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The efficiency of using some integrated control methods in controlling the mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae)

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Abstract

This study evaluated the efficiency of some integrated pest control methods to control the mealybug *Phenacoccus solenopsis* Tinsley under laboratory conditions. It was done by testing the efficiency of some methods, such as insecticides Conan and Actrara, entomopathogenic fungi *Beauveria bassiana,* Nano Calcium silicate, and mineral oil. This experiment was carried out in the insect laboratory for postgraduate studies at the College of Agriculture, University of Kerbala. The results prove that insecticides Conan and Actara significantly affect both nymphs and adults, where the average percentage of nymphs mortality within 24 hours of treatment was 100%. The concentrations of the Conan pesticide were (300 - 400 - 500 mg/L) Whereas the Actara pesticide was in concentrations (0.20 – 0.25 – 0.30 ml/L) respectively. Likewise, the rate of mortality of adults within 24 hours of treatment with Actara and its three concentrations used (0.20 - 0.25 - 0.30 ml/L) and Conan with three concentrations as well (300 - 400 - 500 mg/L) reached 100%. Based on the study's results, both insecticides, Conan and Actara, can be used due to their superiority in mortality rates. In contrast, the mortality rate was 100% in both nymphs and adults within 24 hours of treatment compared to the other treatments used.
Keywords: *Phenacoccus solenopsis* **,** Mealybugs, entomopathogenic fungi

Introduction

The cotton mealybug, *Phenacoccus solenopsis* Tinsley**,** causes severe damage directly and indirectly to ornamental plants, which leads to a decrease in flower production and thus affects their aesthetic appearance, which fails to achieve the goal for which these plants were planted for [1]. In Iraq, ornamental plants began to expand and spread due to the improvement in the standard of living, culture, and taste among many people, as their Interest in recreational and luxury aspects has increased significantly, which has led to an increase in the number of nurseries, which has helped spread pests and increase their numbers on ornamental plants in those nurseries [2]. Mealybugs are often described as invasive insects due to their small size, as they usually live hidden in their environment and are widely transmitted on goods during international trade [3]. The mealybug, *Ph. solenopsis* Tinsley (Hemiptera: Pseudococcidae) is one of the most destructive insects of cultivated plants that suck plant sap. The success of this insect pest is due to its environmental resilience and resistance to chemical pesticides, which makes controlling it difficult and very expensive. Therefore, there is a need for alternative, safe methods to prevent its numbers from reaching the critical economic limit [4].

The damage caused by mealybugs is related to their feeding on the plant sap and their secretion of honeydew, which leads to the emergence of black mold and the transmission of some viral diseases, causing the leaves to fall after they turn yellow, general weakness in plant growth, and in some cases its mortality [5]. Bacterial control has been widely used to control the mealybug, *Ph. solenopsis*, and the fungus *Lecanicillium lecanii*, which is an insect-pathogenic fungus from the class (Hyphomycetes), was used. It infects many insects of the scale family, thrips, aphids, order Diptera, and membranous. Wings, Homoptera, Mites, and Lepidoptera in all climatic conditions [6].

Studies showed that the fungus *L. lecanii* was effective at 2, 3, 4, 5, 6 g/l concentrations in combating the mealybug *Ph. solenopsis* [7]. It was also concluded in one study that submerging some plant leaves with the fungus *L. lecanii* at a concentration of 1 in 10 spores/ml led to the killing of the aphid *Magoura japonica* by 60% after 8 days of treatment with the fungus, while in the case of mixing it with the fungus *Beauveria bassiana*, its efficiency increased to a percentage The mortality rate reaches 90.05% [8,9].

In another study, it was shown that the mealybug, *Ph. solenopsis*, is one of the destructive pests of cotton, ornamental plants, and other crops due to its nature in which the insect is multi-staged. A study verified the efficiency of local and different pathogenic isolates of disease-causing fungi in the second nymph stage of the mealybug, *Ph. solenopsis*, under laboratory conditions and by immersion. The experiment used three entomopathogenic fungi: *Beauveria bassiana* (isolates Bb-01, Bb-08), and *Metarhizium anisopliae*. Among all the isolates, B. isolate Bb-08 was effective and highly efficient, with the highest percentage of lethality and the lowest LC_{50} values. LT_{50}. The study showed that Bb-08 could be used in IPM to control the mealybug *Ph. solenopsis* [10, 11]. The aim of study evalation of some integrated methods to control the mealybug *Ph. Solenopsis* under laboratory conditions.

Materials and Methods

1- Breeding Mealybug *Ph. solenopsis*

The samples of the mealybug *Ph. solenopsis* were taken from the Holy Shrine of Hussein's nurseries and the gardens of Martyr Ahmed Zaini Street in Holy Karbala. These samples were transferred to ornamental plants and Rose Mallow China Rose in the College of Agriculture, University of Kerbala greenhouse.

2- Evaluation of the effectiveness of the insecticides Conan, Actara, Nano Calcium silicate and Mineral oil treatment in controlling the mealybug *Ph. solenopsis*.

In the laboratory, several leaves of the rose plant were collected and examined under a microscope to confirm they were infection-free. Several Petri dishes measuring 9 cm were used and sprayed with alcohol to sterilize them. Each dish contained one leaf of the camel rose plant, and a piece of agricultural cork was placed at the end of the leaf and moistened with water. 10 individuals of the insect were added (10 nymphs and 10 adults), in three replicates for each of the three concentrations of the insecticide, where the three concentrations of Conan were taken (0.4, 0.5 and 0.6 g/L), noting that the recommended concentration is 500 mg/L. each treatment was sprayed. With 1 ml of the three concentrations of the insecticide, 1 ml of the diffuser was added to every 1 litre. As for the comparison treatment, the insect was sprayed with water and the diffuser only. The reading was taken after 1, 2, 3, 5, 7, 10, and 14 days of treatment. The mortality has been corrected using Abbott 1925[12].

Figure (1): The process of transferring mealybug adults onto the leaves of ornamental plants and Rose Mallow China Rose.

3- Evaluation of the efficiency of the *B. bassiana* and *Metarhizium anisopliae* fungus in controlling the *Ph. solenopsis* in the laboratory.

Before using the fungus, its viability was tested in experiments by growing it in Potato Dextrose Agar (PDA) medium, where 5 grams of the fungi preparation were taken, which were obtained from the Agricultural Protection Authority / Abu Ghraib, affiliated with the Ministry of Agriculture, where it was placed in the middle of the dish containing the culture medium. The dishes (5 dishes) were transferred after putting on their covers and closed tightly. After that, they were transferred to the incubator at a temperature of 27 + 2 degrees and relative humidity (80 - 85%), and after 4 days, the growth of the parasitic fungus was monitored. Its vitality was confirmed by Assistant Professor Dr. Mohsen Abdel Ali Mohsen Al-Musawi / Department of Plant Protection / College of Agriculture, University of Kerbala.

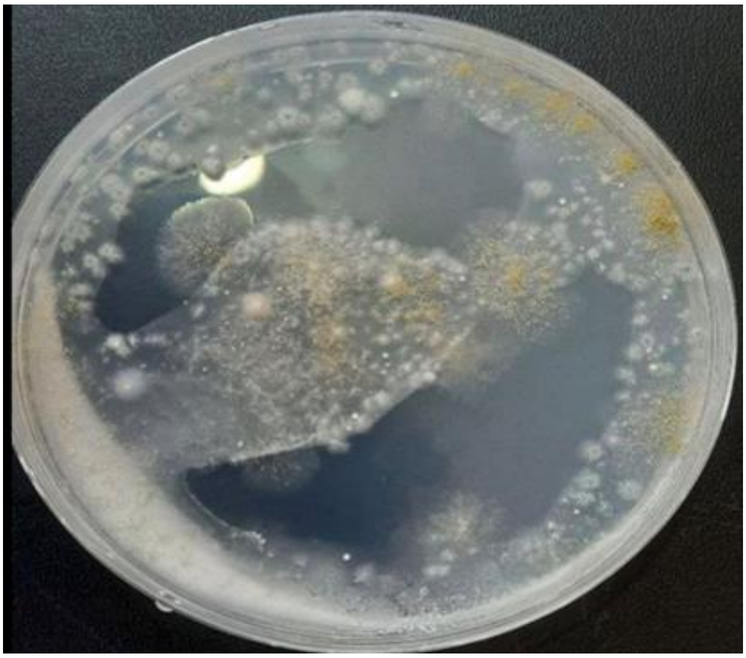

Figure (2): The pathogenicity of the *B. bassiana* fungus.

5 grams (recommended concentration) of the *B. bassiana* preparation were weighed in 1 liter of distilled water with the addition of surfactant at a concentration of 0.2/L. The solution was shaken continuously for homogeneity. After that, three replicates were prepared for each of the nymphs and adults (10 nymphs and 10 adults) as well as the adults (10 individuals on each healthy, insect-free leaf of the rose camel plant for each of the replicates) in a Petri dish with a diameter of 9 cm. A plant leaf was placed at its base, and the end of the blade was wrapped with a piece of agricultural cork and moistened with distilled water every three days to remain moist and soft.

The treatment was done at a dose of 1 ml for each replicate using a small sprayer with a capacity of 250 ml, and the replicates were sprayed from a distance of 10-15 cm. The comparison treatment also included three replicates of each of the nymphs and adults and followed the same previous steps except that the insects were sprayed with distilled water with the surfactant Twin only. After completing the treatment, the dishes were covered and secured with adhesive tape, and the dishes were placed in the laboratory. The dishes were examined, and after 1, 2, 3, 5, 7, 10, and 14 days of treatment, the dead individuals of the mealybug *Ph. solenopsis* infected with the *B. bassiana* and *M. anisopliae* fungus were recorded.

Parameters used in the laboratory experiment

Six treatments and three concentrations were used for each treatment, and three replicates were used for each concentration in addition to the comparison treatment. These materials and pesticides were used in the same way as mentioned below.

Table (1): The types of treatments and concentrations spread in experiments

Treatments	Concentrations
Actrara	0.20 ml/L
	0.25 ml/L
	0.30 ml/L
Conan	0.4 g/L
	0.5 g/L
	0.6 g/L
Beauveria bassiana	4 gm/L
	5 gm/L
	6 gm/L
Metarhizium anisopliae	4 gm/L
	5 gm/L
	6 gm/L
Nano Calcium silicate	0.1 g/L
	0.2 g/L
	0.3 g/L
Mineral oil	0.20 ml/L
	0.25 ml/L
	0.30 ml/L
Control	Water only

Statistical analysis

The results were corrected using the Abbott formula [12], and analyzed statistically. The type of design used was a randomized complete block design (RCBD). The results were also analyzed depending on the design used, a comparison of means was used using L.S.D. at the 0.05 level and the statistical program Genstat [13], was used to analyze the data.

Results and Discussion

Evaluating the efficiency of integrated control methods for the mealybug *Ph. solenopsis*

Treatment of nymphs

The laboratory experiment results showed that all chemical and biological treatments against mealybug nymphs, with different concentrations, showed a clear and significant effect in reducing the number of insects.

The results showed significant differences in the mortality of mealybug nymphs with different periods and concentrations, as both the insecticides Actara and Conan outperformed the rest of the treatments used, giving clear and significant results. The concentrations were different; within 24 hours, three concentrations of each of the two insecticides had the highest percentage. Destruction reached 100% for the three concentrations used. These results are somewhat consistent with what was shown by one of the studies that the pesticide Actara mortality the mealybug *Ph. solenopsis* in the laboratory study at the following rates: 82.98, 91.49 and 95.2 after 24, 48 and 72 hours of treatment with the pesticide Actara, respectively [14]. The superiority of these chemical pesticides, which represent a new generation of systemic pesticides that affect systemically and by contact on the nerve impulse receptors located in the insect's nerve space [15].

As for the pathogenic biocides (*B. bassiana* and *M. anisopliae*) and the rest of the treatments used (mineral oil and Nano Calcium silicate), the fungus *M. anisopliae* outperformed the rest of the treatments, and the concentration of 4 grams was the most effective in reducing the number of the insect. The time factor had a clear effect, as it was observed that the percentage of mortality increased with the increase in the time factor. This is somewhat consistent with a study that evaluated pathogenic fungi such as *B. bassiana*, where three concentrations were used based on previous studies, and the lowest and intermediate doses were very effective, with 69.4% and 53% reductions in mealybug numbers [16].

The effect of mineral oil at 0.20 reduced the number of insects, followed by Nano Calcium silicate at 300 mg, the most effective concentration of the three silica concentrations. The time factor had a clear impact on all parameters, as shown in the table below.

Table (1): The effect of different concentrations of entomopathogenic fungi, insecticides, mineral oil, and Nano Calcium silicate on the mortality rate of mealybug nymphs in Laboratory conditions.

Treatments	Conc.	The percentage of corrected mortality per days								
		1	2	3	5	7	10	14	Aver. of conc.	Aver. of Treat.
Actrara	0.20 ml/L	100	100	100	100	100	100	100	100	100
	0.25 ml/L	100	100	100	100	100	100	100	100	
	0.30 ml/L	100	100	100	100	100	100	100	100	
Mineral oil	0.20 ml/L	46.6	46.6	66.6	66.6	73.3	73.3	73.3	63.7	56.1
	0.25 ml/L	13.3	40	40	40	73.3	73.3	73.3	44.7	
	0.30 ml/L	33.3	46.6	40	46.6	80	86.6	86.6	59.9	
Nano Calcium silicate	0.1 g/L	6.6	13.3	33.3	33.3	40	46.6	46.6	31.3	47.2
	0.2 g/L	20	40	46.6	46.6	53.3	60	60	46.6	
	0.3 g/L	33.3	53.3	60	60	73.3	73.3	93.3	63.7	
Conan	0.4 g/L	100	100	100	100	100	100	100	100	100

	0.5 g/L	100	100	100	100	100	100	100	100	
	0.6 g/L	100	100	100	100	100	100	100	100	
M. anisopliae	4 gm/L	13.3	26.6	53.3	80	100	100	100	100	65.9
	5 gm/L	6.6	13.3	40	53.3	66.6	80	86.6	49.4	
	6 gm/L	26.6	26.6	26.6	40	66.6	73.3	80	48.5	
B. bassiana	4 gm/L	6.6	6.6	26.6	60	66.6	66.6	86.6	45.6	39.6
	5 gm/L	6.6	6.6	13.3	40	60	73.3	80	39.9	
	6 gm/L	13.3	13.3	20	33.3	46.6	46.6	60	33.3	
LSD 0.05	**Treatment: 5.33 , Concentrations: 4.47, Time: 5.12, Interactions: 9.36**									

Adults Treatment

The laboratory experiment results for mealybug adults showed results similar to those for nymphs, as the insecticides Actara and Conan outperformed all treatments within 24 hours in a significant and clear manner, with their three different concentrations, by 100%.

As for entomopathogenic fungi the *M. anisopliae*, at a concentration of 5 grams, was superior to the pesticide *B. bassiana* in reducing the number of insects, and calcium silica, at a concentration of 300 mg, was superior to mineral oil in reducing the number of mealybugs as shown in the table below. This study is in agreement with some studies in which mineral oil was tested on adult females under laboratory conditions and the LC50 values were 29.03, 34.23 and 54.69 respectively after 24 hours of treatment with mineral oil, while after 72 hours of treatment they were 15.04, 24.93 and 29.21 respectively [17].

Table (2): The effect of different concentrations of entomopathogenic fungi, insecticides, mineral oil, and Nano Calcium silicate on the mortality rate of mealybug adults in Laboratory conditions.

Treatments	Conc.	The percentage of corrected mortality per days								
		1	2	3	5	7	10	14	Aver. of conc.	Aver. of Treat.
Actrara	0.20 ml/L	100	100	100	100	100	100	100	100	100
	0.25 ml/L	100	100	100	100	100	100	100	100	
	0.30 ml/L	100	100	100	100	100	100	100	100	
Mineral oil	0.20 ml/L	6.6	33.3	26.6	20	26.6	40	40	27.5	26.2
	0.25 ml/L	0	6.6	20	6.6	40	46.6	60	25.6	

	0.30 ml/L	0	13.3	20	20	40	40	46.6	25.6	
Nano Calcium silicate	0.1 g/L	0	0	20	20	26.6	46.6	46.6	22.8	37.7
	0.2 g/L	13.3	13.3	20	20	33.3	40	53.3	27.6	
	0.3 g/L	60	60	60	60	66.6	66.6	66.6	62.8	
Conan	0.4 g/L	100	100	100	100	100	100	100	100	100
	0.5 g/L	100	100	100	100	100	100	100	100	
	0.6 g/L	100	100	100	100	100	100	100	100	
M. anisopliae	4 gm/L	13.3	40	46.6	86.6	86.6	86.6	86.6	63.7	61.6
	5 gm/L	0	13.3	66.6	100	100	100	93.3	67.6	
	6 gm/L	26.6	40	53.3	60	66.6	66.6	66.6	54.2	
B. bassiana	4 gm/L	6.6	26.6	33.3	46.6	73.3	73.3	73.3	47.5	51.6
	5 gm/L	6.6	33.3	33.3	73.3	80	80	86.6	56.1	
	6 gm/L	6.6	40	46.6	60	60	66.6	80	51.4	
LSD 0.05	**Treatment: 5.33, Concentrations: 4.47, Time: 5.12, Interactions: 9.36**									

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