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# Diagnosis the *Pseudoperonospora cubensis* Causes Downy Mildew in Cucumbers and its Resistance to Potassium Silicate and Extract Eggplant Wild

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# Diagnosis the *Pseudoperonospora cubensis* Causes Downy Mildew in Cucumbers and its Resistance to Potassium Silicate and Extract Eggplant Wild

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**Abstract.** A field experiment was carried out to test the efficiency of potassium silicate and wild eggplant *Solanum eleaegnifolium* normal and nano for the management of downy mildew disease on cucumber caused by *Pseudoperonospora cubensis* under greenhouse conditions by reducing the incidence and severity of the disease and its reflection on the efficiency of the control and the area under the disease progress curve AUDPC compared to the fungicide Energy Previcur (Hcl - Propamocarb and Fosetyl-aluminum). The results of phenotypic and molecular diagnosis using polymerase chain reaction (PCR) technology for the two tested isolates showed that they are *Pseudoperonospora cubensis*. The nucleotide sequences were deposited in the gene bank under accession numbers ON509850 and ON509851. The results of the field trial indicated that the normal potassium silica at a concentration of 2.5 ml $L^{-1}$ prevented the disease completely, with a severity rate and infection rate of 0.00%, it gave the highest reduction recorded with significant differences from the control treatment infected with artificial infestation 45.90% and 24.27%, respectively. They are followed by the normal and nano fungicide treatments. With regard to the effect of different treatments on the percentage of control, the results showed that the highest control percentage was recorded in the treatment of normal potassium silicates (100%), followed by the treatment of nano silicates (65.88%). Whereas, treatments of alcoholic and nano eggplant wild extract gave 51.64% and 50.50%, respectively, and 63.04 % and 63.09 % for the normal and nano fungicides, respectively.

**Keywords.** *P.cubensis*, Potassium silicate, Eggplant wild, Fungicide, Rate of infection.

## 1. Introduction

Cucumber (*Cucmbis sativus* L.) is a widely cultivated crop in open and protected fields. It belongs to the Cucurbitaceae family [1]. The cultivated area of the cucumber crop in 2020 reached 23,821 ha., with a productivity of 242,614 tons. The cucumber crop is affected by many diseases, including the downy mildew disease (*Pseudoperonospora cubensis*), which is spread in many open cultivated areas and serious diseases in greenhouses. It causes losses ranging from 60 - 76% [2].

The widespread use of pesticides generated severe electoral pressure on the pathogenic organism, which led to the emergence of disease strains resistant to the action of pesticides [3]. Therefore, attention has focused on searching for safe methods that may be alternatives to chemical applications or be part of the crop management program, such as natural products, including plant extracts and mineral salts, in controlling pathogenic organisms that cause many fungal diseases that affect plants [4].

Enhancing plant disease resistance through mineral nutrition as an alternative disease management strategy, it was found that potassium silicate salts enhance plant resistance against infection by pathogens by forming protective layers by strengthening epidermal cells and cell walls, as well as stimulating the rapid production of defence compounds through metabolic pathways [5]. As Al-Aswad [6] indicated that the treatment of the cucumber crop with potassium silicate spraying on the shoot at a concentration of 75 ml liter$^{-1}$ led to the protection of the cucumber crop from infection with downy mildew disease throughout the season, where the percentage and severity of infection reached 0.00% with a significant difference from the control treatment (71.12%).

Studies have also tended to use plant extracts using nanotechnology by producing particles loaded with many metals, including silver (Ag) and oxides of some metals such as zinc oxide (ZnO) and iron oxide $Fe_3O_4$ for use in disease control [7]. By 2026, the global production of metallic nanoparticles is expected to reach 10,000 tons [8]. It was found that the chloroplast genome of the extract of the wild eggplant *Solanum eleaegnifolium* is similar to the species of the genus Solanum, as it exhibits the same metabolic behaviour and production of active substances [9], and the ethyl extract of the wild eggplant contains chlorogenic compounds, Kaempferol and Mangiferin, which can be developed as natural pesticides [10]. Therefore, the research aimed to isolate and purify the pathogen *Psedopernospora cubensis*, molecularly diagnose it, determine the nucleotide sequence and deposit it in the gene bank. Testing the efficiency of potassium silicate and the extract of *Solanum eleaegnifolium* in normal and nano formula in controlling downy mildew disease in cucumber crops under greenhouse conditions.

## 2. Materials and Methods

### *2.1. Collecting Cucumber Leaves Infected with Downy Mildew*
The leaves of the cucumber crop plant infected with downy mildew disease and which showed symptoms and signs of the disease were collected from greenhouses in Anbar Governorate, fields of the College of Agriculture, and the symptoms and signs were the presence of spots of yellow or pale green color on the upper surface of the leaves and from the lower surface of the leaf a fluffy growth in a light purple color, then this growth develops to be black and represents the sporangium, it is one of the structures formed by the fungus. The samples were placed in nylon bags, and the date of collection and the area's name were recorded. Then all the samples were transferred to the laboratory and kept in the refrigerator until later used in conducting experiments. Then the pathogen was diagnosed phenotypically using a light microscope with a magnification of 40X, depending on the morphological shape of the fungus structures [1,11] , and molecularly identified using the polymerase chain reaction (PCR).

### *2.2. Preparation of the Alcoholic Extract of the Wild Eggplant Wild*
Samples of the wild eggplant (*Solanum eleaegnifolium*) were collected in the flowering stage from Anbar Governorate and dried in the shade after drying they were crushed in the grinder and then finely sieved and placed in bags marked with a paper indicating the name of the sample and the time of collection and kept until alcoholic extraction according to the Harborne [12] method.

### *2.3. Converting Potassium Silicate, Eggplant Extract, and Fungicide 840% SL Previcur Energy to Nanoform*
The potassium silicate materials and the chemical pesticide Energy Previcur (Hcl - Propamocarb 530 gm l$^{-1}$ and Fosetyl-aluminum 310 g l$^{-1}$) in the laboratory of the College of Agriculture, University of Baghdad, were converted to the nanoform by a physical method by exposing it to an Ultasonic Homogenizer for 6 minutes. This device emits ultrasonic waves that break down particles or particles of materials exposed to it physically and convert them from normal sizes to nanosized using the SPM (Scanning Probe Microscope) and X-RD (X-Ray Diffractometer) [13]. Whereas, the extract of the eggplant herb, it was converted to the nano-form in the laboratory of the College of Science,

University of Baghdad, Department of Biotechnology, as it was loaded on iron metal. A sample of 20 g of the extract was weighed and dissolved in 200 ml of deionized water and then placed in a centrifuge for 10 minutes. The filtrate was separated from the sediment. The filtrate was collected in a glass beaker, and a ratio of 1: 10 ml of plant extract was weighed. Where 20 g of iron metal (powder) was dissolved in 200 ml of the extract and placed in a shaker for 24 hours. Then it was placed in the centrifuge for 20 minutes and the filtrate was separated from the sediment, the filtrate was discarded and 5 ml of deionized water was added and placed in the centrifuge again for 10 minutes. The filtrate was discarded, and the precipitate was collected in a glass dish and placed an oven at 37 $^{\circ}$C for three days [7]. After that, the sample was collected and ground in a ceramic mortar, and it was confirmed that the extract had been converted into a nano-image in the laboratory of the College of Science, Al-Nahrain University, Department of Chemistry, by measuring the size of nanoparticles with an Atomic Force Microscopy device (AFM) in the College of Science / Department of Chemistry / University of Baghdad according to Ding *et al*. method [14].

### *2.4. Field Experiment*

Cucumber (*Cucumis sativus* L.) seeds were used (cultivar Super Faris), with a germination rate of 95% and purity of 99%, produced by the German company Bayer. The process of producing seedlings was carried out in the nursery inside the greenhouse in Anbar Governorate, fields of the College of Agriculture, on 21/12/2021, in cork containers with a total of 104 holes and filled with peat moss after wetting it with water. The seeds were sown at the rate of one seed in each hole. The first germination of the seedling appeared on 27/12/2021. After the seedlings reached the stage of 3-4 true leaves, they are transferred from the cork dishes to the plastic house. The plastic house was prepared for cultivation during the 2022 season, and the collection of agricultural operations of plowing and smoothing was completed, leaving a distance of 90 cm from the two sides of the house and identified five lines for planting at a distance of 80 cm between one line and another, the width of each line is 80 cm. Then the drip irrigation tubes were installed with two tubes for each line, with a distance of 40 cm between one tube and another. After completing the soil preparation operations, seedlings were planted on 16/1/2022 and the experiment's treatments were randomly distributed within one replicate so that each treatment appears once in each replicate. The experiment was carried out according to a Randomized Complete Block Design (RCBD) with three replicates. Leaving a distance of 1 m between one treatment and another to ensure that there is no overlap between the experiment's treatments. The crop service was followed up in the greenhouses, and all the necessary agricultural operations were carried out, including watering, fertilizing, hoeing, and weeding until the plants reaches a good vegetative system suitable for the application of the treatments. The greenhouse plants in Ramadi were contaminated with the fungal vaccine on February 28, 2022 for three terraces according to the treatments, leaving the guard lines uncontaminated. The efficiency of the materials used in the research in the management of downy mildew disease on the cucumber crop was evaluated, by repeating the spraying 8 times at10 days intervals.

The experiment treatments included the aqueous and alcoholic extract of eggplant wild at a concentration of 3 gm $L^{-1}$ and nano-extract at a concentration of 1.5 gm $L^{-1}$ and spraying with normal potassium silicate at a concentration of 2.5 ml $L^{-1}$ and nano at a concentration of 1.25 ml $L^{-1}$ with the use of the usual chemical pesticide at a concentration of 1.5 ml $L^{-1}$ and nano at a concentration of 0.75 ml $L^{-1}$ with the control treatment infected with artificial contamination.

### *2.5. Estimation of the Infection Rate of Downy Mildew Disease*

The rate of infection with downy mildew disease was recorded for the affected plants weekly and for all experimental units, starting from the first appearance of the disease, which was recorded on the date of 23/3/2022. The average number of infected plants was extracted for each treatment, and the infection rate for each treatment was calculated using the following equation:

$$\text{Infection rate}\% = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \text{x}100$$

Infection severity was calculated using a scale adopted by Kitta *et al.* [15], and then used Mckinney's equation [16] to calculate the severity of the disease. The control efficiency was calculated using the equation of Maharjan *et al.* [17]:

$$\text{Disease control\%} = \frac{\text{Disease severity in Control} - \text{Disease severity in treatment}}{\text{Disease severity in Control}} \text{x}100$$

The area under the curve of disease progression was calculated using the equation of Cooke *et al*. [18]:

$$\text{AUDPC} = \frac{1}{2}\sum(2S1 + 2S2 + \cdots SX)$$

Where:
S1 = disease severity on first reading
S2 = disease severity on the second reading

## 3. Results and Discussion

### *3.1. Phenotypic Diagnosis of the Cause of Downy Mildew in Cucumber*

The results of Figures 1 and 2 showed the phenotypic characteristics of the pathological signs of the fungus *P. cubensis* that causes downy mildew on cucumbers by light microscopy in the presence of fungal structures that are in the form of spherical to oval caps that contain a papilla at the top and represent the caps of Sporangia, and the Sporangia are borne on sporangiophores with bilateral branches, at an acute angle from the axis, and with a pointed end, and that this holder carries at the end of one sporangium. This description is consistent with that of Newark *et al.* [19], as they showed that the pathogenic fungus forms oval or spherical sporang*i*a capsules with a papilla-like top, where the sporangiophores holder is at an acute angle and with pointed ends carrying the Sporangium, and the Conidiophores branch irregularly and then become dichotomous.

**Figure 1.** Symptoms of Downy mildew (*Pseudoperonosppora cubensis*).


**Figure 2.** Represents the sporangia (A) and Sporangiophores (B) of *P. cubensis* Under the light microscope with a magnifying glass X40.

*3.2. Molecular Diagnosis of the Cause of Downy Mildew Disease Using Polymerase Chain Reaction (PCR) Technology*

The results of electrophoresis of DNA extracted from isolates of the fungus *Pseudoperonospora cubensis* after multiplication by PCR using the ITS1 and ITS4 primer showed that there were 900 band pairs of molecular weight for each isolate as shown in Figure (3) where the nucleotide sequences were determined in the ITS region of the tested isolates, and compared with the global isolates in the gene bank and it was found that they belong to the fungus *Pseudoperonospora cubensis* and the nucleotide sequences of the two isolates were deposited in the gene bank under the accession number ON509850 and ON509851.

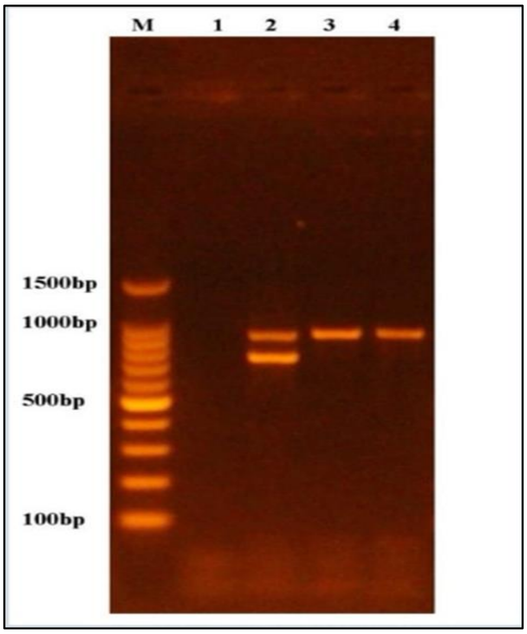


**Figure 3.** The result of electrophoresis of the genetic material of the fungus *P. cubensis.*

*3.3. Field Experiment*

*3.3.1. The Effect of Treatments in Controlling the Fungus P.cubensis in Cucumber*

The results of the first reading in Table (1) showed that all treatments were different among themselves in reducing the rate of infection downy mildew disease on the cucumber crop with significant differences from the control treatment infected with artificial contamination. The treatment of potassium silicate in the normal formula with a concentration of 2.5 ml L-1, which led to the prevention of the appearance of downy mildew disease on cucumbers, came in the first place, as the infection rate was 0.00%. Whereas nanoparticles at a concentration of 1.25 ml $L^{-1}$ it gave an average infection rate of 20.31%. Followed by the treatment of the fungicide by the normal and nano-formula, in which the infection rate was 31.14% and 32.35%, respectively. Then came the treatment of the eggplant wild nano-extract at a concentration of 1.5 ml $L^{-1}$, with an infection rate of 37.85%, followed by the treatment of the alcoholic extract of the eggplant wild at a concentration of 3 ml $L^{-1}$ (36.61%). The aqueous extract of eggplant herb with a concentration of 3 ml $L^{-1}$ (39.29%) ranked last. Compared with the control treatment infected with artificial contamination 40.69%.

In the second reading, the results in Table (1) showed a continued decrease in the rate of infection of downy mildew disease for all treatments. It was noticed that the potassium silicate treatment with the normal formula continued to outperform the rest of the treatments in preventing the infection of downy mildew disease, as the infection rate was 0.00%, followed by the treatment of potassium silicate with the nano formula (18.14%). followed by the treatment of the fungicide Previcur with the nano-formula, which had an average infection rate of (21.29%), while the treatment of the fungicide with the normal formula gave an infection rate of 24.61%. Also, treatment of the alcoholic extract of the eggplant wild at a concentration of 3 ml $L^{-1}$ gave an infection rate of 29.97%, and the treatments of the nano and aqueous extract of the eggplant wild ranked last. In the third, fourth and fifth readings, the results in Table (1) showed a continued decrease in the rate of infection of downy mildew disease on the cucumber crop inside the plastic house for all treatments, as it was noted that the potassium silicate treatment with the normal formula continued to outperform the rest of the treatments, as it led to the prevention of downy mildew disease, with an infection rate of 0.00%

The fungicide treatments in the nano and normal formula came in second place, with an average infection rate of 5.46% and 5.74%, respectively. In third place came the treatments of the alcoholic and nano-extract of the eggplant wild, where the infection rate was (8.18% and 9.76), followed by the treatment of potassium silicate with the nano-formula (12.05%), and the treatment of the aqueous extract of the eggplant wild (28.34%), and that all treatments differed significantly from the control treatment. infected with artificial contamination, which recorded the highest rate of infection of 47.27%.

**Table 1.** The effect of treatments on the rate of infection of downy mildew disease (*Pseudoperonospora cubensis*) in the cucumber crop under the greenhouse condition

| **Treatments**[¥] | **First reading** | **Second reading** | **Third reading** | **Fourth reading** | **Fifth reading** | **Mean** |
|---|---|---|---|---|---|---|
| | **infection %** | **infection %** | **infection %** | **infection %** | **infection %** | |
| Ext 3g $L^{-1}$ | 36.61 | 29.97 | 23.72 | 11.79 | 8.18 | 22.05 |
| Ext.n 1.5 g $L^{-1}$ | 37.85 | 29.31 | 24.49 | 13.19 | 9.76 | 22.92 |
| Ext.w 3g $L^{-1}$ | 39.29 | 35.16 | 30.53 | 29.38 | 28.34 | 32.54 |
| Sp 2.5 ml $L^{-1}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sp.n 1.5 ml $L^{-1}$ | 20.31 | 18.14 | 16.24 | 14.34 | 12.05 | 16.21 |
| Pro. 1.5 ml $L^{-1}$ | 31.14 | 24.61 | 17.83 | 7.37 | 5.74 | 17.33 |
| Pro.n 0.75 ml $L^{-1}$ | 32.35 | 21.29 | 17.58 | 8.20 | 5.46 | 16.97 |
| Co.ps | 40.69 | 42.38 | 44.24 | 45.37 | 47.27 | 43.99 |
| LSD=0.05 | 1.646 | 2.633 | 3.287 | 1.954 | 2.615 | 2.427 |

[¥] Ext = Alcoholic Eggplant Extract, Ext.n = Eggplant Nano Extract, Ext.w = Eggplant Aqueous Extract.
Sp = potassium silicate, Sp. n = nano-potassium silicate, Pro = fungicide Propamocarb HCL, Pro.n = nano- fungicide Propamocarb HCL, Co.ps = control treatment artificially contaminated with *P. cubensis*.

The results of the first reading in Table (2) showed that all treatments were different among themselves in reducing the infection severity of downy mildew disease on the cucumber crop with significant differences from the control treatment infected with artificial contamination. Where the treatment of potassium silicate in the normal formula came in the first place at a concentration of 2.5 ml $L^{-1}$, which prevented the appearance of downy mildew disease on cucumbers. The infection severity rate was 0.00%. As for the nano-particles with a concentration of 1.25 ml $L^{-1}$, the rate of infection severity was 18.06%, followed by the treatment of the fungicide with the normal and nano formula, in which the rate of infection severity reached 28.62% and 29.71% respectively. In the treatment of eggplant wild nano-extract at a concentration of 1.5 ml $L^{-1}$, the rate of infection severity was 35.04%, followed by the treatment of the alcoholic extract of eggplant wild at a concentration of 3 ml $L^{-1}$ (37.19%). The aqueous extract of eggplant wild with a concentration of 3 ml $L^{-1}$ (37.05 %) came in last place compared with the control treatment infected with artificial contamination 38.73%.

In the second reading, the results in Table (2) showed a continued decrease in the severity and rate of infection of downy mildew disease for all treatments, where it was noticed that the potassium silicate treatment with the normal formula continued to be superior to the rest of the treatments in preventing the infection of downy mildew disease, as the infection severity was 0.00%, followed by the treatment of potassium silicate with the nano formula (14.53%). Followed by the treatment of the fungicide Previcur by the nano-formula, as the infection severity reached (19.82%). While the treatment of the fungicide with the normal formula gave an infection severity of 22.16%, and the alcoholic extract of the eggplant wild with a concentration of 3 ml $L^{-1}$ gave a rate of infection severity 26.71%, and the treatments of the nano and aqueous extract of the eggplant wild ranked last. In the third, fourth and fifth readings, the results in Table (2) showed a continued decrease in the rate of infection of downy mildew disease on the cucumber crop inside the green house for all treatments, as it was noted that the potassium silicate treatment with the normal formula continued to outperform the rest of the treatments, as it led to the prevention of downy mildew disease, with infection severity of 0.00%. The treatments of the fungicide in the nano and normal formula came in second place, as the rate of infection severity reached (4.60% and 4.86%) respectively. In third place came the treatments of the alcoholic and nano-extract of the eggplant wild, with a rate of infection severity (7.12% and 8.67%) respectively, followed by the treatment of potassium silicate with the nano-formula (10.48%). The treatment of the aqueous extract of the eggplant wild (26.12%) ranked fourth, and all treatments differed significantly from the control treatment infected with artificial contamination, as it recorded the highest rate of infection severity, which reached 45.90%.

The results of the disease control efficiency (Table 2) indicate that the potassium silicate treatment with the normal formula was superior to the rest of the treatments, where the control efficiency reached 100%, followed by the potassium silicate treatment with the nano formula (65.88%), and the fungicide treatments with the nano and normal formula recorded a control efficiency of 63.04 and 63. 09%, respectively, while the treatments of aqueous, nano and alcoholic extracts of eggplant wild gave 31.48%, 50.50% and 51.64%, respectively.

The results of reducing the infection rate and the severity of infection due to the application of potassium silicate treatments in the normal and nano formula, the fungicide in the regular and nano formula, and the alcoholic, nano and aqueous extract of the eggplant herb by spraying on the vegetable parts of the cucumber crop grown in a greenhouse on the area under the disease progression curve AUDPC are reflected in Table (2). The area under the disease progression curve AUDPC in the potassium silicate treatment with the normal formula was 0.00% with a significant difference from the control treatment infected with artificial contamination (187.99%), followed by the treatment of potassium silicate nanoparticles (65.04%).While the area in the treatments of the fungicide in the normal and nano forms was (75.51% and 75.55) respectively, while in the treatments of the alcoholic, nano extract, and aqueous extract of the eggplant wild , the area under the disease progression curve amounted to 98.40% and 100.6, and 131.44% respectively.

**Table 2.** The effect of treatments on the infection severity of downy mildew disease (*P. cubensis*) in the cucumber crop under the greenhouse condition.

| Treatments¥ | First reading | Second reading | Third reading | Fourth reading | Fifth reading | Mean Infection Severity % | Control efficiency | AUDPC |
|---|---|---|---|---|---|---|---|---|
| | severity % | severity % | severity % | severity % | severity % | | | |
| Ext 3g $L^{-1}$ | 37.19 | 26.71 | 21.34 | 9.60 | 7.12 | 20.39 | 51.64 | 98.40 |
| Ext.n 1.5 g $L^{-1}$ | 35.04 | 28.07 | 21.54 | 11.08 | 8.67 | 20.88 | 50.50 | 100.06 |
| Ext.w 3g $L^{-1}$ | 37.05 | 28 | 25.90 | 27.43 | 26.12 | 28.90 | 31.48 | 131.44 |
| Sp 2.5 ml $L^{-1}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100 | 0.00 |
| Sp.n 1.5 ml $L^{-1}$ | 18.06 | 14.53 | 14.63 | 12.58 | 10.48 | 14.05 | 65.88 | 65.04 |
| Pro. 1.5 ml $L^{-1}$ | 28.62 | 22.16 | 16.01 | 6.29 | 4.86 | 15.59 | 63.04 | 75.51 |
| Pro.n 0.75 ml $L^{-1}$ | 29.71 | 19.82 | 16.46 | 7.26 | 4.60 | 15.57 | 63.09 | 75.55 |
| Co.ps | 38.73 | 40.0 | 42.50 | 43.81 | 45.90 | 42.18 | —— | 187.99 |
| LSD=0.05 | 1.783 | 3.087 | 3.725 | 2.156 | 2.407 | 1.610 | 3.705 | 7.501 |

¥ Ext = Alcoholic Eggplant Extract, Ext.n = Eggplant Nano Extract, Ext.w = Eggplant Aqueous Extract Sp= potassium silicate, Sp. n = nano-potassium silicate, Pro = fungicide Propamocarb HCL, Pro.n = nano- fungicide Propamocarb HCL, Co.ps = control treatment artificially contaminated with *P. cubensis*. AUDPC = Area Under Disease Curve

The results indicated that potassium silicate treatments of the normal and nano-formula were more efficient in reducing the rate of infection and severity of infection (Table 1, 2 ). This is due to the fact that potassium silicate salts enhance the resistance of the plant against infection with pathogens by strengthening the epidermal cells and also increasing the thickness of the cellulose membrane and the complex compounds in the epidermal cell layer, this leads to the formation of protective layers, and these protective layers inhibit the penetration of the pathogen and make the cells of the host plant less sensitive to the degrading enzymes secreted by the pathogen [20].
Devrim *et al.* [21] stated that silicate treatment is beneficial to the plant as it works to promote plant growth as well as protect plants from infection with fungal diseases, and that all these activities positively affected the resistance against the disease and increased production, and this is in agreement with many researchers they used potassium silicate to control downy mildew and other diseases that affect agricultural crops. It was shown that Al-Aswad [6] showed that treating the cucumber crop with potassium silicate by spraying on the foliage at a concentration of 75 ml liter$^{-1}$ led to the protection of the cucumber crop from infection with downy mildew disease throughout the season. The rate and severity of infection was (0.00%), with a significant difference from the control treatment (71.12%), and in a study that showed the use of different concentrations of potassium silicate in the normal and nano formula as spraying on the foliage in the control of powdery mildew disease on summer squash caused by the fungus *Podosphaera xanthii* inside the plastic house led to a reduction in the rate and severity of the infection of the disease [22].
The effect of the fungicide Previcur Energy with the regular and nano-formula on reducing the rate and severity of infection of downy mildew disease, which contains two active substances Hcl Propamocarb and Fosetil and had a role in direct resistance against pathogenic fungi. propamocarb Hcl inhibits the accumulation of the fungal cell membrane by preventing the formation of zoosporangia as well as affecting the biosynthesis of lipids in fungi. Whereas, Fosetil works directly by preventing the formation of spores, as well as preventing the penetration of the mycelium inside the plant if it is used preventively [23], and all these activities positively affect the resistance against the disease and increased production, and this is in agreement with many researchers. They used the fungicide Previcur Energy 840%SL in the resistance of downy mildew disease. The effect of the alcoholic, nano and aqueous extract of the wild eggplant herb on its effect on the pathogenic fungus, results showed a clear effect in reducing the severity and rate of infection, and that the reason for the direct role in the resistance against the pathogen through its effect on the spores or the fungal mycelium. This is consistent with what was mentioned by Salam *et al.* [24], who showed that plant extracts have several mechanisms in inhibiting fungi, including physical inhibition through the occurrence of an adsorption process for the plant extract molecules on the surface of spores and mycelium and thus impede the reproduction process or by mechanical inhibition, where it was found that after drying the plant extract on the surface of the leaves, it forms a solid membrane around the spores and sclerotia, which leads to the prevention of their germination, and that all these activities of the plant extract positively affected the resistance of the plant against the fungus, and this is consistent with a number of researchers who used plant extracts to control fungal diseases. Margaritopoulou *et al*. [25] reported that the extract of *Reynoutria sachalinensis* proved to be effective in controlling powdery mildew on zucchin, and it significantly reduced conidia germination. Billet *et al*. [26] also found that stilbenoid-rich grape cane extract (GCE) was effective against downy mildew on Grape *P. viticola* reduced infection by 35%, and the alcoholic extract of *aloe vera* leaves was effective in inhibiting *M. phaseolina* by 96.36% [27].

## Conclusion
The results of the phenotypic and molecular diagnosis using the polymerase chain reaction (PCR) technology of the two tested isolates, *Pseudoperonospora cubensis*, showed that it is the cause of the downy mildew disease in cucumber, and the nucleotide sequences were deposited in the gene bank under accession number ON509850 and ON509851. The spraying of potassium silicate, extract of the wild eggplant wild (*Solanum eleaegnifolium* L.), and the fungicide Previcur Energy regular and nano

have a positive effect in controlling the disease in cucumber crop under protected conditions, and they recorded the best results in reducing the rate and severity of the infection and its reflection on the rate of disease control and the area under the curve of disease development AUDPC compared to the artificially contaminated control treatment.

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