Storage Survey of the Date Moth (*Ephestia cautella*) and Evaluation of the Efficacy of Certain Biological Agents in Limiting its Infestation

Riham Kareem Alwan
Al-Mussaib Technical College, Al-Furat Al-Awsat Technical University
Email: com.riham@atu.edu.iq

Abstract:
The results of the survey in selected regions of Babylon Governorate (Al-Musayib, Al-Iskandariyah, Saddat Al-hindiyah, Al-mahawil, and Al-mashrou) indicated that the insect was prevalent particularly in the month of October to December, where the highest infestation levels were recorded in Al-Musayib and Al-mashrou during December.. The laboratory results showed that the different concentrations of the extracts and duration of exposure to alcoholic extracts had a significant effect ($P \leq 0.05$) on the larval mortality rates with the alcoholic extracts showing a certain superiority over the aqueous extracts. In particular, the aqueous extract of *Dodonaea viscosa* seeds had the highest mortality rate of 61.44% and 54.80% against the second and the fourth larval instar respectively at the concentration of 0.75 mg/ml after a period of one week. On the other hand, the lowest rate (8.00% and 5.13% respectively) was recorded in the concentration of 0.25 mg/ml, after 24 hours. In the case of the aqueous extract of Cuminum cyminum, the highest mortality rates were 66.78% and 51.55% at the concentration of 0.75 mg/ml after one week among second and fourth instar, respectively. The lowest mortality rates of these instars were 15.50% and 10.31% with 0.25 mg/ml concentration after 24 hours, respectively. Moreover, the findings on the alcoholic extracts of the *D. viscosa* and *C. cyminum* seeds on the life cycle immature stages of the pest revealed that *D. viscosa* was much more effective than C. cyminum. The alcoholic extract of *D. viscosa* had the highest mortality rate of 87.30 and 68.54% respectively. In the meantime the *C. cyminum* extract had mortality rates of 80.00 and 68.54 in stars, respectively. In the experiment with the fungal filtrate of *Trichoderma harzianum* at the concentration of (10, 5, 2.5 and 0 mg/ml) in the period (1, 3 and 7 days), the experiment showed that the maximum effect was 90.00% of the second instar and 78.15 percent on the fourth instar. The research concludes that the effectiveness of these treatments is proportional to the concentrations and durations of exposure thus making them more effective in pest control. Therefore, alcoholic extracts and biological agents are suggested as promising

ISSN 2072-3857

alternatives to be applied in Integrated Pest Management (IPM) programs and have environmentally-friendly properties.

Keywords:
Ephestia cautella , Biological Agents ,Larval Instars ,Alcoholic Extracts , *Dodonaea viscosa* , *Cuminum cyminum,* Fungal Filtrate *Trichoderma harzianum.*

Introduction :

Date palms and date fruits are prone to a number of pests as major threats to dates after harvest and storage [19]. Pest infestation in stored products may increase on a large scale, with the percentage of infestation reaching 4 percent right after harvest and even 42 percent after half a year unless it is treated properly and in a timely manner. The date moth, Cadra cautella (Walker), is one of the most important stored-product pests, and a very destructive and ubiquitous insect of the order Lepidoptera. The host range of this pest is wide and in both fields and storehouses and attacks a wide variety of stored food commodities. Although its main host is stored dates, it also infests dried figs, raisins, walnuts, almonds, grains, legumes and other food sources. This insect leads to huge losses of economy to date production in Iraq since the moment of harvest up to the time of marketing and consumption [20].

The storage-pest problems have been controlled using various traditional means such as date pressing and even agricultural quarantine to reduce the damage; but, these are sometimes not adequate. As a result, chemical control has been extensively utilized because of the simplicity of its application, affordability, and quick effectiveness. Some of the most significant ones are carbon tetrachloride (CCl_4) and methyl bromide (CH_3Br). The latter is especially popular as a colorless, odorless, and non-flammable organic substance, which is the main fumigant in the case of the treated packaged dates [6, 37].

It is reported that the effective control of the insects that infest dates in fields and storehouse is not an easy task since it involves organized activities and concurrence among date producers, the owners of the factory, and date packaging units [14]. Because of the common issues and hazards of irrational and incorrect application of chemical pesticides in the control of stored-products, which has a negative impact on human and animal health, many scientists have switched to finding substitutes of chemicals of lesser risk, which further reduces the evolution of insect resistance [27].

ISSN 2072-3857

The last twenty years have witnessed a major trend in the academic and industrial circles towards the manufacturing of biopesticides that are acceptable in the environmental context. These are categorized into botanical or microbial materials, toxins or other natural products that can be incorporated into any Integrated Pest Management (IPM) program against different pests [18]. In the modern method of the research, emphasis is placed on finding the alternatives to synthetic pesticides like the use of toxic and insect-repellent botanical extracts, as well as on the use of alternative methods of control including bio-insecticides, the use of essential oils, and entomopathogenic fungi [8].

Particular plant extracts (*Dodonaea viscosa* and the seeds of Cuminum cyminum) were chosen in the present study in addition to biological agents (fungi). The Trichoderma spp. are also known to have a wide range of strains, which are extensively used as biological control agents against various plant diseases and pathogens. Moreover, a number of species of Trichoderma, especially T. harzianum, have been used as a safe control agent against insect pests in the stored product [2].

The use of botanical extracts is preferred as they are natural and safe substances derived from plants, containing compounds analogous to synthetic pesticides that have proven effective in pest control. These extracts may act as repellents, antifeedants, growth inhibitors, or lethal agents against various insect stages. Recently, there has been a significant increase in interest regarding natural plant products with insecticidal properties, characterized by their rapid environmental degradation and high toxicity toward insect pests [25, 33]. In this context, both alcoholic and aqueous extracts from the seeds of *D. viscosa* and *C.cyminum* were utilized to induce mortality in the various stages of the date moth, *C. cautella*.

The study aimed to:Conduct a storage survey, identification, and laboratory rearing of the date moth, *Ephestia cautella*, in Babylon Governorate.Prepare botanical extracts from *Cuminum cyminum* and *Dodonaea viscosa* seeds and evaluate their efficacy in controlling the life cycle of the insect. Isolate and identify the fungus *Trichoderma harzianum* and investigate its biological activity against the insect.

Materials and Methods:

Storage Survey of the Seasonal Presence of the Date Moth, *C. cautella*, Using Sticky Traps

A survey of the storage was carried out in various locations within the Babylon Governorate such as Al-Musayib, Al-Mashrou, Al-Iskandariyah, Saddat Al-Hindiyah,

and Al-Mahawil. The survey began on August 1, 2025, and went on to December 30, 2025, taking a duration of five months. Paper sticky traps were used, in the form of pyramids, with the open side on the traps, and the bottom was covered with white sheets of adhesive. These traps were suspended at a height of 2 meters within the date storehouses. Three traps were installed in each storehouse, distributed at equal intervals along its length, and the adhesive sheets were replaced as necessary [9, 15]. Morphological identification was performed based on taxonomic keys, confirming the insect as the date moth, *C. cautella*.

Pest Rearing and Identification:

The samples were stored in plastic containers (14 cm high and 10 cm diameter) holding a semi-synthetic diet made of (405 g crushed wheat, 60 g glycerin, 30 g date syrup and 5 g yeast) [3]. The containers were lined with muslin cloth, tied with rubber bands and incubated at a temperature of 25+2 C and a relative humidity of 60- 70 to get different larval instars. This was repeated a few times to purify and to acquire larvae of various ages to be used in experiments; the insect colony was reared through a few generations.

Preparation and Maintenance of the Insect Colony:

To obtain the required larval instars, ten pairs of adult date moths, *C. cautella* (males and females), were isolated during the mating process and placed in plastic containers (10 cm in height and 8 cm in diameter) containing the aforementioned synthetic diet. The different developmental stages were monitored. For the treatments involving aqueous extracts, alcoholic extracts, and the fungus, the larval instars were isolated using three replicates plus a control for each concentration.

Collection and Preparation of Plant Samples:

At the local markets in Babylon Governorate (Al-Musayib District), *Dodonaea viscosa* and Cuminum cyminum seeds were purchased in the form of dried ready-to-use seeds. The electric grinder was used to grind the dried seeds and leaves separately into a coarse powder. The powders thus formed were placed in plastic bags and refrigerated until further use.

The Fungus *Trichoderma harzianum*:

The fungi isolate was retrieved from the Pathology Laboratory of Postgraduate Studies at the Department of Biological Control Techniques at Al-Mussaib Technical College. The isolate was morphologically identified based on its cultural characteristics on PDA, such as colony color (initially white, turning to dark green), rapid growth

rate, and the microscopic appearance of branched conidiophores and globose conidia. The isolate was grown in Petri dishes in sterile Potato Dextrose Agar (PDA). After the incubation period, the dishes were kept in the refrigerator to be used later.

Preparation of Plant Extracts:

Preparation of Cold Aqueous Extracts of *Dodonaea viscosa* and *Cuminum cyminum* Seeds

Cold aqueous extracts for both *D. viscosa* and *C. cyminum* seeds were prepared individually following the method described by [11], as modified from [22]. The seeds and leaves of both plants were ground using an electric grinder. Subsequently, 20 g of the powder from *D. viscosa* seeds and *C. cyminum* seeds were separately placed in 500 ml glass flasks, to which 400 ml of chilled sterile distilled water was added. A magnetic stirrer was used to mix the plant material after which the solution was allowed to stand after 24 hours (to allow maximum extraction) but covered very well to avoid contamination.

Solution was then filtered using Whitman No. 1 filter paper. The filtrate was centrifuged at 3000 rpm and 10 minutes to remove any foreign material. A supernatant (filtrate) was prepared and the precipitate was disposed of. The extract was then put in an electric oven at 40-45 C to extract the dry residue (crude extract). The residue was put in glass vials (which were small and tightly closed) and stored in the refrigerator until needed (the empty weight of these vials was also recorded). This was reiterated a number of times in order to get enough crude active material to perform the experiments.

The biological activity of the cold aqueous extract was determined by dissolving 5 g of the dry residue of each extract in 100 ml of distilled water to make a Stock Solution of 5% (or 50 mg/ml). Experimental concentrations were prepared by adding a surfactant (Tween-20).

Preparation of Alcoholic Extracts for *D. viscosa* and *C. cyminum* Seeds

The alcoholic extracts were prepared following the method described by [23]. A 10 g weight of the dry powder for both *D. viscosa* and *C. cyminum* seeds was placed individually into a Soxhlet extractor. Then 200 ml of ethyl alcohol was added and the extraction was carried out over a period of 24 hours at 45 o C. The crude active ingredients of the plants were extracted and concentrated into the extracted samples. This was done several times until an adequate amount was acquired. The product was then dried in an electric oven at 40 -45 C. The

dry residue was weighed and placed in tightly closed glass containers with known weights and placed in the refrigerator until utilized.

Preparation of Extract Concentrations:

The aqueous extracts were then made into a stock solution by dissolving 5 g of the crude extract with the addition of 3 ml of the surfactant (Tween 20) and the resulting solution was brought to a final volume of 100 ml with distilled water. The control was made of distilled water alone.

The concentrations of the alcoholic extracts were prepared by putting 5g of alcoholic extract into 5 ml of 99.7 ethyl alcohol followed by the addition of 3 ml of Tween 20. The volume was brought to 100 ml with distilled water to create a 5 per cent stock solution (equivalent to 50 mg/ml). The experimental concentrations (0.25, 0.50 and 0.75) were made based on this stock. The control group of this treatment was 5 ml of ethyl alcohol that was diluted to 100 ml by distilled water [5].

Culture Media:

Potato Dextrose Agar (PDA):

A water bath was used to dissolve 39 g of ready-to-use PDA (Himedia, India) in 1 liter of distilled water in a 1-liter glass flask to prepare the medium. Tetracycline antibiotic (250 mg/L) was added. The medium was transfered into 250ml flasks (150ml-flask), closed with cotton plugs and sterilized in an autoclave at 121C and 15 psi pressure over 20min. The flasks were cooled and kept in the refrigerator until they are used [7].

Potato Dextrose Broth (PDB):

The broth was prepared by boiling 200 g of peeled and sliced potatoes in 500 ml of distilled water in a 1-liter glass beaker. A clean gauze cloth was used to filter the mixture and the filtrate was obtained. Next, 20 g dextrose were added and the volume was brought up to 1 liter using distilled water. The broth was subculture into 250 ml flasks (150 ml each) and autoclaved at 121 °C and 15 psi to a total of 20 minutes. The fungal filtrate was prepared using this medium [10].

Preparation of Fungal Filtrate:

After PDB preparation (see above), the Tetracycline was added to the flasks at 250 mg/L and three fungal discs were inoculated on the edge of a culture that was 7 days old. All the flasks were incubated at 25 ± 2 °C and shaken by hand after every 3-4 days to promote a homogenous growth of fungi. The culture was then filtered after 28 days using Whatman No. 1 filter paper and Buechner funnel with vacuum pump. Final sterilization of the filtrate was done by filtration using a Millipore microfilter. The product of the filtration process was placed in tubes and refrigerated. Three

concentrations (2.5, 5 and 10 percent) were prepared by adding certain volumes of the filtrate with the help of sterile medical syringe and adding the volume up to 100 ml with sterile distilled water.

Statistical Analysis:

Analysis of the experiments was performed based on a Factorial Experiment under a Completely Randomized Design (C.R.D.). The differences were tested using the Least Significant Difference (L.S.D.) test at a probability level of 0.05 to establish the significance of the differences. The percentages of mortality were adjusted using the formula of Abbott [1].

Results and Discussion :

The findings in Table (1) demonstrate the storage survey of the *E. cautella* occurrence in the study sites with the help of sticky traps. Results indicate that the insect was very noticeable in the last 3 months of the survey (October, November and December) but there was a decrease in population in August and September. These findings are in line with the findings of [12] who got the highest activity of insects in January and then in November and October (4.99, 4.75, and 4.25, respectively) and lowest activity was recorded in August and September of the same year. This fluctuation is mainly attributed to the suitability of environmental conditions, especially temperature and relative humidity, which directly affect the insect's biological activity and population density

Moreover, [15] indicated that the highest levels of *E. cautella* prevalence were observed in the Al-Kifl and Al-Qasim areas with other regions recording moderate levels of infestations. The findings are also consistent with [17], in which the 2010 pheromone trap capture study showed that the highest population density was in October, November and December after which it was in April, May and June. On the same note, [32] observed that date moth was the most successful insect species in date storeshouses following a prolonged storage time.

ISSN 2072-3857

Table (1) illustrates the survey areas for the date moth, *E. cautella*, in selected regions of Babylon Governorate

Location	Date				
	1/8	91/	101/	1/11	1/12
Al-Musayib	-	+	+	++	+++
Al-lskandariyah	-	+	-	++	++
Saddat Al-hindiyah	-	-	-	-	++
Al-mahawil	-	-	+	+	++
Al-mashrou	-	-	++	++	+++

- (-) No infestation , (+) Low infestation level , (++) Moderate infestation level , (+++) High infestation level.

Table (2) results indicate a strong positive correlation between the concentration of the aqueous seed extract of *D. viscosa*, exposure time and percentage of date moth larva, *C. cautella* mortality. The maximum mortality rate of 61.44% at a concentration of 0.75 mg/ml after one week of treatment, and the minimum mortality rate of 8.00% at a concentration of 0.25mg/ml after 24 hours were observed in the second larval instar. In the fourth larval instar, the mortality rate was highest at 0.75 mg/ml (54.80) after one week with the lowest being 0.25 mg/ml (5.13) after 24 hours. It was noted that with increased concentration and exposure period, the mortality rate increased dramatically. In particular, the mortality rates at the concentrations of 0.75 mg/ml of the second instar were (46.24, 49.11, 53.33, and 61.44) % at (24, 48, 72 hours and one week), respectively.

Regarding the fourth instar at the same concentration, mortality rates were (37.30, 45.40, 48.56, and 54.80)% for the same time intervals. Statistical analysis revealed significant differences between treatments (at a probability level of $P \leq 0.05$); the Least Significant Difference (L.S.D.) value for the interaction between concentrations and time intervals was 5.48 for the second instar and 4.34 for the fourth instar. The study results indicated that the interaction between larval ages, extract type, and concentrations across different time periods showed that increasing the extract concentration led to an increased impact on various larval stages compared to the control treatment. The aqueous extract affects the larval stages during feeding, leading to

ISSN 2072-3857

toxicity and mortality. This may be attributed to larval death from malnutrition due to the presence of antifeedant compounds in the plant. These findings are consistent with [29], who reported that *Dodonaea viscosa* extracts possess high efficacy as repellent and protective agents against various insect pests, significantly reducing infestation levels due to their potent biological compounds.

Table (2). Effect of different concentrations of *D. viscosa* seed aqueous extract on the mortality of the larval instars of the date moth, *E cautella.*

Second instar						Fourth instar					
Concentration Mg/ml	Period				Infestation Rate After Treatment	Concentration Mg/ml	Period				Infestation Rate After Treatment
	24	48	72	Week			24	48	72	Week	
0	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00
0.25	8.00	11.15	15.70	20.23	13.77	0.25	5.13	9.90	2214.	19.12	12.09
0.50	29.00	32.40	36.03	41.13	34.64	0.50	22.20	25.40	20.28	33.30	27.28
0.75	46.24	49.11	53.33	61.44	52.53	0.75	37.30	45.40	65.48	54.80	46.77
Adult stage	20.81	23.17	26.27	30.07		Adult stage	16.66	20.75	22.75	26.81	
LSD 0.05	Concentrations		For periods:		For interference:	LSD0.05	Concentrations		For periods:		For interferenc
	3.06		4.05		5.48		2.09		3.00		4.34

ISSN 2072-3857

These findings are consistent with those reported by [12, 21], whose results indicated that the second larval instar is more sensitive to the extract than the fourth instar. A total mortality rate of 77.98% was recorded at the highest concentration for the second instar, compared to 60.89% for the fourth. This increased sensitivity may be attributed to the reduced thickness and incomplete development of the cuticle in early instars. Furthermore, the voracious feeding behavior of second-instar larvae to ensure growth and development leads to a higher intake of toxins into their bodies. Alternatively, the plant may contain compounds that inhibit the feeding process.

This study also found that the effects of aqueous extracts of cumin and fennel on the larvae of the *Trogoderma granarium* are similar to those reported by [38]. That experiment found that these botanical extracts have repellent effects at any concentration applied (1%, 3 percent and 5 percent). Peak repellency occurred at 90% with a concentration of 5 percent of the aqueous extract of cumin in the solution and 251 repellent force. On the other hand, the minimum was 30 per cent at 3 per cent concentration of the fennel aqueous extract with a force of 58.33. In general, cumin had a better repellent effect than fennel and the general means were 142.4 and 112.6 cm, respectively, These findings are further supported by [30], who demonstrated that plant extracts possess high repellent and toxic activities against various stages of stored product insects, confirming their effectiveness as eco-friendly alternatives to chemical pesticides.

In Table (3) it can be seen that the concentrations of the aqueous extract of cumin seeds *C. cyminum*, duration of exposure, and the percentage of mortality of the date moth larvae *C. cautella* have a positive correlation. The maximum mortality was 66.78% at the concentration of 0.75 mg/ml after one week of treatment and the minimum mortality rate was 15.50 at the concentration of 0.25 mg/ml after 24 hours in the case of the second larval instar.

In the case of the fourth larval instar, it was found that the maximum death rate was 51.55 percent at a concentration of 0.75 mg/ml after a period of one week and the minimum at 10.31 percent at 0.25 mg/ml after 24 hours. In particular, the mortality rates of the second instar at a concentration of 0.75 mg/ml were (48.33, 52.52, 55.48 and 66.78) of the periods (24, 48, 72 hours and one week), respectively. Regarding the fourth instar at the same concentration, the rates were (39.99, 41.84, 45.94, and 51.55%) for the same time intervals.

ISSN 2072-3857

Statistical analysis revealed significant differences between treatments (at a probability level of P \le 0.05). The L.S.D. value for the interaction between concentrations and time intervals was 7.20 for the second instar and 4.66 for the fourth instar.

Table (3). Effect of different concentrations of cumin (Cuminum cyminum) seed aqueous extract on the mortality of the larval instars of the date moth.

Second instar						Fourth instar					
Concentration Mg/ml	Period				Infestation Rate After Treatment	Concentration Mg/ml	Period				Infestation Rate After Treatment
	24	48	72	Week			24	48	72	Week	
0	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00
0.25	15.50	18.22	20.20	25.88	19.95	0.25	10.31	14.61	9218.	20.00	15.80
0.50	31.90	35.60	40.00	44.10	37.90	0.50	24.40	28.71	6030.	37.71	30.22
0.75	48.33	52.52	55.48	66.78	55.78	0.75	39.99	41.84	.94 45	51.55	44.83
Adult stage	23.93	26.58	28.92	34.19		Adult stage	18.67	21.29	23.57	27.31	
LSD0.05	Concentrations		For periods:	For interference:		LSD0.05	Concentrations		For periods:	For interferenc:	
	5.11		3.45	7.20			3.01		3.00	4.66	

The impact of these extracts may be attributed to the presence of alkaloids, toxic substances, or bioactive compounds that interfere with nutrient absorption in the digestive tract, ultimately leading to mortality [28]. These findings are consistent with those of [13]. Other compounds may act as antifeedants, causing insect death, or the effect could be due to the entry of these extracts through the spiracles (respiratory openings), subsequently affecting the nervous and digestive systems.

Furthermore, [12] demonstrated in a previous study that the cold aqueous extract of fennel seeds (Foeniculum vulgare) achieved the highest mortality rates for the second and fourth larval instars of the date moth at a 1% concentration after 72 hours,

ISSN 2072-3857

with rates of 53.30% and 43.30%, respectively.

Table (4) shows the influence of various levels of alcoholic extract containing cumin seeds and the duration of exposure on the mortality percentage of the second and fourth instar of the date moth. The maximum mortality of the second instar was 80.00% at the concentration 0.75 mg/ml after 7 days of treatment and the maximum mortality of the fourth instar was 68.54 at the same concentration and duration. On the other hand, the lowest mortality of the second and fourth instar was 29.87% and 21.56, respectively, at a concentration of 0.25 mg/ml after 7 days. It was also noted that the mortality rates rose with increased concentrations as well as time of exposure; the mortality rate of the second instar was (29.87, 55.31 and 80.00) under concentrations of (0.25, 0.50 and 0.75) at end of the 7 days exposure time. Statistical analysis indicates significant differences between treatments.

The increase in mortality rates may be attributed to the presence of bioactive compounds in the cumin seed extract that act as insect toxins or affect specialized target tissues, leading to increased mortality across different larval stages. Additionally, the extract may influence the food conversion efficiency of the treated larvae [35].

Table (4). Influence of various concentrations of alcoholic extract of cumin seeds on the mortality of date moth larval instar

Second instar						Fourth instar					
Concentration Mg/ml	Period				Infestation Rate After Treatment	Concentration Mg/ml	Period				Infestation Rate After Treatment
	24	48	72	Week			24	48	72	Week	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	12.99	19.83	22.22	29.87	21.23	0.25	7.97	13.78	18.99	21.56	15.58
0.50	34.31	37.00	42.89	55.31	42.38	0.50	25.78	29.00	31.56	38.33	31.17
0.75	65.43	69.55	75.00	80.00	72.50	0.75	48.52	57.32	62.22	68.54	59.15
Adult stage	28.18	31.60	35.03	41.30		Adult stage	20.57	25.03	28.19	32.11	

ISSN 2072-3857

LSD0.05	Concentrations	For periods:	For interference:	LSD0.05	Concentrations	For periods:	For interference:
	4.55	5.01	6.23		2.66	3.59	4.64

The research can be correlated to the results of [33], who showed that cumin seed extract had a significant efficacy at all concentrations, leading to the most significant mortality of Khapra beetle, Trogoderma granarium. It is also in line with the results of [4, 31] who reported that the higher mortality rate of the second larval instar compared to the fourth one is connected to physical characteristics of the second larval instar the layer of cuticle is significantly thinner than that of later stages. Additionally, [30] found out that the alkaloid extracts of the leaf of Moringa oleifera, Conyza dioscoridis and Cymbopogon citratus exerted considerable influence on the mortality rates of different stages of the saw-toothed grain beetle with the highest mortality of 73.18. A high mortality rate (90 percent) of all the immature stages of the date moth, Ephestia cautella (Walker), was also reported Also [26] by an extract of the tobacco (Nicotiana tabacum) residues, made alkaloidal.

Table (5) indicates that different concentrations of the alcoholic extract of *D. viscosa* seeds and the length of exposure determine the percentage of second and fourth instar larva mortality of the date moth. This was maximum at the rate of 0.75mg/ml, one week of treatment, with the percent mortality of the second and fourth instar being 87.30 and 73.30 per cent respectively. In contrast, the least mortality was noted at 0.25mg/ml, 16.20 percent and 9.00 percent after 24 hours of treatment in the second and fourth instar, respectively. These findings reveal that there is a positive relationship between longer exposure time and increased concentration and elevated mortality rates.

For the second instar at 0.75 mg/ml, mortality rates progressed as follows: (73.20, 76.00, 79.40, and 87.30%) after (24, 48, 72 hours, and one week), respectively. Likewise, the rates of the fourth instar at the same concentration were (49.00, 55.70, 65.55 and 73.30) at the same periods. The statistical analysis showed that there were significant differences between treatments and the Least Significant Difference (L.S.D. 0.05) of the interaction of concentrations and periods of time

ISSN 2072-3857

was 6.23 in case of the second instar and 4.64 in case of the fourth instar. The rise of percentage of mortality could be explained by the existence of bioactive compounds in the Dodonaea seed extract that serve as toxins that affect the target tissues of the insect or depending on the food conversion efficiency of the treated larvae [36].

Table (5). Effects of different alcoholic extracts of *D. viscosa* seeds on the mortality of date moth larval instar.

Second instar						Fourth instar					
Concentration Mg/ml	Period				Infestation Rate After Treatment	Concentration Mg/ml	Period				Infestation Rate After Treatment
	24	48	72	Week			24	48	72	Week	
0	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00
0.25	16.20	20.10	28.30	36.50	25.28	0.25	9.00	11.70	19.16	22.00	14.72
0.50	44.80	52.70	60.00	69.00	56.63	0.50	26.50	29.00	30.34	45.00	33.70
0.75	73.20	76.00	79.40	87.30	78.98	0.75	49.00	55.70	55.65	73.30	60.89
Adult stage	33.55	37.02	41.92	48.02		Adult stage	21.13	24.01	29.01	35.08	
LSD0.05	Concentrations		For periods:	For interference:		LSD0.05	Concentrations		For periods:	For interferenc:	
	4.55		5.01	6.23			2.66		3.59	4.64	

The findings are consistent with those of [21], which indicated that the second larval instar is more sensitive to the extract than the fourth instar. A total mortality rate of 77.98% was recorded at the highest concentration for the second instar, compared to 60.89% for the fourth. This increased sensitivity may be attributed to the reduced thickness and incomplete development of the cuticle in early instars. Furthermore, the voracious feeding behavior of second-instar larvae to ensure growth and development leads to a higher intake of toxins into their bodies. Alternatively, the plant may

ISSN 2072-3857

contain compounds that inhibit the feeding process.

Table (6) indicates that there were great differences in the effect of the fungal filtrate concentrations after 7 days because the concentrations were evident to impact the second and fourth larval instar. In the case of the second larval instar, the maximum mortality rate was 90.00% at 10 mg/ml after a period of one week and the minimum rate was 17.99% at 2.5 mg/ml after 24 hours as compared to none in the control treatment. The highest mortality rate was also observed at 10 mg/ml, which was 78.15 per cent after one week and the lowest was 14.78 per cent after 24 hours in the fourth larval instar, compared to the control (0.00 per cent).

The results also indicate that the efficacy of the fungus *T. harzianum* is concentration-dependent. Increasing the concentration of mycotoxins leads to higher mortality rates as these toxins enter the insect's body through contact with the body wall, ingestion, or via the spiracles. Additionally, the fungus possesses the ability to penetrate the body wall, particularly at the intersegmental membranes (segmental joints), which weakens the insect's defensive capacity and increases its susceptibility to disease [16, 24].

Table (6). Effect of different concentrations of *T. harzianum* filtrate on the mortality of the larval instars of the date moth.

Second instar						Fourth instar					
Concentration Mg/ml	Period				Infestation Rate After Treatment	Concentration Mg/ml	Period				Infestation Rate After Treatment
	24	48	72	Week			24	48	72	Week	
0	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00
2.5	17.99	21.19	27.90	38.45	26.38	2.5	14.78	15.78	80.19	24.11	18.62
5	41.55	49.77	54.33	65.79	52.86	5	28.44	31.23	34.38	48.99	36.75
10	74.65	78.22	81.21	90.00	81.02	10	53.22	66.33	59.71	78.15	67.32
Adult stage	33.54	37.30	40.86	48.56		Adult stage	24.11	28.34	32.43	37.81	
LSD0.05	Concentrations		For periods:	For interference:		LSD0.05	Concentrations		For periods:	For interfer	

ISSN 2072-3857

							enc:
	7.11	5.88	6.99		6.01	4.44	5.89

These results are consistent with the findings of [35], which indicated that the time required for the fungus to kill the insect depends on the physical structure of the exoskeleton. Individuals with a rigid cuticle require a longer period for the fungus to penetrate and cause death, whereas those with a less rigid body wall are eradicated in a shorter time.

Conclusions:

The final months of the year represent the most critical period for infestation of stored dates in Babylon Governorate .The study confirms that early larval stages (the second instar) are more sensitive and susceptible to biological and botanical control agents compared to advanced stages. The alcoholic extracts of D. viscosa and C. cyminum seeds, along with the T. harzianum fungal filtrate, are promising and sustainable alternatives to traditional chemical pesticides (such as Methyl Bromide) for protecting stored products.

Recommendations:

The use of D. viscosa alcoholic extracts as part of Integrated Pest Management (IPM) programs to control stored products because they are very effective and environmentally safe. Developing adoption of biological control agents (fungi) in storehouses to decrease the use of chemical pesticides which result to insect resistance. The necessity of implementing preventive control measures before the peak of insect activity in October to minimize economic losses.

ISSN 2072-3857

References:

1. Abbott, W. S.(1925) . A method of computing the effectiveness of an insecticide.J.Econ.Ent.,18:265-267.
2. Abdelgaleil SA, Gad HA, Hamza AF, Al-Anany MS. (2021). Insecticidal efficacy of two inert dusts and Trichoderma harzianum, applied alone or in combination, against Callosobruchus maculatus and Callosobruchus chinensis on stored cowpea seeds. Crop Prot 146: 105656.
3. Ahmed , M. S . H ., Hameed , A . A And Kadhum , A .A . (1986) . Disinfestation Of Commercially Packed Dates By A Combination Treatment . A Cat Aalimen . 15 (3): 221 – 226 .
4. Al- Moajel ,N,H. (2004). Testing some various botanical powders for protection of wheat grain against *Trogoderma granarium* Everts .Journal of Biolog.SCie.22(1): 1-8.
5. Al-Amara, M. S. J. (2009). Study of the effect of some biological and chemical control agents on the Khapra beetle Trogoderma granarium (Everts). Master Thesis, College of Agriculture, University of Basrah, 110 pages.
6. Al-Dhahery, S . H. (2008). Methyl Bromide Alternatives For Post-Harvest Disinfestation Of Dates .
7. Al-Hattab, A. S. M. (2015). Evaluation of the efficacy of Metarhizium anisopliae filtrate and some physical techniques in controlling the Saw-toothed grain beetle Oryzaephilus surinamensis L. (Silvanidae: Coleoptera). PhD Thesis, College of Agriculture, University of Kufa, 99 pages.
8. Ali RA, Sagheer M, Sahi ST, Rasul A. (2022). Factors influencing the combined efficacy of microbial insecticides and inert dusts for the control of Trogoderma granarium. Int J Trop Insect Sci 42(1):425–433.
9. Ali, Z. M. (2015). Effect of tobacco plant waste extract (Nicotiana tabacum L.) on some biological performance aspects of the date moth, Ephestia cautella (Walker) (Lepidoptera: Pyralidae). Master Thesis, University of Kerbala, College of Agriculture.
10. Al-Khafaji, A. M. H. H., & Al-Jubouri, K. D. H. (2010). Effect of organic fertilizers and nutrients on the growth and seed production of onion (Allium cepa L.). Diyala Journal of Agricultural Sciences, Iraq, 2(2), 64-83.
11. Al-Mansour, N. A. (1995). Effect of different extracts of the Devil's Claw plant Ibicella lutea (Martyniaceae) on the biological performance of the whitefly Bemisia tabaci (Genn.). PhD Thesis, College of Science, University of Basrah, 126 pages.
12. Al-Shalji, A. A. H., & Rashid, Y. D. (2024). Study of the effect of aqueous and oil extracts of fennel seeds (Foeniculum vulgare) and the fungus Trichoderma harzianum on the date moth, Cadra cautella (Lepidoptera: Pyralidae).
13. Al-Taee, F. N. A. (2021). Evaluation of the efficacy of some biological agents in controlling the southern cowpea weevil, Callosobruchus maculatus (Fab.). Master Thesis, Al-Mussaib

Technical College, Al-Furat Al-Awsat Technical University, 66 pages.
14. Al-Yasiri, J. H. (2014). Store pests and pests transmitted with plant consignments in agricultural quarantine. Agricultural Quarantine, Iraq.
15. Al-Zubaidi, T. S. A. (2022). Efficacy of some plant extracts and the filtrate of the fungus Beauveria bassiana in controlling the date moth (Ephestia cautella). Master Thesis, Al-Mussaib Technical College, Al-Furat Al-Awsat Technical University, Iraq.
16. Boucias,D.G.and Pandland ,J.C.(1991). Attachment of mycopathogens Bouzabata, A. , Cabral, C. , Gonçalves, M. J. , Cruz, M. T. , Bighelli, A. , Cavaleiro, C. , Casanova, J. , Tomi, F. , & Salgueiro, L. (2015). Myrtus communis L. as source of a bioactive and safe essential oil. Food and Chemical Toxicology, 75, 166–172.
17. Dakhel, S. H., Al-Hakkak, Z. S., & Al-Azzawi, A. F. (2012). Field study to test the resistance of different strains of the fig moth, Ephestia cautella (Walker), to phosphine gas.
18. Dara, S. K. (2021). Biopesticides: categories and use strategies for IPM and IRM. *E-Journal of Entomology and Biologicals. Ucanr. Edu/Blogs/Blogcore/Postdetail. Cfm*.
19. El-Shafie, H.A. (2017). Alternatives To Methyl Bromide For Disinfesting Date Moth , Cadra Cautella , In Stored Dates . Outlooks On Pest Management ,28(1), 17-20 .
20. Fayyadh, M. A., Zaidan, M., & Al-Hadani, M. A. (2022). Date Palm Pests. Baghdad, Al-Kut University College, 273 pages.
21. Fraenkel, G.S .(1969). Evaluation off onr thought J on Secondary plant Substances . Entomol . EXP. Apple. 12:473-486.
22. Harborne, J. B. 1973. Phytochemical methods. Halsted Press. John Wiley and Sons New York. 278 PP.
23. Harborne, J.B. (1984). Phytochemical methods. Chapman and Hall, New York. 288P. hebator. J. Stored Prod. Res., Vol.21, Np.2, pp.65-68.
24. Hatem, Riam Bassem (2020).Evaluation of the efficiency of organic solvent extracts of Clarissa macrocarpa and the filtrate of the fungus Trichoderma harzianum on some biological performance aspects of the green peach aphid Myzus persicae (Hemiptera: Aphididae). Master's thesis, Al-Musaib Technical College, Al-Furat Al-Awsat Technical University, 54 pages.
25. Isman, M. B. (2020). Botanical Insecticides in the Twenty-First Century—Fulfilling Their Promise? *Annual Review of Entomology*, *65*(1), 233–249. https://doi.org/10.1146/annurev-ento-011019-025010.
26. Kahu, Z. M. A., & Al-Rubaie, H. M. K. (2015). Effect of crude alkaloid extracts of tobacco plant waste (Nicotiana tabacum) on the immature stages of the date moth Ephestia cautella (Walker). Karbala Journal of Agricultural Sciences, 2(1.(
27. Karanastasi E, Kavallieratos NG, Boukouvala MC, Christodoulopoulou AD, Papadopoulou AA (2020). Effect

of three entomopathogenic nematode species to *Trogoderma granarium* Everts (Coleoptera: Dermestidae) larvae on stored-wheat. J Stored Prod Res 88:10164

28. Metspalu, L. ; Hiiesaar, K. ; Joudu, J. and Kuusik, A. (2001). The effects of certain toxic plant extracts on the larvae of Colorado Potato beetle Leptinotarsa decemlineala (Say) . Institute of plant protection , Estonian Agriculture University p. 93-100.
29. Mogahed, M. I., & Gesraha, M. A. (2005). Efficacy of Dodonaea viscosa plant extract on some insect pests infesting cotton plants under field conditions. Annals of Agricultural Science, Ain Shams University, Cairo, 50(2), 739-747.
30. Mona, S. Z., Hassan, A. S., & El-Kashlan, I. H. (2021). Biological Activity of Some Plant Essential Oils Against the Khapra Beetle, Trogoderma granarium (Coleoptera: Dermestidae). Journal of Plant Protection and Pathology, 12(1), 49-58.
31. Omran, I. M. (2021). Study of some taxonomic and biological aspects of the insects Rhyzopertha dominica and Oryzaephilus surinamensis with reference to their control. PhD Thesis, College of Science, University of Basrah, 303 pages.
32. Qader, F. A. (1998). A diagnostic and ecological study of date moth species belonging to the genus Ephestia (Lepidoptera: Pyralidae) and the use of inherited partial sterility technique in controlling its most important species. PhD Thesis, College of Agriculture, University of Baghdad, 143 pages.
33. Radhiyo, G. A. (2020). Evaluation of the efficacy of some commercial nano-compounds and alcoholic extracts of some plants in controlling the Khapra beetle, Trogoderma granarium Everts 1898 (Coleoptera: Dermestidae), under laboratory conditions. Master Thesis, College of Agriculture, University of Kufa, Republic of Iraq.
34. Rahman SFS, Singh E, Pieterse CM, Schenk PM.(2018). Emerging microbial biocontrol strategies for plant pathogens. Plant Sci. 267:102–111.
35. Rezende,S.R.F.;Curvello,F.A.;Fraga,M. E.Reis,R.C.S.;Castillo,A.M.C.and Agostinho,T.S.P. (2009) Control of the *Alphitobius diaperinus* (Panzer) (Coleoptera:Tenebrionidae) with entomopathogenic fungi.Revista Brasileirade ciencie Avicola,11(2)121_127.
36. Saleem , M . :Engstyon , M, savoa J . and pihlag , K. 2002 . Interaciton of flof medicinal plant extracts with human Advenoceptor subtypes . Univercity of Tueku , finland , 75c , 332-338 .
37. Stejskal,V., Vendl, T., Aulicky ,R ., & Athanassiou, C . (2021). Synthetic And Natural Insecticides: Gas, Liquid, Gel And Solid Formulationsfor Stored-Product And Food-Industry Pest Control. Insects, 12(7), 590 .
38. Yahya, W. A. (2021). Effect of aqueous and hexanic extracts of cumin and fennel seeds on the larvae of the Khapra beetle Trogoderma granarium (Everts). Mesopotamia Journal of Agriculture, 40(2), 245-253.

ISSN 2072-3857