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Original article

Influence of gold and silver nanoparticles on the germination and growth of *Mimusops laurifolia* seeds in the South-Western regions in Saudi Arabia

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ABSTRACT

In the Saudi Arabia, the tree of *Mimusops laurifolia* is suffering from a severe slow growth, in addition to their weakness of natural regeneration, and lack of artificial regeneration to improve their renewal growing. This tree is suffering from extinction because of the misuse of them. The aim of this study is to investigate the effect of gold (Au) particles and silver (Ag) nanoparticles to speed the germination and growth of *Mimusops laurifolia* trees. This study shows the importance of nanotechnology to contribute the topic of scientific researches and to enrich the scientific libraries of new and affective techniques in the field of physics and botany. We have tried to study the effect of gold and silver nanoparticles on the seeds of *Mimusops laurifolia*. After the treatments by these granules' nanoparticles on germination, the result was completely negative and there was no germination and in all the transactions the germination rate were zero, even after the usage of Sulphuric acid to seeds to soften the test of the seed. This study concludes by following-up the leaf growth of seedlings of *Mimusops laurifolia* after the treatments of gold and silver nanoparticles, it was noted as positive impact of silver nanoparticles, and there was obvious increase in both number and size of the leaves compared with the seedlings, which has transmitted by gold nanoparticles and with the control seedling.
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1. Introduction

The *Sapotaceae* family encompasses about nearly 800 tropical species with majority of the large trees. Many of the trees of this family bear edible fruits. In the Saudi Arabia, only a couple of species were found (*Mimusops lauriflora* and *Sideroxylon buxifolia*); is documented as the small tree which is located at the Southwestern region of Asir (Hegazy and Doust, 2016). The species *Mimusops laurifolia* belongs to the species *Mimusops*, which is majorly distributed in the India; confirms for the usage in the traditional medicine (Eskander et al., 2006). This species belongs to the plant in the family of *Sapotaceae* as initially described by the Linnaeus in 1975. In the Saudi Arabia, *Mimusops laurifolia* is grown in the southern region with the low growth of the trees in additional to the lack of artificial and natural regenerations and the extinction of exploitation (Hall et al., 2009). *Mimusops laurifolia* is also known as the (Forssk)/ Friis is known as the largest trees' species in the Arabian Peninsula; native of Yemen, Saudi Arabia, Ethiopia and Somalia (Bafeel et al., 2012). This is an evergreen tree contains the leathery leaves bunched at the branches of the peaks. The *Mimusops lauriflora* tree is entails with white colored small flowers molded at leaf axils; yellow-colored egg-shaped fruit is disseminated through frugivorous birds and mammals (Hall et al., 2010). This similar type of fruit is tasted by the humans (Addis et al., 2005). The Mimusops leaf is connected with Egyptian tombs as leaf fragments documentation in *Mimusops* from Egyptian tombs has been reinvestigated anatomically and equated with the recent material. The upper epidermal layer of leaves of Mimusops since ancient Egypt are certainly from *Mimusops lauriflora* and the existence of hypodermis is known as a valued character for the documentation of Mimusops leaves from the tombs (Friis et al., 1986). In the Saudi Arabia, the tree of *Mimusops laurifolia* is suffering from a severe slow growth, in addition to their weakness of natural

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regeneration, and lack of artificial regeneration to improve their renewal growing. This tree is suffering from extinction because of the misuse of them. Nanoparticles deals with the nanomaterials that own molecular and atomic dimensions of below the nanometers (Khan et al., 2019). Nanotechnology provides with multiple applications that contributes for solving the modern problems and the major importance of this technology is to contribute in solving the problems of slow growth trees (Shang et al., 2019). In the crop production, plant pests and pathogen origins the constant reduction and the new concept, nanotechnology has directed towards the latest concepts in agricultural products. The applications of nanotechnology in agriculture is discovered presently in plant hormone delivery and seed germination (Worrall et al., 2018). Nanotechnology is confirmed as the present ongoing technology with numerous applications; however, still it requires the advanced techniques to solve the current era problems in the plants. Nanoscience is defined as the study that deals with the characterization of Nano-materials with chemical and physical mechanical properties and associated studies phenomena arising from the decrease in size. Nanotechnology is also defined by the use of new properties that we have learned from nanoscience and applied in different fields of science to acquire new technologies (Teli et al., 2010). Therefore, the aim of this study is to investigate the effect of Au granules and silver Ag nanoparticles on the rapid growth and growth of *Mimusops laurifolia* trees. Another importance of this investigation is to enrich scientific libraries with the latest-effected techniques in the field of plant physics.

2. Materials and methods

The *Mimusops laurifolia* seeds were brought from King Abdul-Aziz City for Science (KACST) and Technology and the lactus seeds were brought from King Khalid University in the Abha premises. The seeds were soaked in the distilled water to remove the shortness from the seeds of fennel and then soak in water distilled for 48hrs and stored in the refrigerator, and then were transferred to petri dishes and follow the growth for two months. Later on, it was boiled in distilled water which place the seeds of fumigation in a glass cup with water preheated to boiling point for three periods of 0.5, 1 and 1.5 min, using 20 seeds per period, and then put the seeds after treatment directly on wet filter leaves in petri dishes (El-Juhany et al., 2009).

2.1. Seedlings

Nine seedlings were divided into three groups for each treatment, three control seedlings, three seedlings treated with gold nanoparticles and three seedlings treated with silver nanoparticles, where the plant is irrigated every 48hrs, control seedlings are irrigated only with water, and the seedlings treated with Nano-gold are irrigated with added water. The Nano WNT so that (every 0.5 L of water is added to its 20 mL of Nano- gold) as well as for seedlings treated with silver nanostructures but is added (20 mL of Nano).

The initial measurements were calculated for lengths and number of papers prior to start the transactions. Both the seeds were documented from each seedling and the measurement of the length and width (old sheets before the treatment), taking the measurement for one-six months and observations were documented. The two seeds of each-seedlings were identified after the treatment and the measurement of both length and width was taken after the treatment for new sheets and measured for every month until continuous six months. The observations were documented for the further use. Using the Planometer, the area of the leaves was measured.

2.2. Preparation of gold and silver Nanoparticles:

For the preparation of silver nanoparticles Silver nitrate ($AgNO_3$) was used by Techno Pharmchem, India, Trisodium citrate ($Na_3C_6H_5O_7$). It has arrived without any treatment and to prepare all the solutions deionized water was used.

2.3. Preparation of silver nanoparticles

The silver nitrate solution was prepared by dissolving it in deionized water, placed on the magnetic steering device and then added Trisodium citrate solution until we obtained a yellow color solution.

2.4. Preparation of nano gold particles

The gold solution was prepared by dissolving chlorohydrin acid in deionized water, placed on the magnetic steering device and then added Trisodium citrate solution until we obtained a red color solution.

2.5. Differences between the three groups control group, the two groups

The two experiments (Mimusops Laurifolia treated with gold and silver nanoparticles) in the area of leaves before treatment and after 6 months of treatment with gold and silver nanoparticles.

Statistical analysis: Independent sample T-test results for differences in the area of old and new leaves after 6 months in the first experimental group (gold nanoparticles).

3. Results

The results of Ficus seeds study of *Mimusops laurifolia* showed no seed germination and no gamete rate was observed in all the treatments when treated with either sulfuric acid, boiled water or soaked in the water (see Fig. 1).

3.1. Analysis and characterization of nanoparticles

The nanoparticles of both silver and gold were characterized through UV spectroscopy in the field of visible and ultraviolet radiation. The device was used in the central laboratory at King Saud University, where it showed peak absorption of 1000 nm for nanoparticles, and at the top 500 nm for nanoparticles (Figs. 2 and 3). Measurement size of nanotubes in Zetasizer in the central laboratory at King Saud University, where the usual size of

Fig. 1. Seeds of *Mimusops laurifolia*.

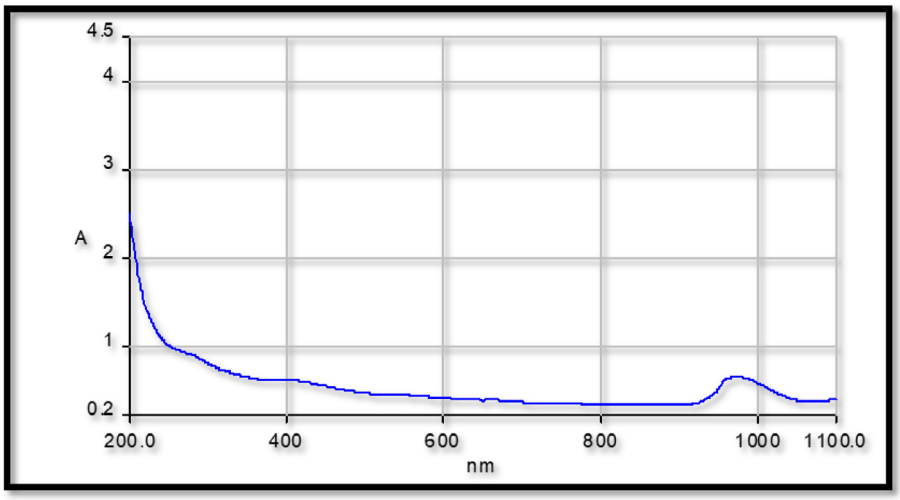

Fig. 2. The UV device (central laboratory – King Saud University) shows the spectral analysis of the absorption of silver nanoparticles at the top 1000 nm.

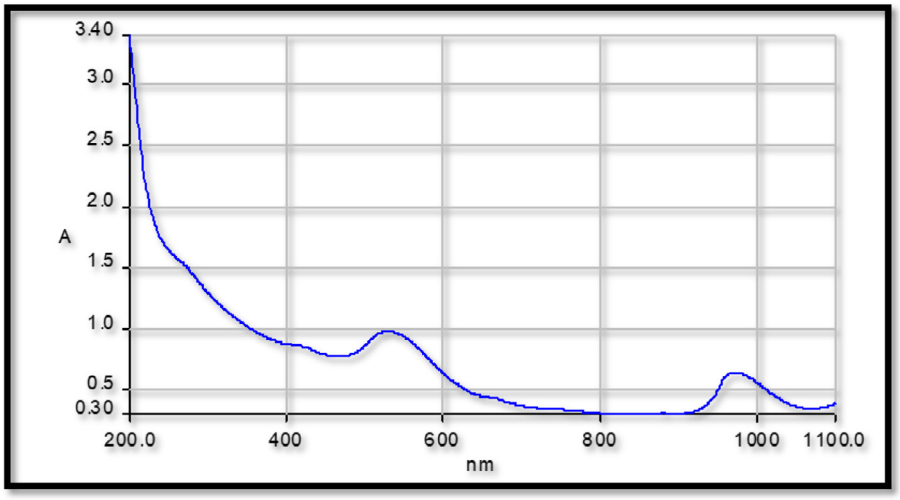

Fig. 3. The UV device (Central Laboratory – King Saud University) shows the spectral analysis of the absorption of gold nanoparticles at the top 1000 nm.

nanoparticles is 22 nm (Fig. 4). The average size of nanoparticles is 8 nm (Fig. 5). The images of gold and silver nanoparticles were taken with TEM electron microscope in the central laboratory of King Saud University, showing different forms and shaped of the Nano-gold and silver particles respectively (Figs. 6–8).

3.2. Study of Ficus seedlings Mimusops laurifolia

The initial measurements of seedlings of *Mimusops laurifolia* before treatment with gold and silver nanoparticles were as follows: The 36cms is minimal seedling length and 12-sheet is the average number. The average length in 1 leaf is 12 cm. the average width is 4.2 cm. for leaf the, appeared seedling length and width is known to be 9.5 and 3.1 cm (Table1). Seedlings treated with gold nanoparticles: the average length of the seedling 22 cm, the average number of leaves 7 leaves, the average length of the paper is 10.2 cm and the average width of 4 cm, for the second paper was an average length of 8.4 cm and the average width of 3 cm (Table 2). The seedlings of Mimusops laurifolia treated with silver nanoparticles: the average length of seedling 32 cm and the average number of leaves 15 sheets, the normal length of the paper is 8.5 cm and the usual width of 3.3 cm, and for the second paper has an average length of 8 cm and the average width of 3.7 cm (Table 3).

3.3. First month of gold and silver Nano treatment

Ficus control seedlings: The average length of seedlings were 36cms and 12 leaves sheets were the minimal number and the average length of leaf is between 1 and 12cms and the average width is 4.2cms, while for the second paper, the average length is 9.5cms and average width is 3.1 cms (Table 1).

4. Measurement after four months of gold and silver Nano treatment

Ficus control seedlings: the average length of seedlings 36 cm and the average number of leaves 13 sheets, average length of sheet 1 is 12.3 cm and then average width is 4.2 cm, while for sheet 2 it is average length 9.5 cm and average width 3.2 cm. the average length for the paper was 2.3 cm and the average width 0.9 cm (Table 1).

Ficus seedlings treated with gold nanoparticles: the average length of seedling 22.6 cm and the average number of leaves are

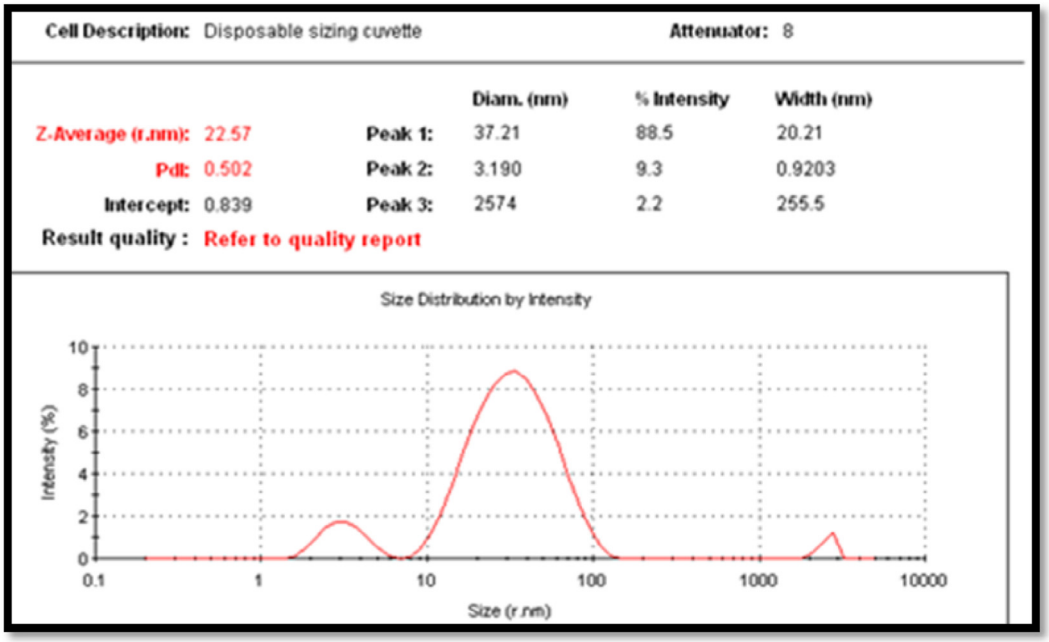

Fig. 4. Zetasizer of silver nanoparticles.

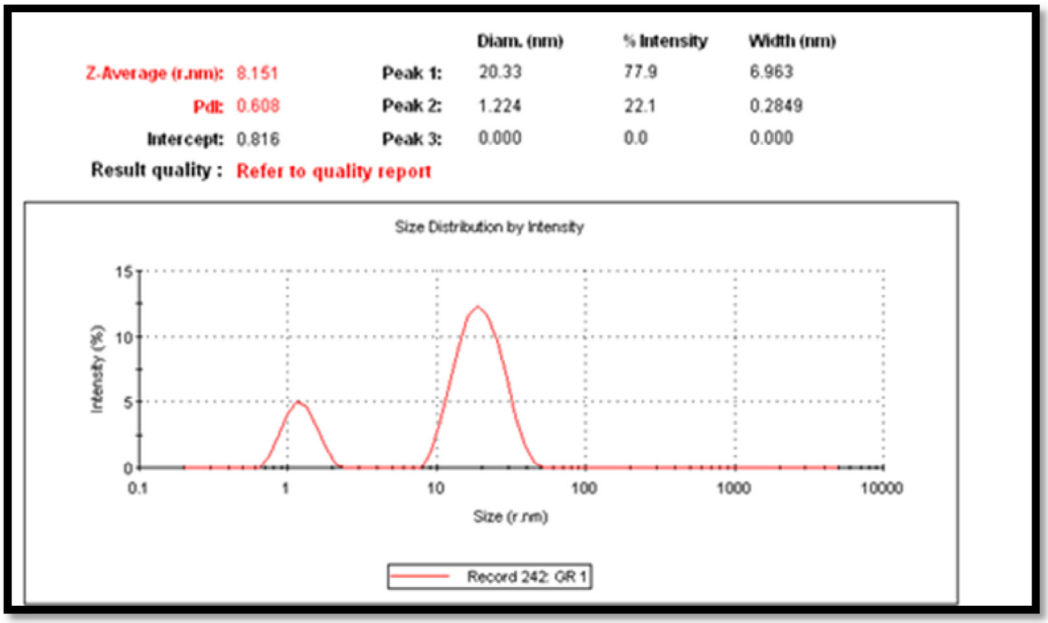

Fig. 5. Zetasizer of gold nanoparticles.

8 sheets, and for sheet b1 the average length is 10.8 cm and the average width is 4.2 cm. the average length of the paper was 9.1 cm and the width were 3 cm a 3.7 cm wide and 1.2 cm wide (Table 2).

4.1. Ficus seedlings treated with silver nanoparticles

The average length of seedlings was 35.5 cm as the average number the leaves are 20 sheets, while for sheet 1 the average length of seedlings is 9 cm and the width is 3.4. Sheet 2 has an average length of 8 cm and a width of 3.8 cm, a sheet of average length 7.7 cm, average width 3.3 cm, b sheet average length 11.5 and average width 4.3. The paper c has an average length of 4.5 cm and an average width of 1.5 cm (Table 3).

4.2. Measurements after five months of gold and silver Nano treatment:

4.2.1. Ficus control seedlings

The average length of seedlings 36 cm, the average number of leaves 15 sheets as for paper1, the average length of paper was 12.3 cm, the average width was 4.2 cm, and the average length of paper 2 is 9.6 cm wide and 3.2 cm cm wide. For paper a, the average length is 7 cm the average width is 2.9 cm, the

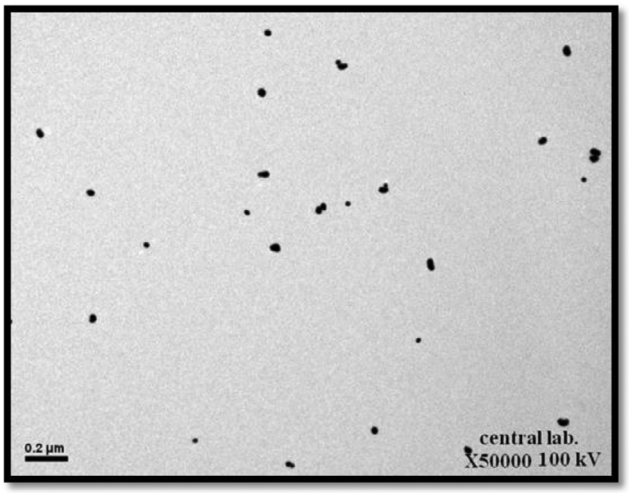

Fig. 6. Transmission Electron Microscopy (TEM) images of synthesized gold nanoparticles.

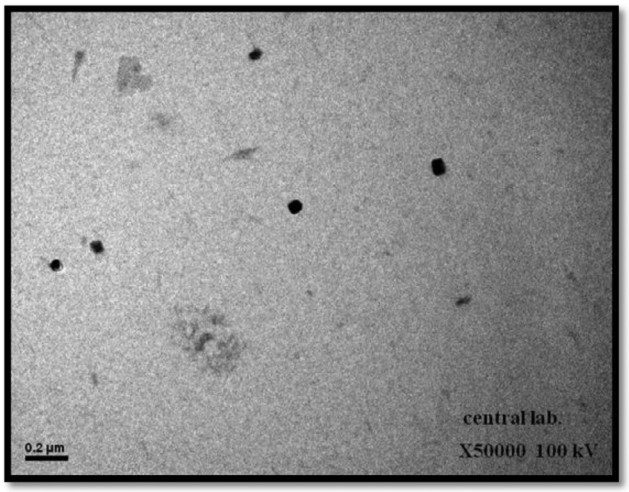

Fig. 7. Transmission Electron Microscopy (TEM) images of synthesized silver nanoparticles.

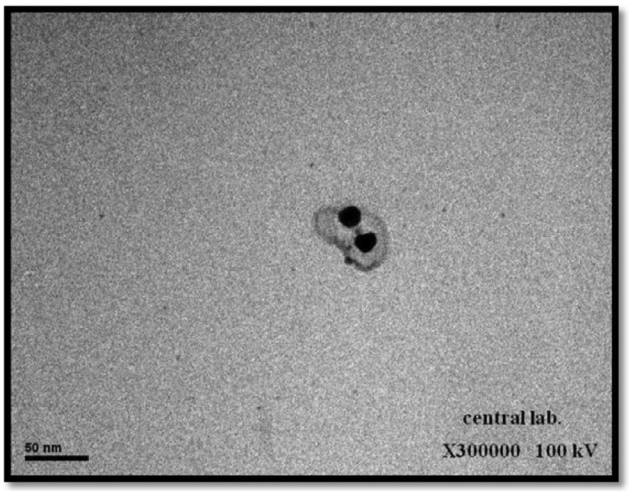

Fig. 8. Transmission Electron Microscopy (TEM) images of synthesized silver nanoparticles.

average length of sheet b is 5 cm and the average width is 2.3 cm (Table 1).

Ficus seedling treated with gold nanoparticles: the average length of seedlings is 22.8 cm, the average number of leaves are 8 sheets, while for paper 1 they are 10.8 cm long and the average width is 4.2 cm. the average length of paper 2 is 9.1 cm, the average width is 3 cm, the average length of paper a is 8.9 and the average width is 3.3 cm (Table 2).

Ficus seedlings treated with silver nanoparticles: average length of seedlings 36.5 cm and average number of leaves 21 and the average length was 9 cm and the width was 3.4 cm. the average length of sheet 2 is 8.2 cm and the average width is 3.8 cm, the average length of sheet a is 8.1 cm. the average width is 3.5 cm, the b sheet has an average length of 11.6 cm and the average width is 4.3 cm. the average paper c was 10 cm and the average width was 3.5 cm (Table 3).

4.3. Measurements after six months of gold and silver Nano treatment:

Ficus seedlings control: the average length of seedlings 36 cm and the number of leaves 15 sheets, as for paper 1, the average length is 12.3 cm and the average width is 4.2 cm. it is 9.6 cm long and 3.2 cm wide, while sheer a is 7.9 cm long. The width is 3.2 cm, and paper b has an average b has an average length of 6.8 cm and an average width of 3 cm (Table 1).

Ficus seedlings treated with gold nanoparticles: the average length of seedlings 22.8 cm and the average number of sheets is 8. The average length was 10.8 cm and the average width was 4.2 cm. for paper 2, the average length was 9.1 cm and the average width was 3 cm. a 9.5 cm wide and 3.5 cm wide (Table 2).

Ficus seedlings treated with silver nanoparticles: the average length of seedlings was 37 cm and the average number of leaves 22.the average length was 9 cm and the average width was 3.4 cm.the average length was 9 cm and the average width was 3.4 cm. the average length is 8.2 cm, the average width is 2 cm and the average width is 3.8 cm. paper a 8.2 cm and the average width 3.6 cm, paper b was an average length of 11.6 cm and average width is 4.3 cm. the average length of paper is 10.5 cm and the average width is 3.7 cm (Table 3).

5. Discussion

The aim of the current study was to inspect the effect of Au granules and silver Ag nanoparticles on the rapid growth and growth of *Mimusops laurifolia* trees in the Saudi Arabia. The current study results after an exposure and treatment of Ficus seedlings, the effect of silver nanoparticles was catalytic to increase growth. The average height of Ficus seedlings during 6 months was 5.16 cm. the treatment of gold nanoparticles was 0.8 cm, while in the control seedlings the average rate was 0.07 cm. the growth of the leaves was followed during this study to examine the effect of Nano-gold and silver treatment on them, and it turned as: gold nanoparticles had no effect on leaf growth in Ficus, but in seedlings. Treatment with silver nanoparticles in Ficus plant was a significant increase in the number and area of leaves. Compared with gold-treated seedlings and control seedlings, this is consistent with a study (Odum, 2007) carried out by studying the effect of silver nanoparticles on the growth of tomato plant, he planted tomatoes in concentrated solution of known silver nanoparticles. The size of used silver particles ranged from 10 to 50 nm and plant growth is observed significantly. Our study is also consistent with the effect of nanoparticles on plant growth speed. Some of its parts with a study (Khodakovskaya et al., 2013) on tomato plant treated with tubes. Carbon nanotubes (CNTs) have doubled the number of flowers and fruits compared to control.

Table 1
The average measurements of Mimusops laurifolia seedling (control) are shown within six months.

Average dimensions of new leaves [cm] Average width	Average dimensions of old leaves [cm] Average length	Average width	Average length	Average number of total leaves	The average length of the seedling [cm]	Duration
		4.2	12	12	36	Initial measurements
		3.1	9.5			
		4.2	12	12	36	First month
		3.1	9.5			
		4.2	12.2	13	36	Second month
		3.2	9.5			
0.5	1.5	4.2	12.3	13		Third month
		3.2	9.5			
0.9	2.3	4.2	12.3	13	36	Fourth month
		3.2	9.5			
2.9	7	4.2	12.3	15	36	Fifth month
2.3	5	3.2	9.6			
3.2	7.9	4.2	12.3	15	36	Sixth month
3	6.8	3.2	9.6			

Table 2
the average measurements of Mimusops laurifolia seedlings (silver nanoparticles) are shown within six months.

Average dimensions of new leaves [cm] Average width	Average dimensions of old leaves [cm] Average length	Average width	Average length	Average number of total leaves	The average length of the seedling [cm]	Duration
		3.3	8.5	15	32	Initial measurements Before treatment
		3.7	8			
		3.3	8.5	19	33	First month
		3.7	8			
		3.3	8.5	19	34	Second month
		3.7	8			
0.7	2.5 (A)	3.4	8.7	19	34.5	Third month
1.5	6 (B)	3.8	8			
0.4	1 (C)					
3.3	7.7 (A)	3.4	9	20	35.5	Fourth month
4.3	11.5 (B)	3.8	8			
1.5	4.5 (C)					
3.5	8.1 (A)	3.4	9	21	36.5	Fifth month
4.3	11.6 (B)	3.8	8.2			
3.5	10 (C)					
3.6	8.2 (A)	3.4	9	22	37	Sixth month
4.3	11.6 (B)	3.8	8.2			
3.7	10.5 (C)					

Table 3
The average measurements of *Mimusops laurifolia* seedlings (gold nanoparticles) are shown within six months.

Average dimensions of new leaves [cm] Average width	Average dimensions of old leaves [cm] Average length	Average width	Average length	Average number of total leaves	The average length of the seedling [cm]	Duration
		4			22	Initial measurements Before treatment
		3	8.4	7		
		4	10.2		22	First month
		3	8.4	7		
		4.2	10.4		22.2	Second month
		3	9	8		
0.8	2 (A)	4.2	10.6		22.4	Third month
		3	9	8		
1.2	3.7 (A)	4.2	10.8		22.6	Fourth month
		3	9.1	8		
3.3	8.9 (A)	4.2	10.8		22.8	Fifth month
		3	9.1	8		
3.5	9.5 (A)	4.2	10.8			
8	22.8	Sixth month				

The results of effect of Nano gold and silver on germination of Ficus seeds of *Mimusops Laurifolia* are coefficients showed encouragement and promote the germination of Ficus seeds of *Mimusops laurifolia* that after two months of seed cultivation. In the petri dishes there was no germination, the germination rate was zero. In this study also did not give granules. Gold and silver nanoparticles have no stimulating result on the germination of seeds in the Ficus plant and this is consistent with the study done by

(Castiglione et al., 2011) exposing the plant species *Zea Mays L.* and *Vicia Larvogenesis L.* for a range of concentrations ranging from 0.2% up to 4% of Nano TiO_2 and this led to delay germination. The results of our study were also somewhat consistent with a study (Al-Sihany, 2013) in which the effect was reported. Silver granules, spherical gold and bacillus nanoparticles on the germination and growth of some crop plants bean plant Phaseolus Vulgaris, Wheat Triticum Vulgare, Wild plants California Plantago Lavandula Pubescents, where the results of this study that the solutions of Nano gold and silver Bacillus and the spheroids led to the significant decrease in the final germination percentage for all the study plants and the percentage varied decrease depending on the type of seeds of the plant under study and the type of Nano solutions. This study was also inconsistent (Srinivasan, 2010) where they sprayed tomato plant seeds with carbon nanotubes resulting in an increase in seed germination. The current study is also inconsistent with the (Yin et al., 2012). Differences may be inconsistent with the results of our study with some previous study, due to the difference of plant species and also the difference of nanoparticles used.

However, when studying the effect of gold and silver nanoparticles on the seeds of juniper and lactation after treatment with these nanoparticles, to determine their effect on germination, the result was completely negative where there was no germination, that is the germination rate zero in all transactions, and even after the use of sulfuric acid on the seeds so as to soften the shortness. *Mimusops laurifolia* seedlings of gold and silver nanoparticles for six months. The result of seedlings where the effect of nanoparticles was very stimulating to increase the growth of these trees. The average growth rate of seedlings in six months was 5.16 cm and the average growth rate of these trees under the influence of granules Gold nanoparticles 0.8 cm, while in the seedlings of control, the average growth rate 0.7 cm. some slight effect of nanoparticles has been observed.

The description of plant Ficus *Mimusops laurifolia* were the huge trees upto 30 m high. The leaves are contiguous toward the end of the branches. The neck is approximately 4 cm long. The blade is oval, 9 cm long and 4.5 cm wide (Collenette and Arabia, 1999). The plant is a large, thick trunked tree, up to 30 m in length, leafy, elliptical leaf blade with a full rim and a sharp round top, 9 cm × 4.5 cm, Fig. 6. The flower is a large, elongated armpit. The length of the neck is 20 mm. the cup is thick and brittle. There are external ways and internal clamps. The external spindles are 7 mm long and the interior is slightly shorter. The crown has a length of 9 mm. the fruit is white, yellowish- brown, 4 cm long and 2.5 cm wide, edible with sweet taste and shiny brown seeds (Chaudhary, 1999) (Fig. 1).

6. Conclusion

In conclusion, the present study result confirms through following-up the leaf growth of seedlings of *Mimusops laurifolia* after the treatments of gold and silver nanoparticles, it was noted as positive impact of silver nanoparticles, and there was obvious increase in both number and size of the leaves compared with the seedlings, which has transmitted by gold nanoparticles and with the control seedling.

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