The efficiency of using integrated control agents to manage the Dubas bug *Ommatissus binotatus* lybicus De Berg (Homoptera: Tropiducidae) in Karbala Governorate

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Abstract

This study aims to rate the efficiency of using chemical pesticides, bio-fungicides, and the interaction between them against the nymphal and adult stages of the Dubas insect (*Ommatissus binotatus* lybicus De Berg). Anyhow, the laboratory and field results of the pesticides significantly affected the treated phases. The field results of the treatments were significantly increased after around two weeks, as for the average percentage of death in the treated nymphs. It reached 89.29-75.03-72.5-71, respectively. The results of the interaction treatments between fungal biocides (*Beauveria bassiana*, *Paecilomyces* sp, *Beauveria bassiana*, *Metarhizium anisopliae*, *Metarhizium anisopliae,* and *Paecilomyces* sp) were significantly increased after two weeks of treatment, as the average percentage of death of the treated nymphs reached 63.95 -77.19 -63.5, respectively. The laboratory results of the treatments were significant for the pesticides used after nine days of treatment, as the average percentage of death of the adults reached 86.01 - 39.25 -32.16 -36.81, respectively. Moreover, the interaction coefficients between the fungal biocides mentioned in the paragraph above were significant after nine days of treatment. The average percentage of treated adults' deaths reached 38.13 -39.64 37.57 - 86.02 to treat the interaction between the chemical pesticide Actara and *B. bassiana*. The chemical pesticide Actara excelled in the field experiment, as it gave the highest percentage of mortality when used at concentrations of 1-1.5 g/L after two weeks of treatment. The average percentage of nymphs killed was 89.29.

As for the laboratory experiment results, the chemical pesticide Actara was also superior, as it gave the highest mortality rate for adult females. The average mortality rate for adult females reached 86.01 after nine days of treatment compared to the rest of the treatments using other pesticides.

Keywords: Dubas, *Ommatissus binotatus lybicus, Beauveria bassiana ,Paecilomyces* sp. ,*Metarhizium anisopliae*

Introduction

The date palm, *Phoenix dectylifera* L., is a fruit tree belonging to the Palmaceae family. This genus includes about fourteen species spread in tropical and subtropical regions [1]. In addition to that, Iraq is also considered one of the oldest palm habitats in the world, which is also agreed upon by religious and historical texts [2]. The date palm is distinguished by its importance and value, whether economic, social, or religious.

Iraq is one of the countries that occupied the first positions over the past years, as it is considered one of the important countries in terms of its abundance of date palms. The number of planted trees exceeded 30 million palm trees until 1980 AD. Thus, Iraq was one of the most critical major countries producing dates worldwide [3]. The production of dates for the 2020 season, for all varieties, was estimated at (735.4) thousand tons, an increase of (15%) over last year's production, which was estimated at (639.3) thousand tons. Baghdad Governorate occupied first place in production, estimated at (126.2) thousand tons, followed by Babil Governorate, estimated at around (117.9) thousand tons. At the same time, Diyala Governorate ranked third, with an estimated production of (88.1) thousand tons [4].

The date palm is one of the trees that is tolerant to salt and drought and is generally considered tolerant to all that comes with the desert climate. It is the only sublime tree that has adapted well to this environment, as it reproduces, blooms, and its fruits mature in restricted weather conditions. It is also the basic foundation for all other desert crops, as it creates a suitable climate for the multiplication and spread of subsistence crops [5]. Under its shade grow many different types of trees, vegetable crops, and fodder. It is the primary source of livelihood for many people, especially in the Middle East region. Its fruits are used as a food substance rich in sugars and other minerals in many countries, in addition to being used to manufacture beverages. It is also used in other ways. For example, the trunk and fronds are used in fencing and local equipment. It was also planted as windbreaks on the edges of various farms, and it is considered one of the means of combating desertification in many Arab countries because it protects the plants that are grown with or under it [6, 7,8].

The date palm is affected by many agricultural pests, including 17 species of insects and mites belonging to ten species and seven orders, in addition to various diseases and infections [9]. The palm Dubas insect, *Ommatissus lybicus*, is considered one of the most important of these pests (Debrgevin). Asche and Wilson, as it infects all types of palm trees, causing serious damage to the vitality of the trees and their productive yield, especially in central and southern governorates of Iraq, where the infestation is severe [10].

Its infection increases in orchards near rivers where palm trees are planted closely together, and palm tree worms infect all palm varieties [2]. The nymphs and adult insects suck the plant juices and secrete the honeydew that covers the fronds, making them appear shiny. The insect causes other indirect damage through the accumulation of dust and mold growth, which hinders the process of photosynthesis, respiration, and transpiration in the palms and leads to general weakness in the affected palms [11]. Severe infestation with this insect leads to hampering the palm tree's growth and reducing its yield, as the infected trees give small fruits with a bad taste, and the amount of sugar in them is small. The fruits sometimes fall before they reach the maturity stage. In addition to the above, the stems present in the infected palms adhere to this insect. The sugary substance secreted by insects leads to their contamination and damage due to the dust adhering to them and the growth of mold on them, which decreases their marketing value or their unsuitability for human consumption. The damage can extend to deciduous crops and those planted under palm trees due to honeydew drops falling on these crops [12].

The costs of chemical control to reduce the pest's damage amounted to 70 million Yemeni riyals in spraying campaigns to combat the pest in Yemen [13]. The insect was studied in its distribution areas, and some biological studies were conducted in Amman [14]. In Iraq [15] and Yemen [13], the insect is widespread and dense in the orchards of the Al-Husseiniya district in Karbala governorate. It spread in an epidemic manner in 2005 due to the cessation of air control campaigns, and the pest still threatens palm orchards despite the continuation of campaigns by the Iraqi Ministry of Agriculture (Personal contact with the Plant Protection Department / Karbala Agriculture Directorate). Therefore, the study aimed to determine the effect of using biopesticides and compare them with chemical pesticides in proportion during the different stages of the Dubas insect on palm trees in the field and laboratory.

Materials and Methods

The field experiment was carried out in one of the orchards of the Al-Wand area, Al-Husseiniya district, affiliated to the Karbala governorate, sacred to the generation. In the autumn (2022), (42) fruitful palm trees with average ages of one variety, Al-Zahdi, were selected and distributed. The treatments were randomly generated with three replicates for each treatment (replicate = palm tree). There were 14 treatments used. The treatments were treated with chemical pesticides, including (Actara pesticide according to concentrations) We will explain them in the table later, and fungal biocides that are pathogenic to insects, including (*Beauveria bassiana*, *Paecilomyces* sp., and *Metarhizium anisopliae*) in different ways. The infection was recorded before treatment, and readings were taken after (24 hours, 48 hours, 72 hours, 5 days, 7 days, 10 days, and 14 days) for two weeks.

Based on the number of live nymphs/palm trees, by taking 10 palm trees/duplicate from four directions in the palm tree (North, East, West, South) The effectiveness of pesticides was extracted using the Henderson and Tilton equation (Shaaban)[16]. The study experiments were analyzed according to a randomized complete block design (RCBD), and a lower-order test was used significant S D L below the 0.05 level of significance to indicate the significance of the results [17]. The results were analyzed using the statistical analysis program Genstat (2009).

Number of individuals after the treatment x number of individuals in the comparison treatment before the treatment

$$\% \text{ pesticide effectiveness } 100 \times \left(1- \frac{\text{No. of individ. after the treat. } \times \text{ No of individ. in the control before the treat.}}{\text{No. of individ. before the treat. } \times \text{ the No of individs in the control after the treat.}}\right)$$

First, the materials used

Pesticides:

1-Fungal biocides pathogenic to insects 1- *Beauveria bassiana* Percentage of active ingredient (1 x 10^7 reproductive units/g) 20% wt The percentage of inert material is 80% by weight total 100% Dosage: 5 grams per liter.

2- *Paecilomyces* sp: percentage of the active substance (1×107 reproductive units/gram) 20% by weight, the percentage of inert material is 80% by weight Total 100%. Dosage: 5 gm/liter sprayed.

3- The biopesticide *Metarhizium anisopliae.* The percentage of the active ingredient (1 x 10^7 reproductive units/gram) is 20% by weight. The percentage of inert material is 80% by weight, totaling 100%. Dosage: 5 gm/liter sprayed.

Chemical pesticide: Actara is a systemic insecticide that works by contact and is designed to combat many boring, sucking insects and insects. Active ingredient: WDG Thiamethoxam 25%.

Table (1): Concentration of treatment and methods of treatment

Treatment	The method of use	Concentration
Actara	**Spray**	**1 g/L**
	Injection	**0.25 g/L**
		0.5 g/L
Beauveria bassiana	**Spray**	**5 g/L**
		7 g/L
Paecilomyces sp	**Spray**	**5 g/L**
		7 g/L
Metarhizium anisopliae	**Spray**	**5 g/L**
		7 g/L
Paecilomyces* sp +*Beauveria bassiana	**Spray**	**5 g/L**
Beauveria bassiana+Metarhium anisopliae	**Spray**	**5 g/L**
Metarhium anisopliae+Paeci-lomyces sp	**Spray**	**5 g/L**

Second: Methods of treatment

* Spraying method

In this method, an automatic sprayer (holder) with a capacity of 100 liters was used, and the treated palm trees were identified before the spraying process. (Marking palm trees) (Picture 1), which ranged in length from (2-4) meters, and before the spraying process, the sprinkler was loaned.

To know the quantity that each palm tree needs (repeated), the spraying process was carried out by the researcher (Mohamed Abd Ali Tami), taking. All necessary precautions (Picture 2), and all treatments (T2, T3, T6, T7, T8, T9, T10, T11, and T11) were sprayed. T12, T13, and T14), and each replicate (Nakhla) was sprayed with (10 liters) of the concentration of the pesticide used while the treatment was sprayed.Comparison with water only (T1), so that the solution covered the entire palm tree, especially the crown of the palm tree (fronds and stems), taking into account

Spraying all external parts of the palm tree.

Figures 1. spray treatment.

Figures 2. treatment.

Figures 3. injection treatment.

*** Injection method**

The palm trees prepared for the injection treatment were identified, and two treatments were taken for the injection process (T4 and T5). Each transaction contains three replicates, as the drill used a hammer operated by a mobile electric generator of capacity. (10 amps) A plastic tube was inserted to make a hole in the palm tree's trunk at a height of 1.25 cm above the ground.

Its length is 20 cm, and its diameter is 2 cm in the trunk of the perforated palm tree. Picture (3), after which the pesticide was injected using a medical syringe. Each replicate (Nakhla) was injected with 20 cc (20 ml) of the pesticide, and after the injection process, the tube's opening was closed with a piece. Made of cotton, it was sealed tightly with wax or clay, which is consistent with previous studies [18, 19,20].

Laboratory experiment:

The laboratory experiment on insect adults was carried out in one of the laboratories of the Plant Protection Department, College of Agriculture, University of Karbala. Dubas was used in this experiment with the same parameters used in the field experiment (according to the concentrations; we will explain them in the table later). Samples were collected randomly from the field identified in the Al-Wand area of Karbala Governorate on 11/19/2022 and brought to the insect laboratory of the College of Agriculture, University of Karbala, Department of Plant Protection. The samples included wickerwork from the field infested with the Dubas insect (adult stage), and dishes were prepared. A transparent plastic container with a diameter of 8 cm and a length of 16 cm (dish = duplicate), with three replicates for each treatment. The test was carried out by placing three to four straws in each dish at a rate of 10-15 adults. The dishes were sprayed with a 1000 ml sprayer after dispersing these pesticides with distilled water, and the percentage of deaths was calculated after 24 hours, 48 hours, 72 hours, 5 days, 7 days, and 9 days of treatment. The study experiments were analyzed according to the complete random design (CRD) model, and significance was tested using the least significant difference (L.S.D.) at the level of 0.05 to indicate the significance of the results [17]. The results were analyzed using the statistical analysis program Genstat (2009). The loss percentages were converted into loss percentages, and the corrected percentages of loss were converted into angular values that were not included in the statistical analysis using the Abbott equation (1925) [21].

$$\text{Abbott's percent corrected mortality} = \frac{\%\ \text{Mortality in treated} - \%\ \text{Mortality in control}}{100\% - \%\ \text{Mortality in control}} \times 100$$

Table (2): Concentration of treatment and methods of treatment

Treatment	The method of use	Concentration
Actara	**Spray**	**0.25 g/L**
		0.375 g/L
Beauveria bassiana	**Spray**	**0.5 g/L**
		1.75 g/L
Paecilomyces sp	**Spray**	**0.5 g/L**
		1.75 g/L
Metarhizium anisopliae	**Spray**	**0.5 g/L**
		1.75 g/L
Paecilomyces* sp *+Beauveria bassiana	**Spray**	**0.5 g/L**
Beauveria bassiana+Metarhium anisopliae	**Spray**	**0.5 g/L**
Metarhium anisopliae+Paeci-lomyces sp	**Spray**	**0.5 g/L**
Actara + *Beauveria bassiana*	**Spray**	**0.25 g/L + 0.5 g/L**

Results and Discussion

The results of the field experiment in Tables (3, 4) showed all chemical and biological treatments against the adults of the Dubas insect, with the treatments used and the different concentrations having an apparent effect in reducing the number of insects. The results showed significant differences in the death of adults of the Dubas insect according to the different periods and concentrations used, as the chemical pesticide Actara was given sprays. The highest mortality rate for adults reached 89.29 using concentrations of 1g - 1.5g during two weeks of treatment compared to the injection treatment, which amounted to 54.64. The mortality rates for adult females varied according to the concentrations used. The 1g concentration gave the highest mortality rate of 90.26 compared to the rest of the concentrations used. Hence, the efficiency of the pesticide on The first day had a lower effect on the death of adults, 62.16%, compared to the progress of time; on the fourteenth day, it reached 99.34%, as we notice an increase in the efficiency of the pesticide as the time factor increased, reaching the highest percentage of death of adults on palm leaves. As for the remaining treatments, the pesticide was injected with the concentrations used (0.25 gm - 0.5 gm). (As it directly affected the death rate of adults using the two concentrations, the pesticide efficiency for killing adults was 54.64. This is for the chemical pesticide, as for the biological treatments that pathogenic insects *Beauveria bassiana*, *Paecilomyces* sp., and *Metarhizium anisopliae*, and at the concentrations used (5-7 grams - 5-7 grams - 5- 7 gm) if directly affected, On the percentage of death of adults using the concentrations for each treatment, the efficiency of the pesticide for killing adults was 75.03 - 75.5 - 71, respectively. We notice an increase in the percentage of death with an increase in the time factor, as shown in the table below. That is, the time factor has a relationship with the increase in the mortality rate of adult females [22]. They indicated that spraying pesticides on the foliage of all parts of the plant positively reduces infection and the number of adults on palm fronds.

Table (3): Efficiency of treatment on mortality of adults of Dubs in the field during in the Autumn (2022).

Treatment	Cont.	Corrected mortality/ days								
		1	2	3	5	7	10	14	Average Con.	Average Treat.
Actara/ Spray	1 g/L	66.16	86.11	92.49	94.56	97.9	99.32	99.34	90.26	89.29
	1.5 g/L	58.50	86.66	87.83	89.94	96.47	99.22	99.66	88.32	
Actara/ Injection	0.25 g/L	32.50	42.61	51.34	65.38	59	64.42	83.31	56.93	54.67
	0.5 g/L	8.44	43.34	45.88	58.42	56.51	71.69	73.72	52.42	
	5 g/L	38.32	70.32	75.07	82.84	83.92	86.93	90.85	75.46	75.03

Beauveria bassiana	7 g/L	39.93	60.35	77.89	82.51	84.17	87.52	89.84	74.60	
Paecilomyces sp	5 g/L	66.59	59.85	74.11	64.56	73.34	75.62	74.37	69.77	72.5
	7 g/L	49.56	67.24	73.68	76.84	81.64	86.27	91.38	75.23	
Metarhizium anisopliae	5 g/L	16.17	42.93	61.01	63.18	72.52	72.07	79.62	58.21	71
	7 g/L	65.60	86.02	82.70	84.91	87.58	88.99	90.75	83.79	
Average time										
LSD 0.05 Treatment: 5.66, Concentration: 3.33, Time: 4.21, Interaction: 8.74										

The results of (Table 4) showed that the interaction treatments between insect-pathogenic fungi had an effect in reducing the number of adults after two weeks of treatment, as the interaction treatment between the two fungi *Beauveria bassiana* and *Metarhizium anisopliae* at the concentrations used of 5 grams for each agent was superior in giving it the highest rate of death for adults, so the average efficiency ratio of the interaction treatment was superior. Between the two fungi, it was 77.19 compared to the interaction treatment between the two fungi *Metarhizium anisopliae* with *Paecilomyces* sp, which gave the lowest percentage of mortality of adults. The average efficiency ratio of the interaction treatment between the two fungi was 63.5 after two weeks of treatment. As for the rest of the treatments used, the interaction treatment between the two fungi *Beauveria bassiana* with *Paecilomyces* sp was at concentrations of 5 grams. Significant differences exist between the treatments used for each factor in giving the adult females a mortality rate of 63.95. The time factor also had a clear effect. It was noted that the mortality rate increased with the increase in the time factor. The interaction treatment between the two fungi, B + M, gave a mortality rate on the first day of 34.96 compared to two weeks later, which also gave a mortality rate of 79.91. Other transactions are shown in Table (4).

Table (4): Efficiency of interaction entomopathogenic fungi on mortality of adults of Dubs in the field during in the Autumn (2022).

Treatment	Con.	Corrected mortality/ days							
		1	2	3	5	7	10	14	Average Treat.
Beauveria bassiana+ Paecilomyces sp	5 g/L each	34.96	57.92	54.73	64.92	79.68	75.59	79.91	63.95
Beauveria bassiana + Metarhizium anisopliae	5 g/L each	50.90	74.07	72.81	78.93	92.11	79.83	91.7	77.19

Metarhizium anisopliae + *Paecilomyces sp*	5 g/L each	22.08	53.83	63.92	64.27	79.42	78.04	82.94	63.5
Average time									
LSD 0.05 Treatment: 4.89, Time: 3.71, Interaction: 6.43									

Laboratory study: Treatment of nymphs
The laboratory results of Table No. (3-4) The treatment of the Dubas insect nymphs with the chemical pesticide and the fungal biocides showed a decrease in the percentage of deaths of the Dubas nymphs for all treatments used for the different pesticides within nine days of treatment, with a significant difference between the chemical pesticide treatment and the biocides used in Table (3). It was observed in Table (3). The chemical pesticide Actara outperformed the rest of the biological treatments, with its concentrations of 0.25-0.375 grams used, with a mortality rate of 86.01% compared to the treatment of the biocide Paecilomyces sp, with its concentrations of 0.5-1.75 grams used, which gave the lowest percentage of mortality, reaching 32.16, as well as the treatments of *Beauveria bassiana* and *Metarhizium anisopliae,* with the concentrations used of 0.5-1.75 it gave a mortality rate of 39.25 and 36.81, respectively. The time factor also had an apparent effect. It was observed that the percentage of death increased with the increase in the time factor. We note the treatment of the fungus.

Table (5): **Efficiency of Actara pesticide and Entomopathogenic fungi on mortality of adults of Dubs in the laboratory condition**

Treatment	Con.	Corrected mortality/ days						
		1	2	3	5	7	9	Average Treat.
B.bassiana + *Paecilomyces sp*	0.5 g/L	10.03	10.03	23.56	43.76	60.6	80.8	38.13
B.bassiana + *M. anisopliae*	0.5 g/L	10.06	10.1	20.2	43.76	63.96	89.77	39.64
M.anisopliae +Paecilomyces *sp*	0.5 g/L	10.03	16.80	23.56	37.03	50.5	87.53	37.57
Actrara + *B.bassiana*	0.25 m/L + 0.5 g/L	69.55	69.55	94.26	94.26	94.26	94.26	86.02
Control	Water	6.66	6.66	6.66	6.66	6.66	6.66	6.66
Average								

LSD 0.05	Treatment: 6.03, Time: 5.34, Interaction: 9.51

Beauveria bassiana, for the first day, gave a death rate of 10.03. For the first day, and after 9 days of treatment, it gave a death rate of 85.28. For the first concentration of 0.5 grams, these were the death rates. Therefore, there is a clear effect concerning time in increasing the death rate, and this applies to all treatments used in the experiment, as in Table (3) compared to the control treatment that was sprayed with water only, which remained constant The results of Table (4) of the interaction treatments between the insect-pathogenic fungi and the laboratory Actara pesticide showed an effect in reducing the number of nymphs after 9 days. The interaction treatment between the Actara pesticide and the *Beauveria bassiana* fungus at the concentrations used of 0.25 gm - 0.5 gm was superior in giving it the highest percentage of nymph deaths, reaching a rate of The efficiency ratio of the interaction treatment between Actara pesticide and the B fungus was 86.02 compared to the interaction treatment between the two fungi *Metarhizium anisopliae* and *Paecilomyces* sp., which gave the lowest percentage of death to the nymphs. The average efficiency ratio of the interaction treatment between the two fungi reached 37.57 after 9 days of treatment. As for the rest of the other treatments used, they were the interaction treatment between The two fungi, *Beauveria bassiana* with *Paecilomyces* sp. and *Beauveria bassiana* with *Metarhizium anisopliae*, at concentrations of 0.5g for each agent and 0.5g for each agent, respectively, gave it a mortality rate of 38.13-39.64. Therefore, there are significant differences between the treatments used. The time factor also had a clear effect on the increase. The rate of death of nymphs increased with the increase in time. The interaction between the two fungi, B+P, gave a death rate on the first day of 10.03, compared to 9 days later, which gave a death rate of 80.8. As shown in the table, we notice an increase in the death rate of nymphs with the progression of time and other treatments [12].

Table (6): Efficiency of interaction between Actar pesticide and Entomopathogenic fungi on mortality of adults of Dubs in the laboratory condition

Treatment	Con.	Corrected mortality/ days							
		1	2	3	5	7	9	Average Con.	Average Treat.
Actara	0.25 g/L	87.52	87.52	87.52	87.52	87.52	87.52	87.52	86.01
	0.375 g/L	80.79	85.26	85.26	85.26	85.26	85.26	84.51	
Beauveria bassiana	0.5 g/L	10.03	16.83	26.93	30.3	40.4	85.28	34.96	39.25
	1.75 g/L	10	13.4	23.56	57.23	71.80	85.28	43.54	

Paecilomyces sp	0.5 g/L	6.66	11.22	17.94	31.41	49.36	67.26	30.68	32.16
	1.75 g/L	12.30	17.98	21.31	37.03	43.76	69.55	33.65	
Metarhizium anisopliae	0.5 g/L	7.77	13.44	21.31	34.77	57.21	69.55	34.00	36.81
	1.75 g/L	10.03	10.03	20.2	49.37	62.84	85.28	39.62	
Control	Water	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66
Average									
LSD 0.05 Treatment: 5.22, Concentration:4.6 , Time: 3.87, Interaction: 8.66									

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