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Original Research Article

Effect of Iron Nanoparticles Prepared from Onion Extract on Cucumber Plant Growth and Production

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Abstract: In recent years, it has been shown that the use of chemical fertilizers negatively affects the environment and public health. Nano fertilizer have been discovered and used, and one of their many advantages is the speed and ease of obtaining them from various plant sources, which are cheap and currently available it's friendly for environment. The field experiment was carried out in the spring season of 2021 in a mixture of salty clay (cohesive soil) for the purpose of studying the effect of spraying synthetic nanoparticles used from iron oxide particles with onion plant extract at concentrations of 100, 200 and 300 parts per million on the growth and yield of cucumber (*Cucumis melo var. flexuosus*). The prepared nanoparticles were identified by the following assays: UV-visible spectrophotometry, XRD, FTIR, TEM, SEM and AFM. The results showed a significant effect of using Nano pesticides, especially with high concentration, in increasing average plant height, plant dry weight, leaf area and total plant yield. It was concluded from this study that the positive effect of Nano-fertilizer prepared with onion extract on plant growth, which led to an increase in cucumber productivity and the quality of its fruits, from that there is the possibility of using it as an alternative to conditional mineral fertilizers, after conducting several studies on the safety of using these plants treated with Nano-fertilizers for humans.

Keywords: Iron nanoparticles, Plant Extract, *(Cucumis Melo Var. Flexuosus*) Yield, *Environment*.

INTRODUCTION

The discovery of nanotechnology is a logical roadmap in various different sciences and engineering integration with biology, chemistry, medicine and physics [1, 2]. Extensive studies on the use of nanoparticles with different metals and their applications with various different plant extracts have proven the tremendous progress achieved by these nanoparticles and their significant impact on the economy, society and the environment. Plants are the basic component of all ecosystems and play critical role in the fate and transfer of engineered nanoparticles into the environment through plant uptake and bioaccumulation [3].

Cucumber (*Cucumis melo var. flexuosus*) is an important vegetable of the cucurbit family, which grows in summer. It is widely cultivated to be accepted and eaten by most people, in addition to its nutritional importance because it contains many vitamins and minerals such as calcium, potassium, silica, phosphorus, and magnesium [4]. Cucumber is also widely used for the purpose of pickling it with popular acid. Obtaining cucumber fruits is considered a viable and profitable economic crop [5]. Therefore, cucumber occupies the fourth place in importance and demand by the consumer among the most important vegetables after tomatoes, peppers, onions and cabbage, and it is currently produced in very large quantities and on a large scale in most regions of the world due to its high consumption by the majority of people [5-

2].There are many studies that used various extracts from plants and microorganisms and used the method of spraying on the vegetative parts, but it was very limited on cucumber plants compared to other crops [6, 7].

The use of nanomaterial in the diagnosis of some plant diseases through the so-called nanoparticle cells, there may be a possibility of using them to increase the production of edible plants such as spinach, cucumber, radish, rye or grains such as corn, rice and wheat [8-10].There are many studies on the synthesis of nanoparticles from plant extracts and their application in agriculture to obtain large amounts of biomass, whether fruits or vegetables, including cucumbers, spinach, cabbage, radishes, carrots, watermelon and tomatoes, using many different precious metals as a catalyst for Nano synthesis to increase Production and cost reduction through the cheapness of the materials used in preparation, rapid access, easy preparation, and do not take long [7-9].

Another study demonstrated the benefit of using 3000 ppm of silver nanoparticle extract for the purpose of combating pathogens of cucumber plants in increasing the yield is high, but he warned against high levels of heavy silver, as a small percentage of the metal was found in the total plant [10, 11].Due to the negative effects of chemical pesticides on human health and the environment and the absence of a previous study in the country, so this study aimed to evaluate the effect of iron nanoparticles using onion extract by spraying method on the vegetative leaves of Cucumber plant to prevent beetles combat the disease of death and fall of the cucumbers leaves which aimed to: 1- Evaluation of the efficiency of these particles in combating the disease and fall of leaf caused by onion extract on some varieties of cucumber (*Cucumis melo var. flexuosus*) in Iraq. 2- Effect of different concentrations of Iron nanoparticles on plant indicators.

Therefore, this study aimed to evaluate the effect of the Nano pesticide prepared from onion extract on cucumber plants in terms of improving growth and increasing production and quality.

MATERIAL AND METHODS

Field Experiment

The field experiment was carried out to grow cucumber plants in the spring season of 2021 on a private farm for Dr. Mizher Al-Hamdani/in Al-Rasheed District/Al-Mahmoudiya/Baghdad. The type of soil is sedimentary with a mixture of clayey alluvial texture and classified into Torrifluvent Typic according to the classification of the modern American table shows some soil characteristics. The land was prepared by plowing and smoothing and the required settlement, and then the transactions were divided into terraces and it was the width of the bench = 3 m, the length = 3 m, the distance between the benches another was 1 m, and its stalks were cut with a width of = 75.0 m. Then it was cultivated cucumber seeds (*flexuosus melo cucumis*) cultivar omarli, a hybrid produced by seeds Turkish'sargeto and with three seeds in a single hole to ensure the process of germination and the distance between plant and another was 60.0 m, and the number of plants in the experimental unit was 20 plants, distributed over four lines, with a plant density 22222.22 plant for each hectar^{1-}, after that, the plants were irrigated. Execution of the experiment was according to the design of the sectors. Complete randomization (D.B.C.R) with three replications for two factors.

The experiment was treated with 0.1, 0.01 and 0.001 ml of iron nanoparticles Fe_2NPsof onion extract using a manual spray method to apply iron nanoparticles turn the stem and leaf part of the plants well after 3~4 weeks of germination before and after the outbreak of the disease. It was used as a positive control treatment and distilled water was used as a negative control. Also, all treatments were sprayed with three sprays on the first vegetative total 17 days after germination and the second 30 days after germination and the third after 60 days of germination. All related service operations have been performed take care of plants, including thinning the plant after two leaves appear it was manually hoeing and weeding the bush and pest control using a Nano pesticide. Irrigation was carried out according to the needs of the plantto be irrigated once a week according [3-11].

Table 1: Physical and chemical characteristics of used experimental soil

Parameters	**Value**
Particle-size distribution (%)	
Sand	24
Silt	41
Clay	
Texture class	Clay loam
CaCo3	% 1.58
Organic matter	3.10
pH (saturated past)	7.65
EC (dS m-1)	1.35
Field Capacity	10.98
Permanent wilting Point	4.09

Parameters	**Value**
Particle-size distribution (%)	
Available water capacity 6.89	6.89
Bulk density 1.7	1.7
Real density 1.33	1.33
P% 0.28	0.28
K% 0.35	0.35
N% 1.3	1.3
Soluble Cation (m L^{-1})	
Ca^{2+} 4.5	4.5
Mg^{2+} 3.25	3.25
Na^{+}	3.50
K	2.25
Soluble anions (m L^{-1})	
$CO3^{-2}$	Tr
$HCO3^{-}$	1.01
CL"	6.09
SO4 "	7.4

Estimated Plant Height (CM)

The length of the plant was estimated using the measuring tape from the area of contact of the plant in the soil to the highest part of the plant for each of the experimental treatments after three months of planting according to [12].

Estimation of Seed Germination Percentage

The percentage of seed germination for different cucumber plant treatments was estimated from the date of sowing the seeds to a period of four weeks, and the rate was extracted according to the following equation:

$$Germination\ \% = \frac{Sprouting\ Plants}{Total\ seeds\ sown}\ X\ 100$$

Estimated Leaf Area of the Plant (Cm^2)

The leaf area of the plant was estimated by calculating the area for three plants for each replicate and the calculation was done on the basis of three leaves from the following regions (lower, middle, upper) for each plant calculated (cm^2), the leaf area per leaf was calculated according to the following equation:

Leaf area = Leaf length x Leaf width x 95.0 according to [10],
Which is 95.0= the cucumber yield constant.
Vegetative Growth

Three plants were randomly chosen and labeled from each plot to measure the growth parameters after 40 and 60 days from transplanting date according to [12].

1. Plant height measure from the surface of soil until the maximum leaf lit.
2. Number of leaves/plant
3. Leaf area meter was measured by Cl-202 laser area meter (U.S.A).
4. Fresh and dry weight of leaves and fruits were measured by drying in forced oven at 70ºC until consent weight.

Estimated Dry Weight of the Plant (G)

Estimate the dry weight of the plant after drying the whole plant with the roots for three days by exposing it to sunlight, three plants for each replicate, and after stabilizing the weight by means of a sensitive scale for each of the experiment.

Yield and Its Components

1. Early yield /plant calculated as the sum of three first picking
2. Total yield /plant

Cucumber Quality

Total Soluble Solid (TSS) was measured by using digital refractometer (PR 101, CO. Ltd. Tokyo, Japan) after 6 weeks of planting.

Nanoparticles Synthesis

Iron Oxide Nanoparticles Preparation

Iron oxide nanoparticles were used for cancer treatment, drug delivery, and treatment, damaged tissues, detoxification of biological fluids, and magnetic resonance imaging [13, 14]. The onion bulb were washed with water and were cut to small pieces then dried in the room under the ceiling bank for 5 days. The dried onions were ground with a regular electric grinder, then 5 grams of dried onion powder were taken and placed in a 100 ml baker, and 50 ml of distilled water was added to it. Then, the mixture was heated at 85°C for 2 hours with continuous stirring, then filtered by centrifugation to separate the impurities. Then Fe3O4 iron salts were added to the previously prepared onion extract and the mixture was heated at 70°C, with continuous stirring using magnetic stirring, when left to cool to room temperature for 1 period / 4 hours. After that, a few drops of 1 Molar of NaOH were added to adjust the pH to 8 in the solution, and we infer that the color changed to dark black, and this confirms the formation of nanoparticles as in Figure 1 [15, 16]. The formation of iron oxide nanoparticlesFe_2NPswas observed after one hour, and electron microscopy images indicated that the resultant particles was spherical in shape, with dimensions in the range of 6.5-6.18 nm. According [17, 18]. Then all nanoparticles measurement was done in Kashan University laboratories/Iran through an agent CAC test located in Baghdad city.

Figure 1: Preparation of Fe_2NPsnanoparticles

UV-Visible Spectroscopy

Average size is determined for the Nanoparticles Fe_2NPswith aqueous extract of onion by performing UV-Vis spectroscopy. This is done by pumping one milliliter of the prepared nano-extract into a test tube and analyzing it at room temperature with an accuracy of 1 nm at a wavelength between 200 and 800 nm, and after decomposing it by exposing it to dynamic light using (Spectroscatter 201) Shimadzu ultraviolet type. Visible Spectrophotometer (UV-1800, Japan). UV-Visible absorption spectrometer [15-17].

X-ray Diffraction (XRD) Determination

XRD measurement was carried out by Phillips X'Pert Pro powder X-ray diffractometer (XRD) (PANalytical, Almelo, The Netherlands) with a copper target (CuKα1, λ = 1.54056 Å). It was operated with a nickel filter at a voltage of 40 kV and a current of 45 mA according to [18, 19].

FTIR-Spectroscopy Determination

An infrared analysis of Iron Nano forms was performed with FTIR - 8400S, SHIMAZW-FTIR spectroscopy with a wavelength ranging between (500 - 4000) cm^{-1} [19].

Scanning Electron Microscope (SEM)

The scanning electron microscope is of the type (TESCAN-VEGA / USA) where the Nano scale particles are scanned with 3 nm beams and 30kv electric voltage knowing that the device is connected and programmed with computer programs to analyze the average particle size in the sample [2].

Particle Size Distribution Analysis

This device is important for determining fast and accurate size distributions of Fe_2NPs (vision 5.34) with a range ranging from (6- 2 µm nm), and the dynamic light scattering at 90 degrees, at temperatures from (-110-5) m using high power 35 mW for a laser diode.

AFM Examination: A three-dimensional image was taken showing theFe_2NPscopper using the deposition method.

Statistical Analysis

The Statistical Analysis System- SAS (2012) program was used to detect the effect of difference factors in study parameters. Least significant difference –LSD test (Analysis of Variation-ANOVA) was used to significant compare between means. Chi-square test was used to significant compare between percentage (0.05 and 0.01 probability) in this study according to [20].

RESULT AND DISCUSSION

The cucumber plant is always infected with trips, the most annoying pest, because it is a carrier of some viruses, and leads to holes and stiffness of leaves and fruits. It is usually treated by spraying with one of the pesticides containing the active substance amidaclopride [21].

Growth Properties

The results of the study of plant growth characteristics and their statistically significant changes for the different treatments of this study are represented in Table No. 2. The results showed that the treatment with a high concentration of 0.1 ml of onion Nano pesticide had a significant increase in the length and roots of the plant, as it was 165.5 and 15.5 cm after 40 and 60 days, respectively, from the date of planting as shown in (Table 2).

While the length and roots of the plant decreased to 13.2, 146.7 cm with a decrease in the concentration to 0.001 ml of onion Nano pesticide. Also, the results of the study showed a significant decrease ($p \geq 0.05$) for the length of the cucumber plant with a decrease in the concentration of the onion nan pesticide, as it was 165.5, 155.8 and 146.7 cm with 0.1, 0.01 and 0.001 ml / liter of onion extract, respectively, compared with the control and standard treatments, 130.5 and 140.2 respectively. It was observed the highest length of root was 14.4 cm with 0.1ml/$L^{-1}$of Fe_2NPs, while the lowest length was 11.8 cm with 0.001 ml/L^{-1} of Fe_2NPs.

The results of the study also showed a significant increase in the number of leaves for each plant of cucumber using the high concentration of Nano-extract of onion, and it decreased significantly ($p \leq 0.05$) with a decrease in the concentration of Nano-extract of onion, where the number of leaves was 28.6, 25.4 and 22.6 with 0.1, 0.01 and 0.001 ml / liter of onion extract respectively compared to the control and standard treatment coefficients, their numbers were 16.2 and 23.0.

The results of the study also showed a significant increase in the leaf area of the cucumber leaf using the high concentration of the onion Nano extract, and it decreased significantly ($p \leq 0.05$) with a decrease in the concentration of the onion Nano extract, as the leaf area was 185.6, 179.3 and 171.5cm^2 with 0.1, 0.01 and 0.001 ml / L, respectively, with onion extract, compared with the control treatments and the standard treatment, as the number was 165.9 and 175.5 cm^2 respectively.

The effect of the Nano-fertilizer used with iron particles in the spray method is attributed to improving seed germination and protecting green leaves from almost of insets [21], which in turn provides sufficient food and chlorophyll which is necessary for the production of fruits [22].

Table 2: Effect of onion Nano-fertilizer on cucumber plant growth characteristics after 40 and 60 days of planting during 2020/2021

Treatments	After 40 days				After 60 days		
	Plant height (cm)	Root length (cm)	No. of leaves	Leaf area(cm^2)	Root length (cm)	Plant height (cm)	N. of leaves
Control	130.5	10.5	16.2	165.9	12.6	125.4	18.3
Urea (N)	140.2	11.6	23.0	175.5	13.5	160.5	25.5
onion extraction (0.1ml)	165.5	14.4	28.6	185.6	15.8	180.0	33.0
onion extraction (0.01ml)	155.8	13.7	25.4	179.3	15.6	167.2	31.5
onion extraction (0.001ml)	146.7	11.8	22.6	171.5	13.2	156.9	28.4
LSD value	11.48 *	2.07 *	5.94 *	14.63 *	2.18 *	16.44 *	5.86 *
* ($P \leq 0.05$).							

Effect of Onion Nano-Fertilizer on Yield

The results of studying the effect of Nano-fertilizers prepared from the use of onion extract on the production of germination percent, total yield, total solids and dry matter of cucumber plants are represented as in Table 3.It was noted that 100% of seed germination of all treatment, that is an excellent impact on seed and planting quality.

The results showed that the treatment with high concentration 0.1 ml of onion Nano pesticide significantly increased ($p \leq 0.05$) the yield of total crop yield, total solids and total dry matter weight of cucumber fruits after 60 days

from the date of planting, compared with the control treatment and the standard treatment as shown in (Table 2).The results showed that as the concentration of onion Nano pesticide increased, the amount of the total yield of cucumber fruits increased significantly ($p \leq 0.05$), as it was 4.50, 4.10 and 2.80 kg for concentrations of 0.1, 0.01 and 0.001, respectively, of onion Nano pesticide.

The results of the study also showed a significant increase ($p \leq 0.05$) of the total dry matter of cucumber fruits with an increase in the concentrations of nanoparticles of onions after 60 days from the date of planting, compared with the control treatment and the standard treatment, as shown in (Table 2). The dry matter weight/cucumber fruit was 445.6, 430.8 and 352.5 for the concentrations of 0.1, 0.01 and 0.001, respectively, of the onion Nano pesticide used in this study. These results were similar to what was found by [9-12].

The increase in the yield of the crop is attributed to the improvement of the growth of the plant treated with the used Nano pesticide, which in turn improves the morphological characteristics of the leaves and the content of chlorophyll, and this physiologically leads to an increase in the yield. These results were agreement with [23-25].

Also, the highest values of total soluble solids TSS 2.49, 2.40 and 2.00 were recorded from treatment with 0.1, 0.01 and 0.001 ml Fe_2NPsrespectively compared with control and standard treatment. These results were identical with [9-23]. The results of the study proved that treatments with onion nanoparticles gave the highest dry matter in plants in (Table 5). The highest dry matter of the crop and the increase in dry matters of the Nano-treatment had a significant effect ($p \leq 0.05$), especially for the high concentrations.

The highest dry matters 445.6 and 430.8 were obtained from treatment with 0.1 and 0.01 ml Fe_2NPscompared with control and standard treatments. Extensive studies have shown that Nano-fertilizer treatment in plant cultivation has a positive and significant effect on improving germination and increasing the leafy area of the plant, and this in turn is associated with improving the photosynthesis process and increasing its rates, which increases the accumulation of total carbohydrates in the leaves, and in turn accumulates in the fruits, which is the main component of the dry matter, as indicated by [4-23].

Table 3: Effect of onion Nano-fertilizer on yield, TSS, and Dry mater of cucumber plants during 2020/2021

Treatments	Germination%	Yield/Plant (kg)	TSS (%)	Dry matter/ fruits (%)
Control (dw)	100	1.99	2.6	352.5
Urea (N)	100	3.65	2.5	388.7
onion extraction (0.1ml)	100	4.50	2.49	445.6
onion extraction (0.01ml)	100	4.10	2.40	430.8
onion extraction (0.001ml)	100	2.80	2.00	352.5
LSD value	---	0.893 *	0.448 *	51.07 *

Nanoparticles Characterization

All Nano analysis was done in laboratory-University of Kashan/Iran through an agent CAC company in Baghdad city.

Synthesis of Iron Nanoparticles

The precipitated Iron particles were measured using UV and visible absorption. The results of the study showed that the average size of nanoparticles is 8.34 nm prepared from onion extract, and the evidence for the formation of nanoparticles is the color change of the plant extract, from pale yellow to greenish black, as in Figure 1. The results were identical to what he found [1-25].

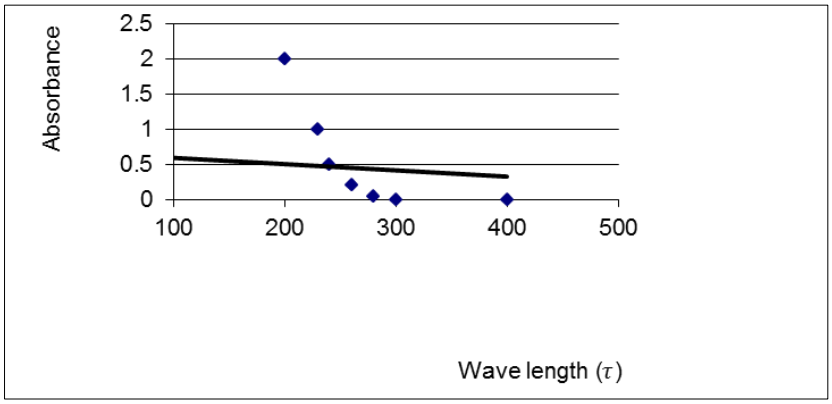

Figure 1: UV-Spectroscopy of Nanoparticles of onion extract

X-Ray Diffraction XRD Analysis

The crystal phases and estimated crystal sizes were determined using an X-ray (XRD- 700 Shimadza maximum - a) X-Ray diffract meter with an electric voltage of 40KV, a current of 30 MA, and a scan range of 100,000-20,000 degrees. Then, using Cu tubes with a copper wavelength of 1.54 Ao, XRD patterns were captured at a scanning speed of 0.12 degrees per second. According to [1-11]. The average size ofFe_2NPs was measured using Debye Scherrer's equation (D = 0.9k/b cos h).

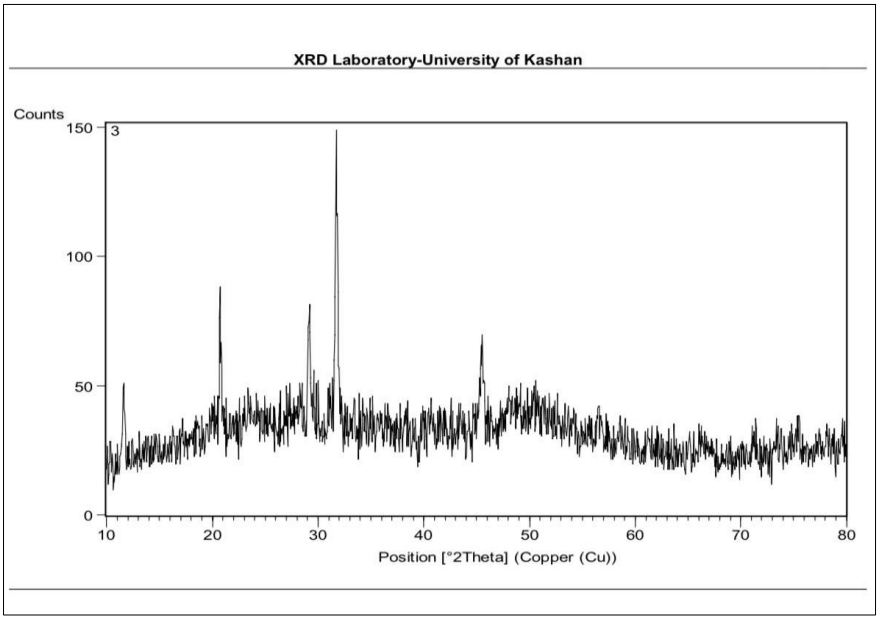

Figure 2: The XRD diffraction of Fe_2NPswith onion extract

FTIR- Spectroscopy

Using FTIR-8400S, SHIMAZW-FTIR spectroscopy with a wavelength range of (500-4000) cm -1, iron Nano forms were analyzed [1-4]. FT-IR is used to identify the particles and functional groups in the synthesized Fe2NPs. Alcohol (OH), Alkane (C-H), Alkene (= C-H), Amine (C-N), and Nitro compounds are represented by the peaks at 3387, 3377.39, 2922, 1645, 15237, 1377, 1246, 1153, 1028, 1028, 9335, 852, 761, 659, 574, 659, 574, 437, 395, 375. (N-O), stretch-Acid (OH) and Ester (C=C) as in figure 3. These results come close to [9].

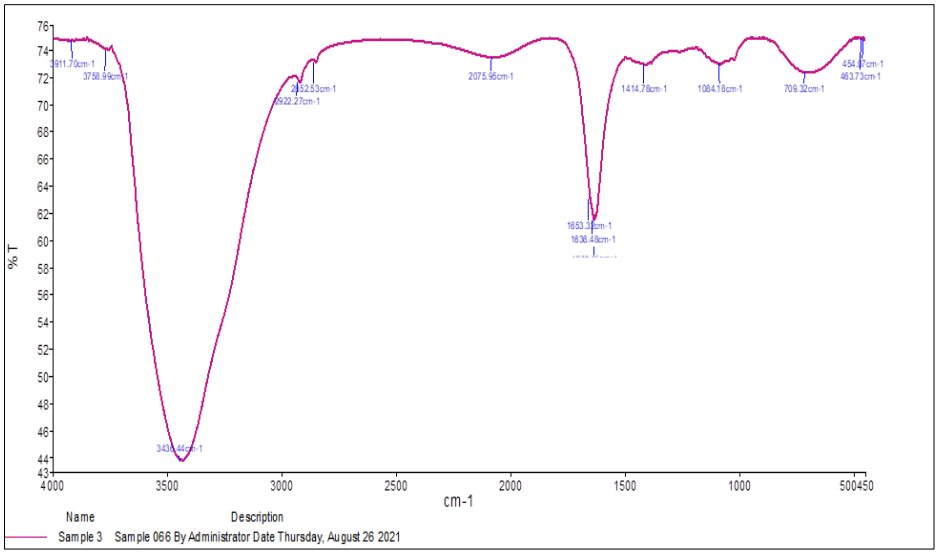

Figure 3: Results of the FT-IR examination of Fe_2NPswith onion extract

Particle Size Distribution Analysis (AFM)

Iron nanoparticles (Fe2NPs, version 5.34) have a size distribution that spans from 6 to 2 nm, and FAM devices are crucial for measuring this range, as well as the dynamic light scattering at 90 degrees, at temperatures ranging from -

110 to 5^0C, while using a laser diode of high power (35 mW). Monodispersed nanoparticles (NPs) with sizes between 35 and 43 nm and their morphology in the absence of critical accumulation are demonstrated as in (Figure 4).

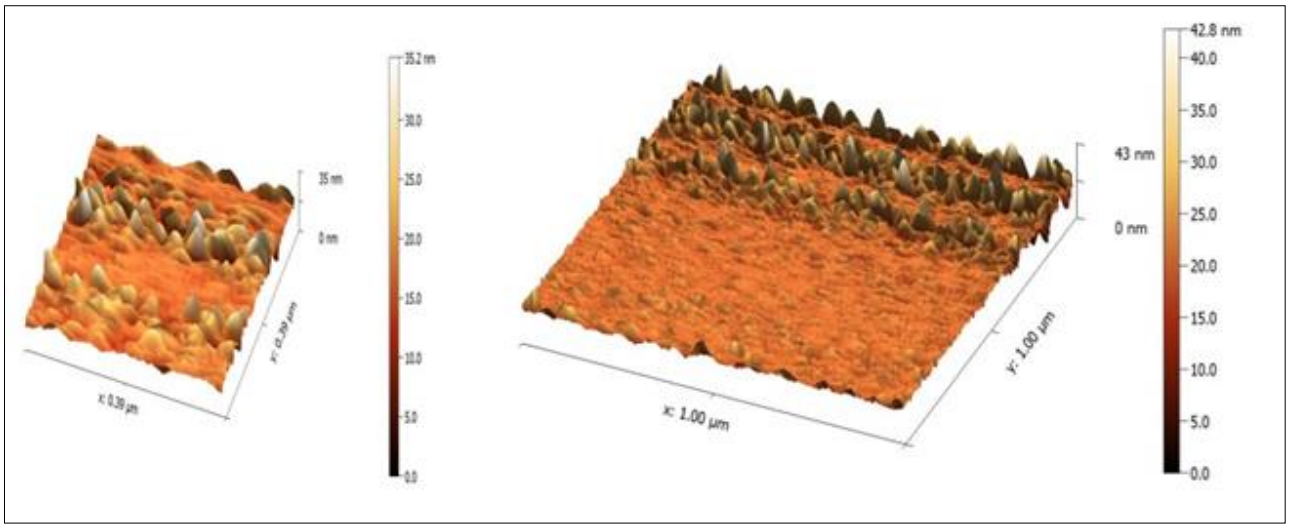

Figure 4: AFM of synthesized Fe_2NPswith onion extract.

TEM: The nanoparticles were studied by electron microscopy after being placed on a carbon-coated copper grid, exposed to air at room temperature, and allowed to dry (TEM). Using Image-Pro plus 4.5 software, we could tell how big the Fe2NPs were just by looking at them. Each value represents the average size of three parallelograms as in (Figure 5) below.

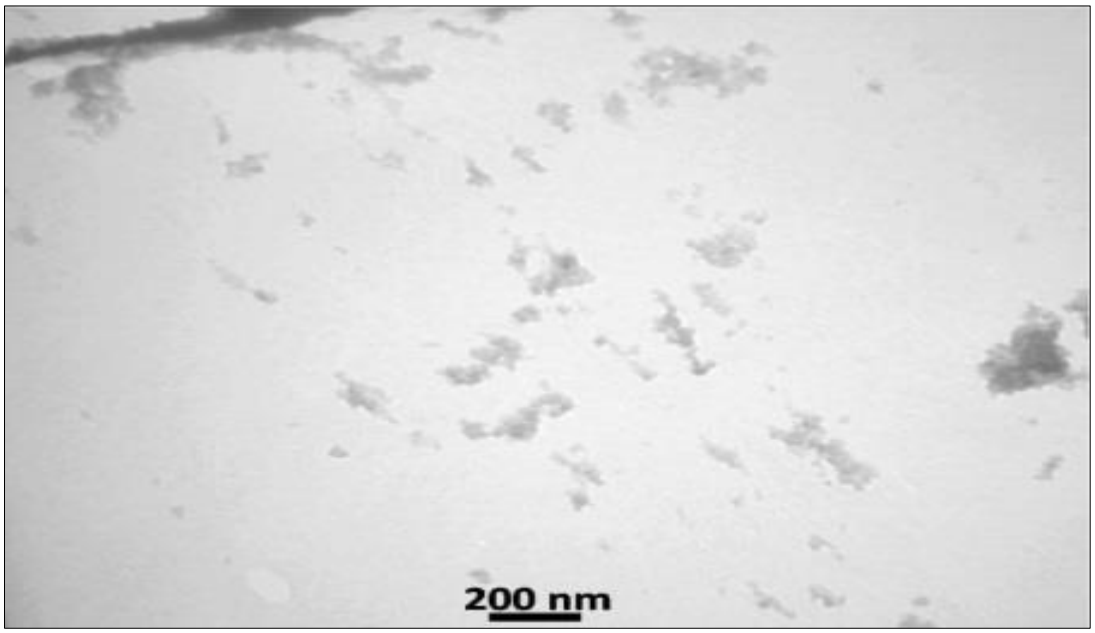

Figure 5: TFM of synthesized Fe_2NPswith onion extract

SEM Scanning Electron Microscope (SEM)

The nanoparticles Fe2NPs are scanned at 3 nm beams and 30 kv electric voltage using a scanning electron microscope of the type (TESCAN-VEGA / USA), which is connected to a computer and configured to analyze the average particle size in the sample [10-26].

It was founded the average size of nanoparticles of onion extra ranges from 35.02-149.5 nm with average about 92.26 nm as shown cleary Figure 6. The results were identical to what was found [9-27].

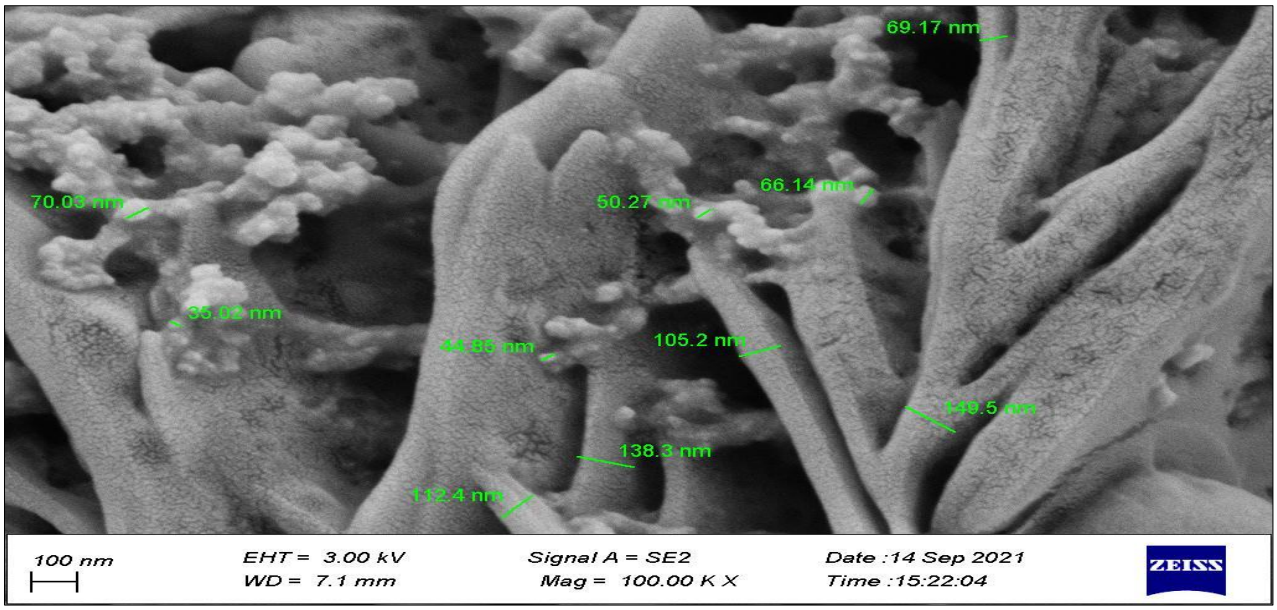

Figure 6: Image of F_2O_4NPs with onion extract using a scanning electron microscope SEM

CONCLUSION

The past decades witnessed many climatic changes that are clear to all, and environmental factors and the accumulation of classically used chemical pesticides and the excessive use of these pesticides are among the most important factors in the problems of modern agriculture. Therefore, the sustainable use of natural resources, including various plants and their extracts treating with different metals and its oxides in Nano synthesis and their use in agriculture is the best solution to preserve human health and the environment. In this study, the inhibition effect of iron nanoparticles synthesizedFe_2NPswith onion extract against beetles and trips in cucumber was evaluated. Our results clearly showed that the iron nanoparticles prevented insects and fungi that cause erosion and rotting of leaves and thus to their stiffness, and this in turn affects the overall cucumber yield. In the current experiment, iron nanoparticles are 0.1 ppm and 0.01 ppm had significant inhibitory effects against beetles and herpes in both field tests, in terms of production quantity, plant length and leaf area, especially the leaves completely free of any diseases, and this in turn gave a high production of cucumber fruits through providing sufficient food and chlorophyll which is necessary for the production of fruits compared to the control and the control treatment. So this study showed that iron nanoparticles can control beetles and herpes under field conditions. Thus, we conclude from this that the use of plant extracts in the biosynthesis of nanoparticles is easier and faster and contributes a promising role in the field of combating various agricultural pests, with an application rate 10-15 times lower than traditional pesticides. This result sheds light on the potential environmental risks of long-term use of Nano pesticides.

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