the plant growth regulator gibberellin played a significant role in improving the efficacy of insecticides compared to their sole application in controlling third-instar larvae of the cotton bollworm under laboratory conditions, achieving relative mortality rates of up to 100%.

who emphasized the potential of jasmonates to strengthen insecticide efficacy by priming plant defense responses. Collectively, these findings support the concept that integrating plant growth regulators such as MeJA with selective insecticides can enhance pest management strategies, suppress insect development, and reduce crop damage(25).

The study confirmed that integrating MeJA with selective insecticides enhances pest suppression and provides a sustainable approach for managing *S. cretica*. Such integration can reduce reliance on chemical insecticides alone, thus contributing to safer and more effective IPM strategies in maize production.

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