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Evaluation of the effects of magnesium oxide (MgO) nanoparticles on adults of *Schistocerca gregaria*

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Abstract

Background: The main objective of this study is to evaluate the effect of magnesium oxide nanoparticles on desert locust adults and thus recommend its use in integrated pest management programs.

Methods: This study investigated the impact of magnesium oxide nanoparticles (MgO) on adult *Schistocerca gregaria*. The insects were treated with Nano and Lambda-cyhalothrin 4% at three different concentrations, in addition to a control group with a concentration of 0.00, 0.150, 0.300, and 0.600 mL/L.

Results: The study revealed a positive correlation between the concentration of nanomaterial mixed with the insecticide and the fatality rate. The study revealed that the half-lethal concentration (LC50) value is 0.050. Furthermore, the results indicated a significant disparity between the impact of nanoparticles and the pesticide, with respective p-values of 0.008 and 0.15 at concentrations of 0.150 and 0.600. However, both substances exhibited an equal effect at a concentration of 0.300. The impact of MgO nanoparticles and the pesticide on insect fertility was evident across all three concentrations of the nanomaterial mixed with the pesticide. The observed fertility rates were 35.4%, 35.4%, and 78.2%, respectively. In contrast, the control group consisting solely of the pesticide showed no difference in fertility, with a rate of 0%.

Conclusion: When magnesium oxide (MgO) nanoparticles and Lambda-cyhalothrin 4% insecticide are mixed, they have a big effect on adult desert locusts (*Schistocerca gregaria*). This is due to the high toxicity of the nanoparticles and their ability to penetrate the insect's cuticle layer, as well as their effect on the respiratory system and the gastrointestinal system of insects. It was shown that increasing the concentration of nanoparticles mixed with this pesticide results in higher mortality rates for both male and female individuals of the species. Additionally, it causes a decrease in the fertility rate, specifically for female insects, when exposed to the pesticide.

Introduction

The desert locust, scientifically known as *Schistocerca gregaria* (Forskal) and belonging to the Orthoptera: Acrididae family, is a very destructive migratory pest that is well recognized as one of the most damaging in the world [1, 2]. A mature bug typically weighs around 2 grams and is a predatory pest capable of consuming a quantity of food equivalent to its own weight on a daily basis [3]. Locusts deprive individuals of sustenance by consuming both their crops and cattle, which are crucial sources of income and survival [4]. The Food and Agriculture Organization (FAO) states that the outbreak produced by this pest presents a significant risk to both food security and livelihoods in regions impacted by climate change [5, 6]. Between 1986 and 1989, a desert locust plague spread to 43 countries following heavy rainfall, resulting in significant agricultural losses amounting to billions of dollars. However, this catastrophe was brought under control through control operations and the influence of unusual winds throughout the year, which pushed the locust swarms across the Atlantic Ocean [7]. The recurring desert locust infestations in Africa have necessitated the utilization of conventional chemical pesticides including organochlorine, organophosphate, carbamate, and pyrethroids as the foundation for preventive actions implemented in recent years to combat this pest [8]. Recently, researchers have noticed that the use of conventional chemical pesticides has substantial adverse consequences for the ecosystem, affecting both plants and animals. This has led many researchers to explore alternative methods of pest control that would have a greater impact on insect pests while minimizing harm to plants and animals. One of these techniques involves the utilization of nanoparticles. Regarding the oxides of chemical elements, examples include magnesium oxide, titanium oxide, silver oxide, zinc oxide, copper oxide, lead oxide, cadmium oxide, and various others. It is cost-effective and has low toxicity, making it highly effective in controlling economically significant insect pests [9]. The main purpose of this study is to assess the impact of magnesium oxide nanoparticles on adult desert locusts and then propose their utilization in integrated pest management initiatives.

Methods

Insect collection and Rearing

The adult insects of *S. gregaria* were obtained from agricultural areas in the villages of Wajihiya sub-district, Muqdadiya district, and Diyala governorate. They were then reared in the insect breeding laboratory at the Department of Biology, College of Education for Pure Sciences, University of Diyala, as described in reference [9]. After implementing various alterations, the boxes were equipped with an aluminum framework measuring (30 cm x 30 cm x 30 cm). Three sides of the boxes were enclosed with wire mesh, while the front side of each box was modified to include a sturdy white cloth arm measuring 30 cm in length and 15 cm in diameter. This arm serves the purpose of facilitating the cleaning process and allowing for the insertion and removal of food medium and other materials into and out of the boxes. Each box is equipped with multiple small holes (10 cm in diameter) at the bottom for egg-laying purposes. Additionally, plastic cups filled with sand of appropriate humidity are placed at the bottom of each box to collect the eggs. The adult insects were supplied with seedlings and wheat bran as their source of nourishment. Three 60-watt bulbs were positioned above the surface to provide heat, and they were activated for 6–8 hours daily to regulate temperature. Subjecting eggs to light that closely resembles sunshine, as it naturally occurs in an outdoor environment. Following egg deposition, little plastic containers equipped with wire mesh were positioned beneath a 60-watt electric lamp for a duration of 6–8 hours. This was done to capture the mosquitoes that serve as a food source for the initial nymph stage, facilitating rapid growth and development post-hatching. Subsequently, the nymphs were set free inside the containers to facilitate their development and maturation, ultimately leading to their transformation into adult insects [10].

Chemicals materials

A specific quantity of the MgO nanomaterial utilized in this investigation was procured from US Research Nanomaterials, Inc., located in Houston, USA, as seen in figure (1 and 2).

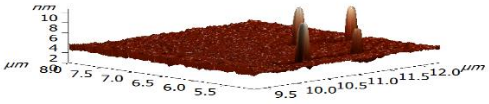

Figure 1: MgO Nanomaterial in 3D.

Treatment adults with nanomaterials

They utilized the procedure outlined in reference [11] for the treatment using nanomaterials. This study utilized magnesium oxide (MgO) to provide treatment to adult *S. gregaria* insects. The treatment involved combining MgO with 1 ml of the pesticide Lambda-cyhalothrin 4% and then adding half a liter of distilled water. The concentrations of MgO employed were 0.125, 0.250, and 0.500 nm. The concoction was distributed across three bottles. Each container in the study represents a certain concentration and is made of transparent plastic with a volume of 1 liter. The treatment of adult specimens commenced by selecting 5 individuals (3 males and 2 females) from each breeding box. These specimens were then transferred into three transparent plastic containers, each with a capacity of 20 liters. Each container contained two Petri dishes: one with wheat seedlings and the other with wheat bran. Prior to placement, the specimens were exposed to a mixture of nanomaterials and pesticides. Each container was subjected to one of the three aforementioned concentrations in order to determine the semi-lethal concentration (LC50) and the fatal concentration. Subsequently, all specimens were observed for any instances of death following treatment with each of the three amounts employed. Two plastic containers, each housing five specimens, were also included as control treatments with the nutrient medium. The first sample was subjected to pesticide treatment alone, while the second sample was subjected to water treatment exclusively. Next, a comparison test was done on the specimens treated in each of the two containers to see how the insecticide worked when it was used alone versus when it was mixed with the nonmaterial. Upon the completion of the treatment for adults, the outcomes were documented in various dedicated tables specifically created for the purpose of statistical examination.

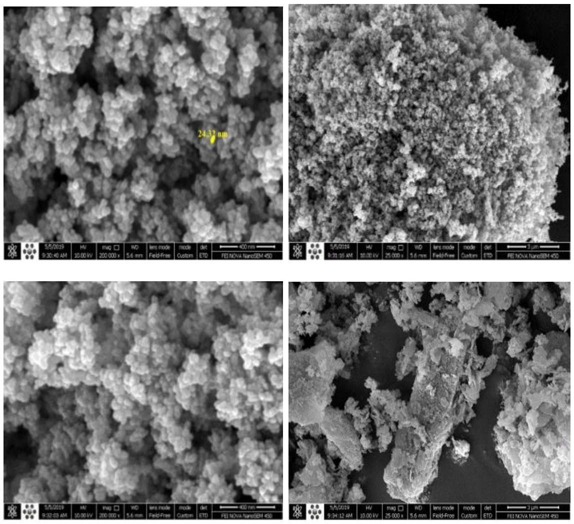

Figure 2: MgO Nanomaterial under electron microscope.

Statistical analysis

Following the laboratory treatment of the specimens, the death rate was determined using the Abbott equation [12]. The values underwent analysis of variance (ANOVA). A statistical analysis using the Honest Significant Difference (HSD) test was performed to determine the disparity between the effects of nanomaterial treatment and pesticide treatment [13]. Additionally, the SPSS statistical analysis application was utilized to do probit analysis in order to determine the LC50 values.

Results

An assessment was conducted to determine the harmful impact of MgO nanoparticles on adult *S. gregaria*. The nanoparticles were combined with the insecticide, and the outcomes were compared to those of specimens treated just with the pesticide after a 10-day period. Table (1) displays the total death rate of adult *S. gregaria* insects following exposure to various doses of magnesium oxide nanoparticles. The table values clearly demonstrate significant differences in the effects of the three concentrations of MgO combined with the pesticide compared to the pesticide concentration alone. Specifically, the concentration of 0.600 mL/L resulted in a substantial mortality rate of 17.43% ± 0.88 b. On the other hand, the concentrations of 0.150 and 0.300 achieved mortality rates of 13.48 ± 0.62 b% and 17.41 ± 0.85 b%, respectively. The percentage of adult mortality in the treatment group with the pesticide alone was 13.35 ± 0.92 bc, 11.22 ± 0.95 a, and 20.92 ± 1.01 c%, respectively. In the control group, where there was no concentration of nanoparticles or pesticide, the mortality rate was 8.58 ± 0.40 a and 13.64 ± 0.85 ab, respectively. Additionally, it was discovered that the LC50 value throughout the treatment is precisely 0.050. Table (2) presents the P value computed at a probability threshold of $P < 0.05$ for MgO and the pesticide. This value determines the difference between their effects on adults of the species *S. gregaria* at three distinct concentrations: 0.150, 0.300, and 0.600 ml/liter. The results of the test at a concentration of 0.150 showed that magnesium oxide (MgO) worked a little better than the insecticide. The value of P was 0.006, indicating equality, while the concentration of 0.300 had an equal effect on them. Regarding the concentration of 0.600, it was determined that MgO exhibited more efficacy compared to the insecticide, with a value of $P = 0.13$. Table 3 shows how MgO affects the fertility (productivity) of *S. gregaria* by measuring the difference in the number of adult insects produced when the plant was treated with the nanomaterial mixed with the pesticide compared to when it was treated with the pesticide alone, at the same concentrations. When the concentration was at 0.00, in the research observed no variation in the rate of adult production. This indicates that the percentage remained at 0, suggesting that the treatment had no impact. However, when different concentrations of

MgO and the pesticide were used, the differences in adult production were 35.4%, 54.8%, and 78.2%, respectively. This implies that the concentration of the nanomaterial at 0.600 mL/L is more potent than the pesticide.

Cumulative mortality rate of adults' treatment with MgO nanomaterial (Mean ± SE)	Cumulative mortality rate of treated adults' treatment with pesticide (Mean ± SE)	Concentrations mL/L
8.58 ± 0.40	13.64 ± 0.85	0.00
13.48 ± 0.62	13.35 ± 0.92	0.150
17.41 ± 0.85	11.22 ± 0.95	0.300
17.43 ± 0.88	20.92 ± 1.01	0.600

Table 1: Effect of different concentrations of MgO on the cumulative mortality rate of *S. gregaria* adults.

The rates followed by the same letters and in the same column do not differ significantly according to Dunkin's multinomial ANOVA at the 0.05 probability level.

The difference	Pesticide	MgO	Concentrations mL/L
P = 0.008	0.82	0.90	0.150
—	0.77	0.77	0.300
P = 0.15	0.84	1.01	0.600

Mean± SE means mean ± standard deviation of the specimens.

Table 2: The difference after treatment is MgO and *S. gregaria*.

Reduction	Number	Concentrations mL/L
0	108.5	0.00
35.4	75.6	0.150
54.8	57.4	0.300
78.2	36.1	0.600

Table 3: Production (fertility) rate of *S. gregaria* adults after treatment with MgO and pesticide.

Discussion

This study assessed the toxic impact of MgO nanoparticles on adult specimens of the species *S. gregaria*. The nanoparticles were combined with the insecticide, and the resulting effects were compared to those observed when specimens were treated just with the pesticide for a duration of 10 days. The mortality rate was determined by probit analysis to ascertain the LC50 value, which was subsequently disclosed. The study examines the beneficial impact of nanoparticles combined with a pesticide, resulting in an enhanced rate of killing when the concentration is raised. Furthermore, it was discovered that the deleterious impacts of MgO nanoparticles commence 24 hours following administration. The study also revealed the impact of the insecticide Lambda-cyhalothrin 4%. When subjected to it, the response is somewhat sluggish in comparison to the impact of the nanomaterial combined with the pesticide. Also, using magnesium oxide nanoparticles with the pesticide is much less likely to hurt plants and animals than using regular pesticides [14]. The elevated mortality rate observed in adults and across all concentrations presented in Table 1 can be attributed to the incorporation of nanoparticles into the pesticide during treatment. This mixture is then introduced into the insects' food, leading to a lethal impact on all organs within their bodies. Table 2 demonstrates that the nanoparticle magnesium oxide has a significant impact on adults. This indicates that there are substantial statistical disparities between the outcomes of therapy with the mixture of magnesium oxide and pesticide compared to treatment with the pesticide alone. Furthermore, the findings presented in Table 3 indicate that there is no discernible distinction. The production rate of adult organisms remained unaffected when exposed solely to the pesticide. However, notable variations were observed when the organisms were treated with different concentrations of MgO in combination with the pesticide. Particularly, the highest concentration of MgO (0.600 mL/L) exhibited greater efficacy compared to the pesticide alone. Several studies have examined the impact of Nano-materials on economically significant insect species. [15], investigated the impact of a Nano-composition containing LPIDIUM on several biological and biochemical aspects of the insect *Schistocerca gregaria* (Orthoptera: Acridae). The study specifically focused on examining the effects of a Cress Lepidium sativum seed oil emulsion on the five-day-old nymphs of this species. The study revealed that the Nano-emulsions of *L. sativum* oil, at concentrations of 5% and 10%, resulted in a prolonged nymph stage, a higher mortality rate, and significant deformities in the nymphs compared to the control group after three days of treatment. The researchers have determined that employing an *L. sativum* nano-composition to manage the fifth instar of *S. gregaria* nymphs is a novel and encouraging approach that warrants future consideration. Sabbour [16] conducted a study in Egypt to assess the harmful impact of nano-dystroxin on the desert locust species *Schistocerca gregaria*. The study involved evaluating the effects of nano-dystroxin in both laboratory and semi-field settings. The findings indicated that the LC50 concentration of nano-destruxin exhibited an increase when newly hatched nymphs and adults were treated with a concentration of up to 250×10^4 Spores/ml in laboratory conditions. Conversely, a significant decrease was observed in the other stages after treatment, resulting in a concentration of 114×10^4 Spores/ml under semi-field conditions. The mortality rate following treatment in semi-field settings decreased significantly to 2.2 ± 1.2, compared to 2.4 ± 5.3 and 12.2 ± 2.2 under laboratory circumstances. The study verified that the substantial decline is attributed to the insufficient ability to fully regulate the environmental conditions during the application of nanomaterials in the field.

Author Contributions

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Formal Analysis: Mohammed, N. AL-Owaidi
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Writing – Hussein, M. Prism, Mohammed, N. AL-Owaidi
Writing – Review & Editing: Hussein, M. Prism, Mohammed, N. AL-Owaidi

Conflict of Interest

The authors declare that there is no conflict of interest.

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