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Research Article

Protective role of biosynthesized silver nanoparticles synthesized using sesame oil as biocontrol approach against *Erwinia amylovora* causing fire blight in pears (*Pyrus communis* L.)

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Abstract

Erwinia amylovora, the primary cause of fire blight, is thought to be one of the most difficult crop diseases to eradicate. The study aimed to evaluate the performance of essential sesame oil (SO) and silver nanoparticle synthesized by sesame oil SO-AgNPs against *E. amylovora*. Using GC-MS, it was found that essential sesame oil contains the main component of the oil was sesamin, asarninin, heptane, c-Sitosterol, anethol, and trimethyl -6- ((s) - 4-methylcyclohexan – 3 – en-1-yl)) tetrahydro -2H-pyran. The diluted sesame oil (SO) was used as a reducing agent in synthesis of AgNPs in aqueous solution. By using UV-Visible spectrophotometry (UV–Vis), Dynamic Light Scattering (DLS), High Resolution Transmission Electron Microscopy (HRTEM), and Fourier Transformer InfraRed (FTIR) analysis, the produced Ag NPs were studied. The average particle size of the spherical Ag NPs was determined to be 54.98 nm using data from HRTEM and DLS. SO-Ag NPs (20 µg/ml) showed a promising antibacterial against *E. amylovora*, producing a 22.9 mm Zone of Inhibition (ZOI) against *E. amylovora*, followed by SO-Ag NPs (10 ug/ml) that gave 18.2 mm ZOI., compared to gentamicin that produced 13.2 mm ZOI. The most effective inducers were SO-Ag NPs at 10 ug/ml, which decreased the percentage of disease severity by 27.5 and increased the percentage of protection against disease infection by 68.39%. SO-Ag NPs was the most effective inducers which decreased the contents of Malonaldehyde (MDA) and H_2O_2 by 41.3% and 77.1%. Applying SO-Ag NPs or SO lowered the level of malondialdehyde (MDA) and hydrogen peroxide (H_2O_2) and improved the fruit set and yield in

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infected trees. We could assume that, to prevent *E. amylovora* fire blight disease in pears, SO-Ag NPs, SO are safe, effective, and environmentally friendly alternatives to conventional antibiotics.

Keywords: biocontrol agents; *Erwinia amylovora;* nanoparticles; sesame oil

Introduction

Phytopathogens cause an annual 20-40% reduction in crop yield (Srivastava *et al*., 2016). One of the most damaging bacterial diseases of pears (*Pyrus communis* L.) is fire blight, which is caused by necrogenic Gram-negative bacteria *Erwinia amylovora* (Medhioub *et al*., 2022). It poses a significant economic threat to pome output globally (Medhioub *et al*., 2022). Few prevention strategies can truly halt the spread of illness. The most effective treatment for the plants was thought to be removing the infected branches from the orchard due to the absence of effective control strategies (Medhioub *et al*., 2022). Other approaches included the use of chemical control and antibiotics such kasugamycin, oxytetracycline, and streptomycin (Wallis, 2020). Natural products derived from plants have valuable attention nowadays because of their different pharmacological characteristics (Chopra and Dhingra, 2021). Sesame is regarded as a very significant plant because of its many medicinal and commercial uses (Mushtaq *et al*., 2020). It has many pharmacological activities viz., analgesic, anti-inflammatory, hypotensive, antiviral, and wound healing (Mohamed *et al*., 2021). *Sesamum indicum* L. is the main cultivated species of the Sesamum genus which has 37 species (Nyongesa *et al*., 2013). The majority of the world's edible oils come from the top thirteen oil seed crops, of which this oil is ranked ninth (Kumar *et al*., 2011). However, an HPLC examination of sesame oil revealed that its total lignin concentration was 9.32%, which consisted of 2.78% sesamolin and 6.54% sesamin (Reshma *et al*., 2010).

Plant microbial infections have become increasingly resistant to numerous antibiotics as a result of improper treatment application, pathogen cell growth, and virulence (Cai *et al*., 2018; Sagheer *et al*., 2024). Additionally, harmful bacterial cells can produce biofilms that shield them from antimicrobial drugs (Roy *et al*., 2018; Dsouza *et al*., 2024). Thus, it is now essential for experts and those who are interested in scientific study to develop cutting-edge methods that can eradicate plant diseases (Kini *et al*., 2024). The development in nanotechnology has led to remarkable progress in the creation of smart nanomaterials for use in agriculture, namely in the field of therapeutic nutrients (El-Batal *et al*., 2023; Elkhodary *et al*., 2023). According to earlier research, pathogenic microorganisms, whether bacterial or fungal, can be treated using nanoparticles instead of antibiotics (Abbas *et al*., 2024). Nanotechnology have received much attention in the last time were used in different fields such as agricultural, biomedical and pharmaceutical applications (Hashem *et al*., 2022; Saied *et al*., 2022; Saied *et al*., 2022; Lashin *et al*., 2023; Shehabeldine *et al*., 2023). Plant pathogens were effectively combated by silver nanoparticles (Ag NPs) (Wallis, 2020; Rahuman *et al*., 2021). The size and geometry of Ag NPs determine their interactions with microbes in most cases (Salem *et al*., 2020). This investigation aimed to study the positive performance of green biosynthesis silver nanoparticles by essential oil of sesame against *Erwinia amylovora*, it is regarded as one of the hardest crop infections to eradicate.

Materials and Methods

Sesame oil (Sesamum indicum)

The essential oils chemical compounds were purchased from Harraz for Herbs, Oil & Natural Extracts Trading Company, Cairo, Egypt.

Gas chromatography–mass spectrometry (GC-MS) analysis

According to Passari *et al.* (2017) the chemical composition of samples was performed using Trace GC1310-ISQ mass spectrometer (Thermo Scientific, Austin, TX, USA) using the TG-5MS direct capillary column (30 m × 0.25 mm × 0.25 μm film thickness). The components were identified by comparing their mass spectra and retention periods to those of the NIST 11 and WILEY 09 mass spectral databases.

SO-AgNPs biosynthesis

Diluted sesame oil (SO) was used as a reducing agent in the synthesis of silver nanoparticles in aqueous solution (silver nitrate 1 mM) at room temperature and stirring conditions for 24 hrs. according to Ratri *et al.* (2020). This step was performed without the use of additional chemicals as capping and reducing agents. The effects of SO and silver salt substrates on the time processing and morphology of the silver nanoparticles were also explored.

Characterization of SO-AgNPs

Firstly, the optical property of the formed bimetallic SO-AgNPs was tested by UV-Vis. (JASCO V-560, USA) from 250 to 900 nm (Attia *et al*., 2019). It must be mentioned that we must auto-zero the instrument by the sample without silver nitrate before the measurements. For the average particle size diffusion of the produced SO-AgNPs, we conduct dynamic light scattering (DLS-PSS-NICOMP 380, USA).The structure of the pure sesame oil (SO) with silver nanoparticles (SO-AgNPs) was analysed by HR-TEM (HR-TEM, JEM2100, Jeol, Japan) (Chandrakar *et al*., 2022). Investigation by FTIR spectroscopy was achieved (Costa *et al*., 2016) by using the Vertex 70 (Bruker) spectrometer employing the ATR procedure; a diamond crystal was applied for this purpose. All the peaks under analysis were performed in the average IR range, more precisely, between 400 and 3500 cm^{-1} wavelengths.

Source of pathogen

As we previously article (Attia *et al*., 2019), the plant pathogen *Erwinia amylovora* was recognized both biochemically and genetically as *E. amylovora* after it was isolated from blighted branches of the pear.

In vitro antagonistic activity

The disc diffusion method was used to carry out antibacterial activities. Plates with nutrient agar media were made, sanitized, and set. The sterile discs were dipped in two concentrations (10 & 20 μg/ml) of solutions (SO, SO-AgNPs). They were then put on the nutrient agar plate and incubated for 24 hours at 37 °C. Inhibition zones were measured (Sharaf *et al.*, 2022). To find out how the SO and SO-Ag NPs affected the tested *E. amylovora*, a standard antibiotic disc (6.0 mm in diameter) such as Gentamicin (CN; 125.0 μg/ml) was used.

In vivo study

This study was conducted during two consecutive seasons 2021 and 2022 at the Faculty of Science, Al-Azhar University, Cairo farm. 20 trees (2 years old) were inoculated with 5000 bacterial cells of *E. amylovora*. Seven days later, trees were divided into 4 groups and adopted in a completely random design. as follows: T1 - Infected control. T2 - Infected treated with SO-AgNPs at (10 μg/ml); T3- Infected treated with SO at (10 μg/ml); T4- Infected treated with Gentamicin (CN; 125.0 μg/ml), With the beginning of flowering,1 mm steel needle was used to penetrate the pulp, through the drop, to a depth of 6 mm. Disease symptoms were assessed 45 days after injection and severity was evaluated according to Bahadou *et al.* (2018). Percent protection was calculated using the following formula: Protection % = A–B/A × 100%, where, A = PDI in non-inoculated control plants B = PDI in -treated trees.

Morphological indicators

Fruit set percentage and Total yield/ tree (kg/ tree): when fruits reached the maturity stage, the number of mature fruits/tree multiple of average fruit weight (g.) was noted as kg/tree.

Metabolic indicators for pear resistance

The procedure of Hu *et al*. (2004) was used to assay the MDA content in fresh leaves. Fresh leaf samples (0.5 g) were extracted with 5% trichloroacetic acid and centrifuged at 4000× *g* for 10 min. Two milliliters of the extract was mixed with 2 mL of 0.6% thiobarbituric acid (TBA) solution and were then put in a water bath for 10 min. also established for hydrogen peroxide H_2O_2 content (Mukherjee and Choudhuri, 1983). In this method, fresh leaves (0. 5 g) were added to 4 mL of cold acetone then 3 mL of the extract was mixed with 1 mL of 0.1% titanium dioxide in 20% (*v*:*v*) of sulfuric acid and the mixture was then centrifuged at 6000 × *g* rpm for 15 min. The formed yellow color was measured at 415 nm.

Feasibility study

The material cost for one tree sprayed times the number of additions x the total number of trees / fed (169 trees)

Produced fruit kg/tree x number of trees / nourished (169 trees).

Price of one kg pear in the farm x tree yield kg/fed

The price of one kg pear (12 & 15 LE) in the first and second season, respectively.

Statistical analysis

The accumulated results were subjected to a one-way ANOVA. While mean differences were determined using the least significant difference using CoStat (CoHort, Monterey, CA, USA) was used to demonstrate statistically relevant differences between treatments at $p < 0.05$. Results are shown as mean ± standard errors (n = 3).

Results

GC-MS analysis

The data presented in (Table 1) showed that the GC-MS analysis of sesame fixed oil recorded the main component of the oil was sesamin (21.87) $C_{20} H_{18} O_6$ followed by other probability asarninin (19.8 %) $C_{20} H_{18} O_6$; heptane (17.12 %) $C_{15} H_{24} O$; c-Sitosterol(9.9 %) $C_{29}H_{50}O$; anethol (3.61 %) $C_{10}H_{12}O$ and2,2,6-trimethyl -6- ((s)- 4-methylcyclohexan – 3 – en-1-yl)) tetrahydro -2H-pyran – 3- ol (5.84 %) $C_{15}H_{26}O_2$.

On the other hand, many fatty acids and hydrocarbon were recorded after fragmentation oil, 2-decenal $C_{10}H_{18}O$ (0.31%); 2, 4-decadienal $C_{10}H_{16}O$ (0.40 %); (E)-a-famesene $C_{15}H_{24}$ (0.28); 2-furanmethanol, tetrahydro-a-a-, 5-trimethyl-5-(4-methyl-3-cyclohexen-1-yl) (0.51%) $C_{15}H_{26}O_2$; butanoic acid, 3- methyle-2-methoxy-4-(2- propenyl) phenyl estr (0.66%) $C_{15}H_{20}O_3$; (z)-2-(Hexa-2, 4-diyn-1-ylidene)-1, 6-dioxaspiro [4.4] non-3-ene (1.06 %) $C_{13}H_{12}O_2$; (z)-2-(Hexa-2, 4-diyn-1-ylidene)-1, 6-dioxaspiro [4.4] non-3-ene (3.54%) $C_{13}H_{12}O_2$; hexadecanoic acid, methyl estr (0.33%) $C_{17}H_{34}O_2$.

Table 1. GC-MS assessment of sesame oil

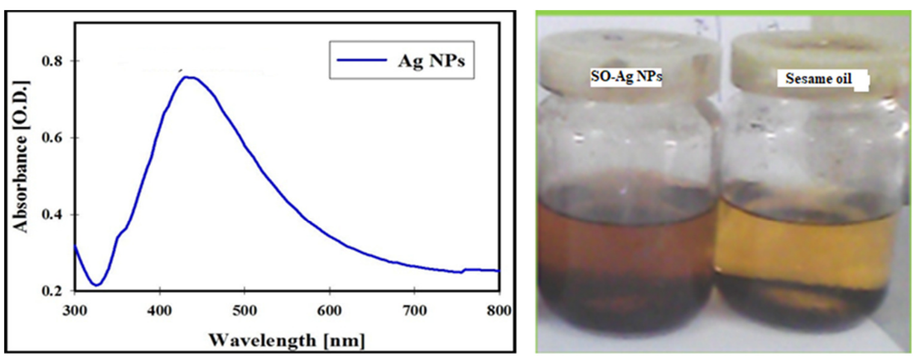
No	Compound name	RT	Area %	Peak area	activity	Reference
1	Sesamin $C_{20}H_{18}O_6$	47.93	21.87%	966347195.62	Antimicrobial and Antioxidant reductive inhibitor cancer. Sesamin is a phytoestrogen, or plant estrogen, is a lignan that can be found in the hulls of sesame seeds.	(Anju., *et al*. 2021)
2	Asarninin $C_{20}H_{18}O_6$	47.98	19.80%	87479846.23	Antioxidant, hypocholesterolemic, nematicide, pesticide, antiandrogenic	(Negi.,*et al*. 2013)
3	Heptane $C_{15}H_{24}O$	48.54	17.12%	756221576.68	Antimicrobial, Anticancer, Diuretic And Anti-inflammatory.	(Jalill 2018)
4	c-Sitosterol $C_{29}H_{50}O$	49.46	9.9%	437414338.62	Antioxidant, anti-inflammatory	(Tiwari., *et al*. 2016)
5	Anethol $C_{10}H_{12}O$	10.47	3.61%	159555781.34	Hepatoprotective, antihistaminic, hypocholesterolemic, antieczemic	(Sarheed and Jaffat 2022)
6	2, 2, 6-Trimethyl - 6- (s) - 4-methylcyclohexan – 3 – en-1-yl)) tetrahydro -2H-pyran – 3- ol $C_{15}H_{26}O_2$	21.18	5.84%	258242155.37	Antioxidant Antimicrobial	(M Fahmy 2020)
7	2-Decenal $C_{10}H_{18}O$	9.86	0.31%	13491977.20	antimicrobial, anti-inflammatory, antioxidant, cancer nematicides	(Khan., *et al*. 2016)
8	2, 4-Decadienal $C_{10}H_{16}O$	11.21	0.40%	17805061.73	Antibacterial, anticancer and antifungal	(Jalill 2018)
9	(E)-a-Famesene $C_{15}H_{24}$	14.62	0.28%	1236866.75	antibacterial and antifungal	(Rocca., *et al*. 1992)
10	2-Furanmethanol, tetrahydro-a-a-, 5-trimethyl-5-(4-methyl-3-cyclohexen-1-yl) $C_{15}H_{26}O_2$	19.21	0.51%	22449387.65	antioxidant	(Mulyono 2010)

11	Butanoic acid, 3-methyle-2-methoxy-4-(2-propenyl) phenyl Estr $C_{15}H_{20}O_3$	23.21	0.66%	29350358.59	Antimicrobial, anticancer and antioxidant	(Mulyono 2010)
12	(z)-2-(Hexa-2, 4-diyn-1-ylidene)-1, 6-dioxaspiro [4.4] non-3-ene $C_{13}H_{12}O_2$	23.89	1.06%	46615485.42	Antimicrobial, anticancer and antioxidant	(Mulyono 2010)
13	(z)-2-(Hexa-2, 4-diyn-1-ylidene)-1, 6-dioxaspiro [4.4] non-3-ene $C_{13}H_{12}O_2$	24.19	3.54%	15645499.67	Anti-insect, antimicrobial, antioxidant, anticancer	(Mulyono 2010)
14	Hexadecanoic acid, methyl estr $C_{17}H_{34}O_2$	24.75	0.33%	14750233.52	antibacterial and antifungal	(Mulyono 2010)

Characterization of AgNPs

UV-Vis spectrum

The UV-Vis spectrum of colloidal solution of silver nanoparticles synthesized from sesame oil have strong absorbance peaks at 430 nm (Figure 1), and the broadening of peaks indicated that the particles are poly-dispersed.



A B

Figure 1. A) UV–Vis. spectroscopy of Ag NPs (synthesized by Sesame oil) and B) the control of SO and SO-Ag NPs

Dynamic Light Scattering (DLS)

Mean particle diameters of essential oils nano emulsion were evaluated by DLS method. The findings of investigates are amassed in (Figure 2). Data indicates the size distribution or population of silver nano-emulsion synthesized by sesame fixed oil using Dynamic Light Scattering Method (Malvern instrument). Dynamic light scattering (also known as photon correlation spectroscopy or quasi-elastic light scattering) is a technique in physics that can be used to determine the size distribution profile of small particles in suspension or polymers in solution.. The average particle size was determined by the DLS method and was found to be 65.85 nm, as shown in (Figure 2).

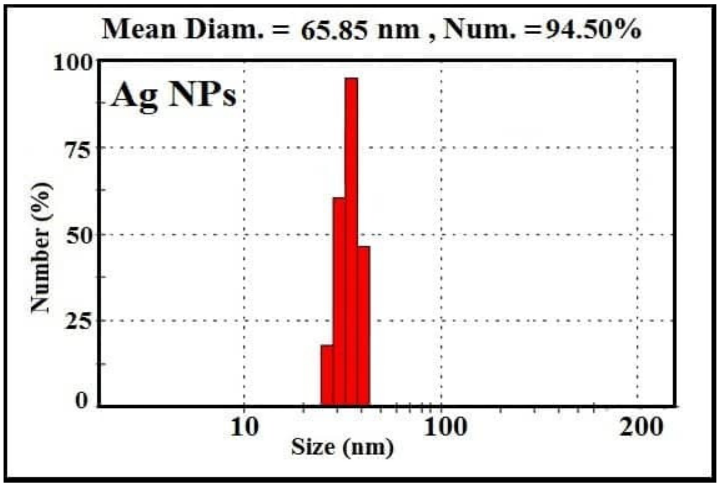


Figure 2. Size dissemination curve of Ag NPs by DLS method

High Resolution Transmission Electron Microscopy (HRTEM)

TEM images show that the formed nanoparticles are almost spherical in shape Figure 3. Some aggregations can be observed in SO-Ag NPs, which is due to greening interactions between Ag and sesame oil. The HRTEM image scaled from 19.19 to 82.58 nm and showed the various shapes of the produced Ag NPs, including pentagonal, oval, and spherical ones with the common average diameter of about 54.98 nm, as illustrated in Figure 3. This allowed for the verification of the common particle size and appearance shape of the Ag NPs.

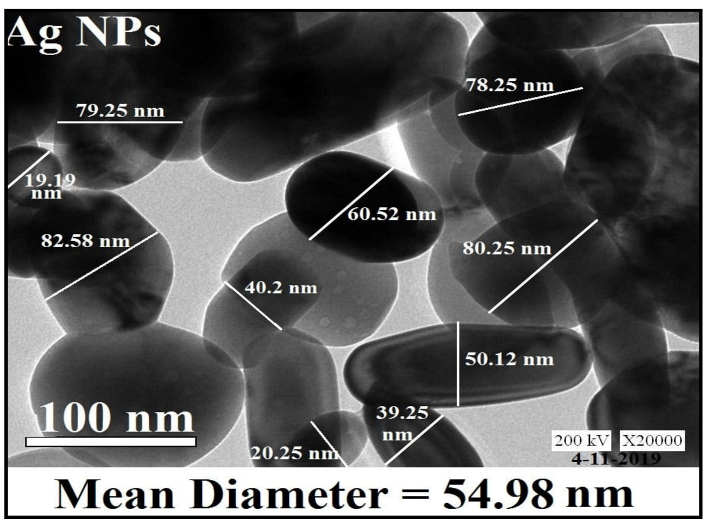


Figure 3. Average particle size distribution and shape by HRTEM of Ag NPs synthesized sesame oil

Fourier Transform Infrared (FTIR) Analysis

The biomolecules in sesame oil that are in charge of reducing and stabilizing silver ions were identified using FTIR (Figure 4). Strong absorption peaks can be seen in the FT-IR spectrum of the green AgNPs from sesame oil at 3735.4112, 3433.031, 2928.717, 1638.359, 1550.34,1455.41,1402, 1046.51, 577.25, 520.28, and 399.19 cm-^{1}. These peaks correspond to different functional groups, such as N-H group (amino acids), the C-O of carboxylic anion, the saturated C-O group, and N-O stretching, respectively (Figure 4). The N-H group, or amino acids, are shown by the absorption peak at 3442 cm-^{1}. FTIR spectroscopy also showed the removal of secondary metabolites following the bio-reduction of silver nanoparticles. This is believed to be the result of Ag ions being reduced by the polyols, which oxidize to unsaturated carbonyl groups with a peak at 1638 cm [1].

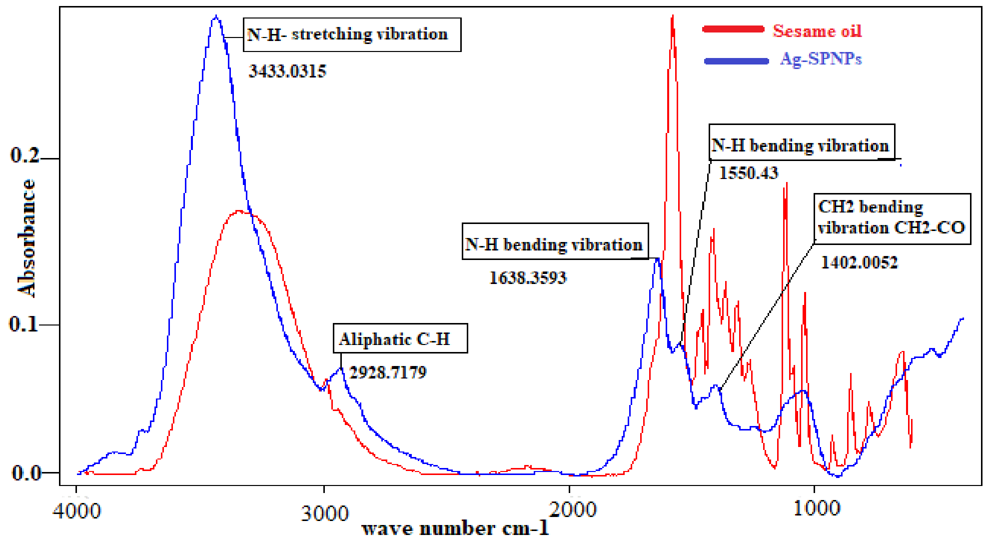
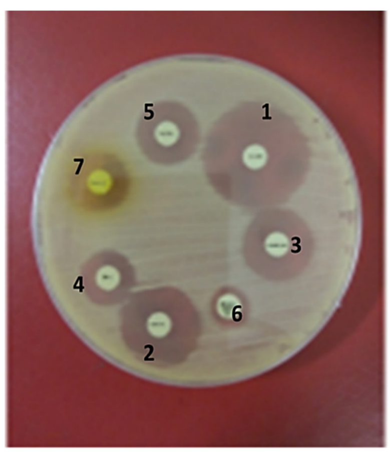


Figure 4. FTIR spectrum of Ag NPs Ag NPs (synthesized by sesame oil), and sesame oil

Inhibition zone of bacterial growth

As shown in (Figure 5 and Table 2), results indicated that, synthesized SO-Ag NPs (20 µg/ml) showed a promising effect as antibacterial factors against bacteria that infected plants, producing a 22.9 mm ZOI against *E. amylovora*, followed by SO-Ag NPs (10 µg/ml) that gave an 18.2 mm ZOI. Similarly, SO observed 12.6 mm at 10 µg/ml and 16.9 mm ZOI at 20 µg/ml. while $AgNO_3$ at (20 and 10 µg/ml) produced (10.0 and 6.6) mm ZOI respectively, compared to gentamicin that produced 13.2 mm ZOI.



1= SO-Ag NPs (20 ug/ml);2= SO-Ag NPs (10 ug/ml);3= So= (20 ug/ml); 4= So= (20 ug/ml);
5= $AgNO_3$ (20 ug/ml); 6= $AgNO_3$ (10 ug/ml); 7= Gentamicin

Figure 5. Effect of various concentrations of sesame oil, SO-Ag NPs $AgNO_3$, and gentamicin on *Erwinia amylofora* sensitivity

Table 2. Effect of various concentrations of sesame oil, SO-Ag NPs $AgNO_3$, and gentamicin on *Erwinia amylofora* sensitivity

	Disinfecting treatments	Concentration	Inhibition zone (mm)
1	SO-Ag NPs	(20 µg/ml)	22.9
2	SO-Ag NPs	(10 µg/ml)	18.2
3	Sesame oil	(20 µg/ml)	16.9
4	Sesame oil	(10 µg/ml)	12.6
5	$AgNO_3$	(20 µg/ml)	16.2
6	$AgNO_3$	(10 µg/ml)	12.1
7	Gentamicin	125.0 µg/ml	13.2

Disease severity (DS) and protection%

The severity of *Erwinia amylovora* infection on pear trees and the effect of tested inducers (Sesame oil, SO-AgNPs $AgNO_3$, and Gentamicin) on disease severity and protection % were recorded in Figure 6. Data showed that application of all tested inducers reduced significantly fire blight percent disease severity (DS) caused by *Erwinia amylovora* compared to diseased control. Nevertheless, data showed that infected plants, the DS increased to 87%. The most effective inducers were SO-Ag NPs at 10 µg/ml and Gentamicin, which decreased the percentage of disease severity by 27.5 and 30% and increased the percentage of protection against disease infection by 68.39 and 65.5% and came next sesame oil reduced, percentage of disease severity by 31.5 and the percentage of protection by 63.7%.

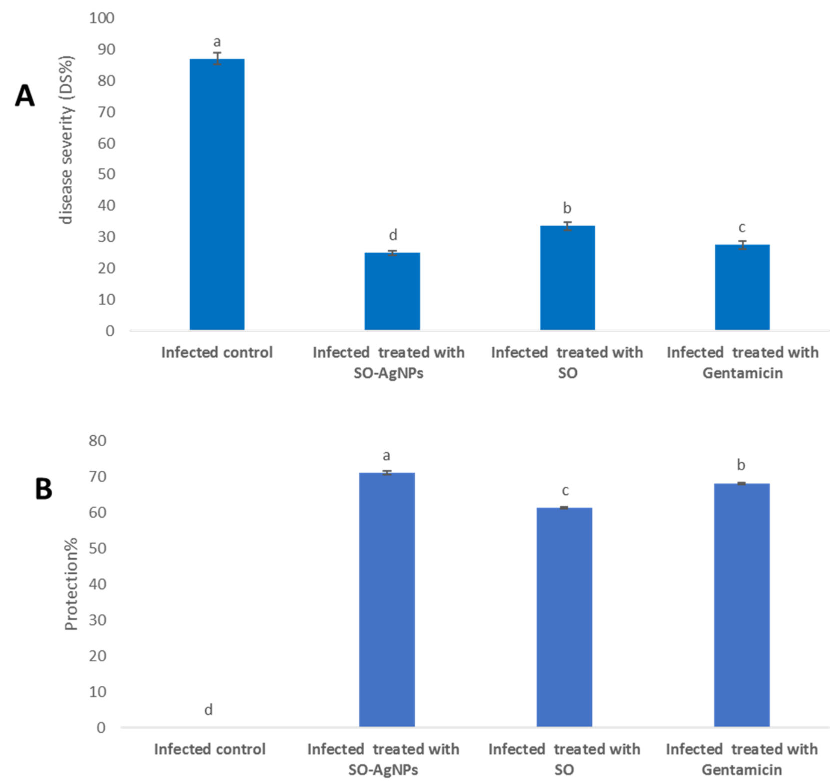


Figure 6: Effect of SO-Ag NPs, sesame oil (SO) and gentamicin on (A) percent disease severity (DS%) and (B) protection% during season 2022

Data represent mean ± SD, n = 3), letters referred to as significant in statically analysis).

Oxidative stress biomarkers

As shown in the results represented in Figure 7 (A, B), *E. amylovora* infection gave highly significant accumulated contents of MDA and H_2O_2. Data showed that the application of all tested inducers significantly reduced the accumulation of MDA and H_2O_2 caused by *Erwinia amylovora* compared to diseased control. The most effective inducers were SO-Ag NPs, which decreased the contents of MDA and H_2O_2 by 41.3% and 77.1% followed by SO which decreased the contents of MDA and H_2O_2 by 33.9% and 60.0% and came next gentamicin reduced, contents of MDA and H_2O_2 by 19.4% and 22.3%, respectively.

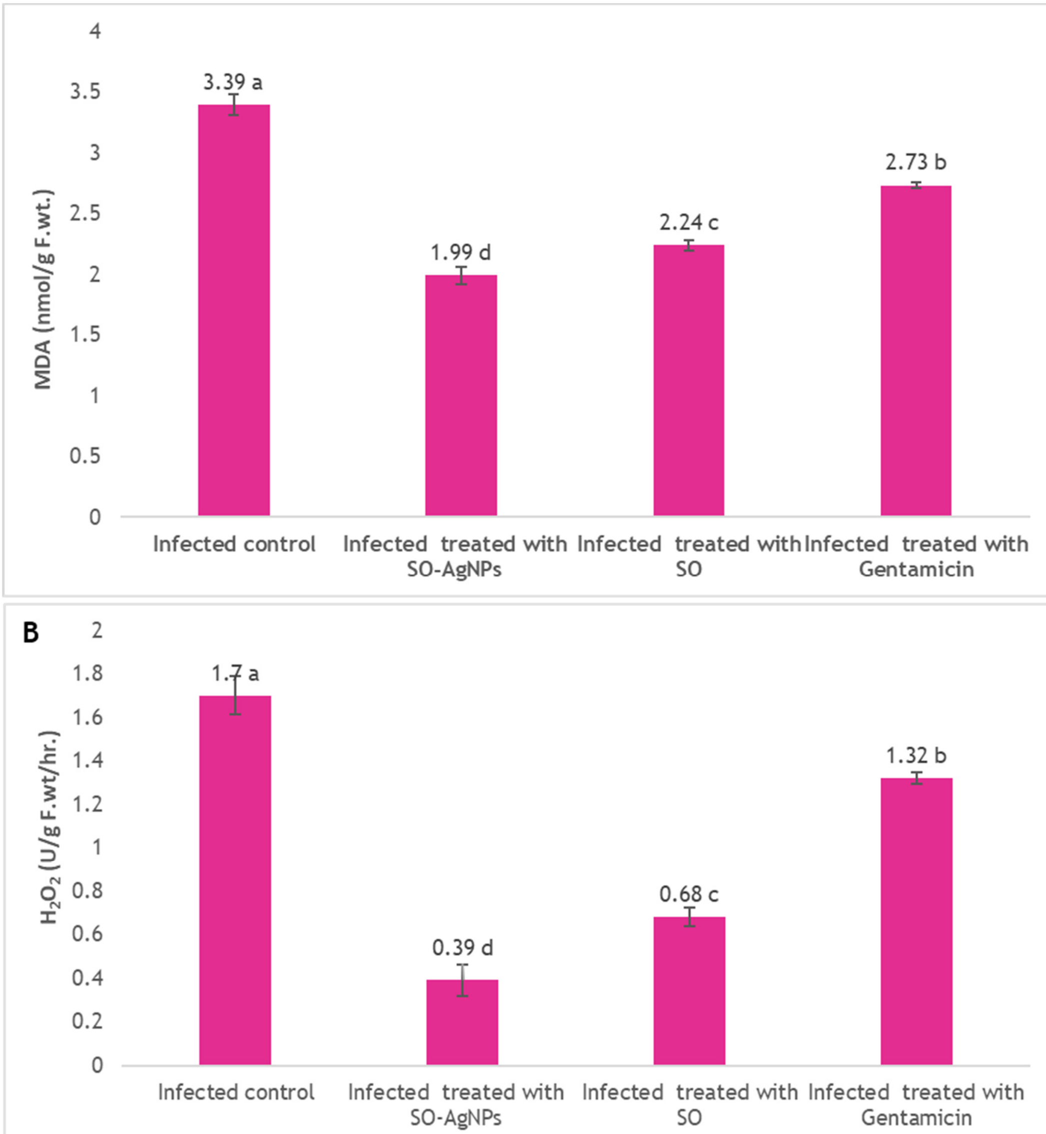


Figure 7. Effect of SO-Ag NPs, sesame oil (SO) and gentamicin on(A)MDA and (B) H_2O_2 during season 2022

Data represent mean ± SD, n = 3), letters referred to as significant in statically analysis).

Fruit set and yield

All treatments led to an increase in the fruit set percentage (Figure 8 and Figure 9) and the amount of yield (gm/tree) Figure 10 (A, B), compared to the infected control trees. The best treatments to increase the set rate and yield (Figure 10 and Figure 11) were foliar spraying of nano-silver, followed by treatment with the antibiotic gentamicin, then treatment with sesame oil, compared to the infected control, which recorded the lowest set rate and amount of tree yield during the two seasons.

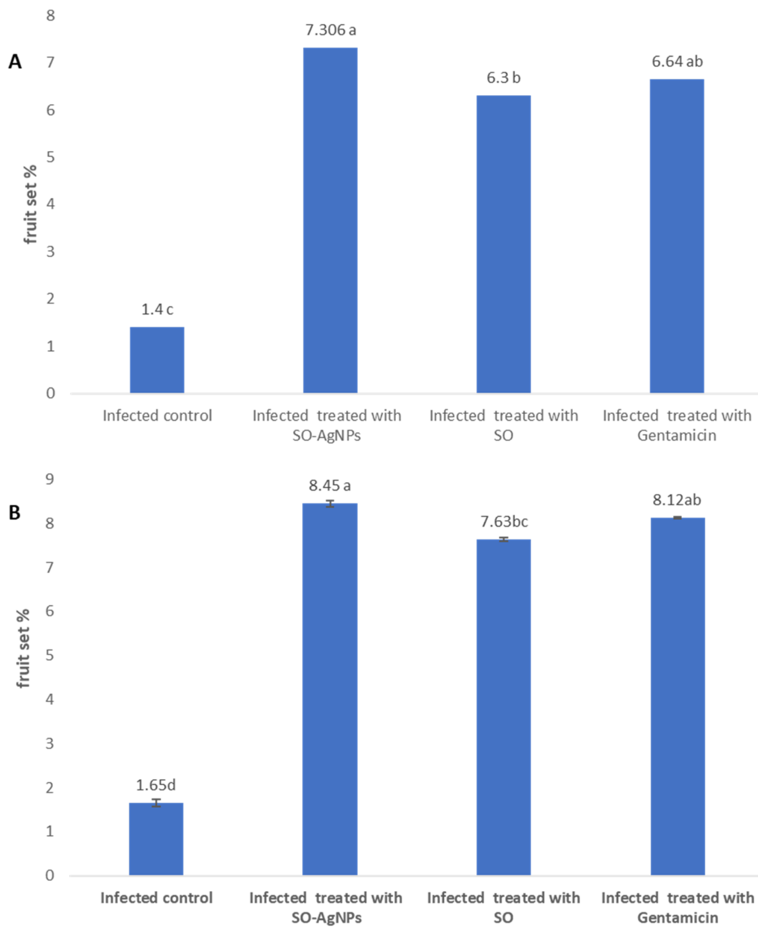
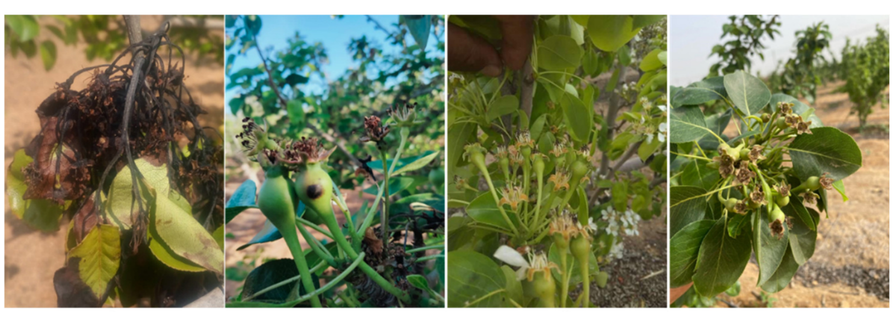


Figure 8. Effect of SO-Ag NPs, sesame oil (SO), and gentamicin on fruit set during (A)season 2021 and (B) season 2022
Data represent mean ± SD, n = 3), letters referred to as significant in statically analysis).



A B C D

A= infected control ; B= infected treated with SO;C=infected treated with SO-Ag NPs ; D=infected treated gentamicin

Figure 9. Effect of SO-Ag NPs, sesame oil (SO), and gentamicin on disease severity and fruit set

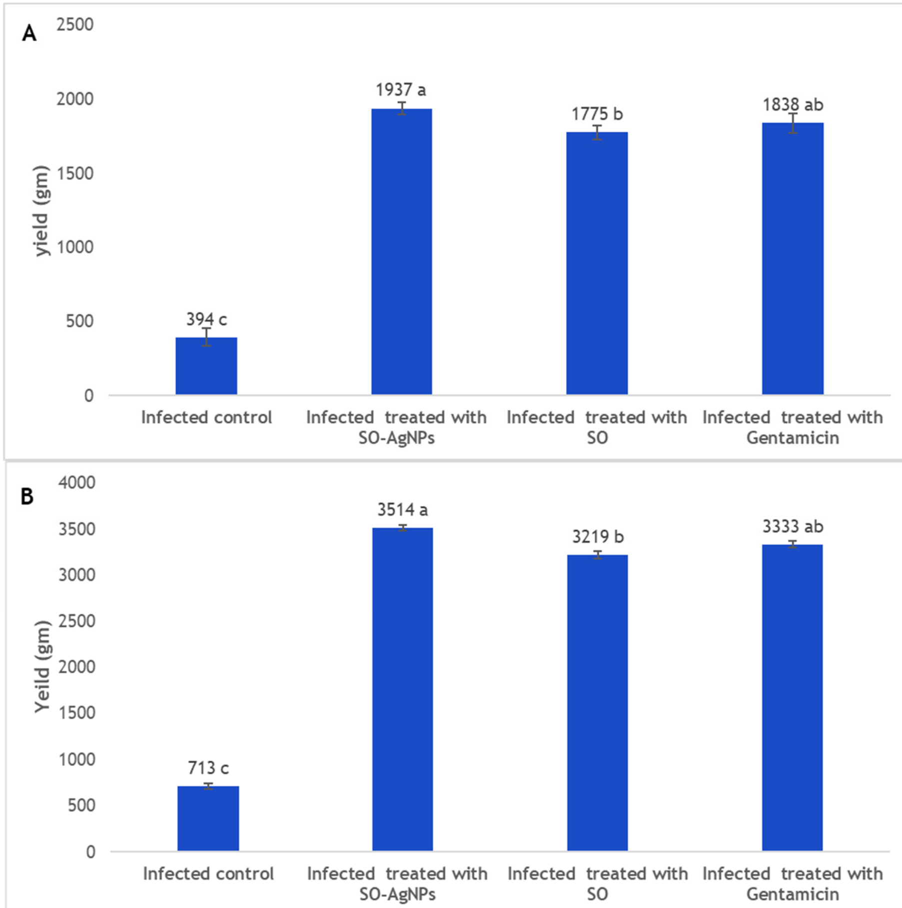


Figure 10. Effect of SO-Ag NPs, Sesame oil (SO), and gentamicin on yield (gm) during (A)season 2021 and (B) season 2022

Data represent mean ± SD, n = 3), letters referred to as significant in statically analysis

A B C D

A= infected control ; B=infected treated with SO;C=infected treated with SO-AgNPs ; D= infected treated with gentamycin

Figure 11. Effect of SO-Ag NPs, sesame oil (SO), and gentamicin on yield (gm)

Feasibility study

In this study, the results in table 3 showed that spraying the SO-Ag NPs gave the highest yield. However, the economic feasibility study showed that the cost of gentamicin (170- 250 LE) compared to the cost of spraying for SO-Ag NPs (34-60 LE) in both season, which was given the highest total income in both season (3894&8848L.E / fed) compared to gentamicin application which given total income in both season (3557&8200L.E / fed) while the control given total income in both season (799 & 1962 L.E / fed).

Table 3. Feasibility study for different treatments applied on of "Le-Conte" pear in 2021 and 2022 seasons

Treatments	Yield/fed (kg)		Cost/fed (LE)		Total income (LE)		Net profit (LE)	
	2021	2022	2021	2022	2021	2022	2021	2022
Control	67	131	water	water	799	1962	799	1962
SO-Ag NPs	327	594	34	60	3928	8908	3894	8848
Sesame oil	300	544	54	80	3600	8160	3546	8080
Gentamicin	311	563	170	250	3727	8450	3557	8200

Discussion

The risks of plant diseases increase with severe climate changes. Fire blight is an epidemic bacterial disease that destroys several economic crops caused by *E. amylofora* (Elad and Pertot, 2014). Thinking about finding effective and safe approaches to alternatives to antibiotics has become necessary. In our current study, the choice of sesame oil and the biosynthesis of nano silver was based on sesame oil containing antioxidants, such as sesamol and sesaminol (Prajapati *et al*., 2022). The present study by using GC-MS, it was found that essential sesameoil contains the main component of the oil was (+) Sesamin, Asarninin, Heptane, c-Sitosterol, Anethol and Trimethyl -6- ((s) - 4-methylcyclohexan – 3 – en-1-yl)) tetrahydro -2H-pyran. Our results agreed with the findings of a previous study by (Warra *et al*., 2016). UV-vis, absorption spectroscopy, employs the visible and ultraviolet portions of the electromagnetic spectrum to analyze samples both qualitatively and quantitatively (Abdelhalim *et al*., 2012). The optical characteristics of nanoparticles are highly responsive to changes in concentration, agglomeration, size, and shape (Sani *et al*., 2013). An increase in absorption rate suggested that there were more nanoparticles, which raised the turbidity of the nanoemulsion. sodium dodecyl sulfate (SDS) addition raised the nano emulsion's transparency and lowered its absorption rate (P>0.05). The fact that SDS reduced the nano emulsion's particle size and that the absorption rate is closely correlated with particle size helps to explain it. There was no discernible variation in the absorption rates of the three types of essential oils when compared (Turek and Stintzing, 2013). The visual appearance seen in the current investigation is consistent with all of the previously mentioned results (Straßmann and Krämer, 2017). Increasing the essential oil concentration increased the quality of the final product by increasing the mean droplet diameters (P>0.05) due to larger droplet collisions and subsequent coalescence during emulsification (Artiga-Artigas *et al*., 2019).

A large peak was seen in the sesame waste's FTIR spectra at 3,298 cm^{-1}, which was identified as the O–H stretching vibrations of cellulose, pectin, hemicellulose, and lignin (Cheraghi *et al*., 2016).

The obtained results unambiguously indicate that the recently produced silver nanoparticles exhibit promise as an antibacterial agent against the pathogens utilized. Our findings corroborate those of (Sarkar *et al*., 2007), who found that AgNPs exhibited higher antibacterial activity than penicillin. Specifically, our results suggest that silver nanoparticles (AgNPs) were more inhibitory against *E. amylofora* than the antibiotic gentamicin. Additional evidence demonstrated that AgNPs adhered to the bacterial cell wall and denatured the proteins, causing the bacterium to die. AgNPs also break the bacterial plasma membrane, which results in the loss of cellular energy (Elakraa *et al*., 2022). Another theory put out by Attia *et al*. (2019) states that AgNPs inhibit cellular respiration through an interaction between their Ag groups and the SH group found in the cell wall of the bacteria. As shown in the current results, sesame oil exhibits considerable antibacterial action and a high zone of inhibition against *E. amylofora*. Sesame oil has antibacterial properties against Lactobacilli acidophilus, Streptococcus mutants, and all bacteria according to Prajapati *et al*. (2022).

This work aimed to induce systemic resistance in pears against infection by *E. amylovora*. Treatment with all studied inducers reduced the percentage of disease index, which was the first standard to govern the appearance of systemic resistance in pear plants. When compared to the infected control, SO, SO-AgNPs, and gentamicin was successful in lessening the severity of the disease. The most effective inducers were SO-AgNPs at 10 ug/ml and gentamicin, which decreased the percentage of disease severity by 27.5 and 30% and increased the percentage of protection against disease infection by 68.39 and 65.5% and came next sesame oil reduced, percentage of disease severity by 31.5 and the percentage of protection by 63.7%. These findings support the hypothesis that NPs (SO-AgNPs and SO) could alter microbial morphology and biofilm formation, limit microbial membrane permeability, and offer a home for oxidative stress genes in response to H_2O_2 production (Narayanasamy and Narayanasamy, 2013; Das *et al*., 2020, Sangave *et al*., 2020; Lesnichaya *et al*., 2022). The treatments led to an increase in yield as a result of an increase in the percentage of fruit set and a reduction in flower burning resulting from fire blight infection related to challenged trees. The results also showed the effect of treatments in reducing the infection rate and reducing damage resulting from oxidative stress as a result of fire blight which led to an increase in the contract rate and the quantity of the yield. according to earlier research (Haynes *et al*., 2020; El-Batal *et al*., 2023). Oxidative stressors brought on by bacterial infection manifest in cells as an increase in H_2O_2 and MDA (Vielma *et al*., 2014, Abdelaziz *et al*., 2023). Oxidative stress caused to a major biotic disturbance in plant cells and raised MDA and H_2O_2 levels in plant leaves (Ye *et al*., 2006; Abd Alhakim *et al*., 2022; Fouda *et al*., 2024). Our findings suggested that treatments with sesame oil, SO-Ag NPs, and gentamicin reduced the amounts of MDA and H_2O_2 in plants infected with *E. amylovora*. Reducing MDA and H_2O_2 levels is a significant indicator that infected plants are recovering from oxidative stress, according to earlier research (Ciriolo *et al*., 1997; Munne-Bosch and Penuelas, 2003).

Conclusions

The present work effectively essential sesame oil (SO) and silver nanoparticle synthesized by sesame oil (SO-AgNPs). The findings of the nano-characterization verified that SO-AgNPs was spherically shaped and in nanoform. Furthermore, the in-vitro antibacterial efficacy of SO-AgNPs against *E. amylovora* was shown to be promising. The current study's findings verify that applying SO-AgNPs to infected plants was successful in lessening the severity of the infection. Furthermore, using SO-AgNPs or SO produced excellent results in boosting fruit set and production as well as lowering stress markers (MDA and H_2O_2), which are crucial in minimizing the harm brought on by an *E. amylovora* infection. This demonstrates that there is interest in these approaches as safe, less coast and efficient alternatives to eradicate fire blight disease.

Authors' Contributions

Conceptualization; M.S.A, S.S.S, E.K.K, MAA, A.A.A and M.A.A, Methodology; M.S.A, S.S.S, E.K.K,A.A.A and M.A.A, Data Analysis; M.S.A, S.S.S, E.K.K,N.M.A, MAA, ME,A.A.A and M.A.A, Figures and tables preparation; M.S.A, S.S.S, E.K.K,A.A.A,N.M.A and M.A.A; Writing original draft preparation; M.S.A, S.S.S, E.K.K,A.A.A, MA, AM and M.A.A, Writing review and editing M.S.A, S.S.S, E.K.K,N.M.A, MA, AM,A.A.A and M.A.A, Resources; M.S.A, S.S.S, E.K.K,A.A.A and M.A.A. All authors have read and agreed to the published version of the manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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