

BIOSYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES USING *OCIMUM TENUIFLORUM* (TULSI) LEAF EXTRACT AND THEIR ANTIFUNGAL ACTIVITY AGAINST CROP PATHOGENS

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ABSTRACT

Nanotechnology has emerged as a promising field for developing sustainable solutions in agriculture and medicine. Among nanomaterials, silver nanoparticles (AgNPs) have gained considerable attention due to their antimicrobial and antifungal properties. In this study, silver nanoparticles were biosynthesized using *Ocimum tenuiflorum* (Tulsi) leaf extract through an eco-friendly green synthesis approach. The plant extract acts as a natural reducing and stabilizing agent, converting silver ions (Ag^+) from silver nitrate ($AgNO_3$) into stable AgNPs. The synthesis was confirmed by a visible color change from pale yellow to reddish-brown due to surface plasmon resonance. The nanoparticles were characterized using techniques such as UV-Visible spectroscopy, X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and transmission electron microscopy (TEM). The antifungal activity of the synthesized AgNPs was evaluated against selected crop pathogens including *Fusarium oxysporum*, *Alternaria solani*, and *Rhizoctonia solani*. The results revealed that Tulsi-mediated AgNPs significantly inhibited fungal growth, demonstrating their potential as an eco-friendly alternative to chemical fungicides in agriculture.

KEYWORDS: Green Synthesis; Silver Nanoparticles; *Ocimum Tenuiflorum*; Tulsi; Antifungal Activity; Crop Pathogens; Nanotechnology; Plant-Mediated Synthesis etc.

Article History

Received: 14 Jun 2025 | Revised: 18 Jun 2025 | Accepted: 25 Jun 2025

INTRODUCTION

Nanotechnology involves the manipulation of materials at the nanoscale level (1–100 nm) where materials exhibit unique physical, chemical, and biological properties. Silver nanoparticles (AgNPs) are among the most widely studied nanomaterials due to their antimicrobial, catalytic, and biomedical applications.

Traditional chemical and physical methods for nanoparticle synthesis often involve toxic chemicals and high energy consumption. Consequently, green synthesis approaches using plant extracts, microorganisms, or natural polymers have gained significant attention as environmentally friendly alternatives.

Ocimum tenuiflorum (Tulsi), a medicinal plant widely used in traditional Indian medicine, contains various phytochemicals such as flavonoids, terpenoids, phenolic compounds, and alkaloids. These biomolecules can act as reducing agents to convert silver ions into nanoparticles and also stabilize them by acting as capping agents.

Plant-mediated synthesis of AgNPs is advantageous because it is simple, cost-effective, and environmentally sustainable. In agriculture, plant pathogens cause significant crop losses worldwide. Fungal pathogens such as *Alternaria*, *Fusarium*, and *Rhizoctonia* are major causes of plant diseases. Biosynthesized silver nanoparticles have shown strong antifungal properties and can be used as potential nano-fungicides to protect crops.

The present research focuses on the green synthesis of silver nanoparticles using *Ocimum tenuiflorum* leaf extract and evaluating their antifungal activity against crop pathogens.

OBJECTIVES OF THE STUDY

- To synthesize silver nanoparticles using *Ocimum tenuiflorum* leaf extract.
- To characterize the synthesized nanoparticles using spectroscopic and microscopic techniques.
- To evaluate the antifungal activity of AgNPs against selected crop pathogens.
- To assess the potential agricultural applications of biosynthesized nanoparticles.

MATERIALS AND METHODS

Materials

- Fresh *Ocimum tenuiflorum* leaves
- Silver nitrate (AgNO_3)
- Distilled water
- Culture media for fungal pathogens

Selected Crop Pathogens

- *Fusarium oxysporum*
- *Alternaria solani*
- *Rhizoctonia solani*

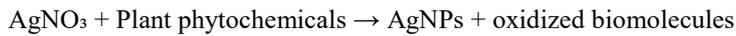
Preparation of Tulsi Leaf Extract

- Fresh leaves were washed thoroughly with distilled water.
- Leaves were chopped and boiled in distilled water for 10–15 minutes.
- The extract was filtered using Whatman filter paper.
- The filtrate was stored at 4 °C for further use.

Biosynthesis of Silver Nanoparticles

The Tulsi leaf extract was mixed with 1 mM silver nitrate solution.

Reaction



Within minutes to hours, the solution color changed from pale yellow to dark brown, indicating nanoparticle formation due to surface plasmon resonance.

MECHANISM OF BIOSYNTHESIS

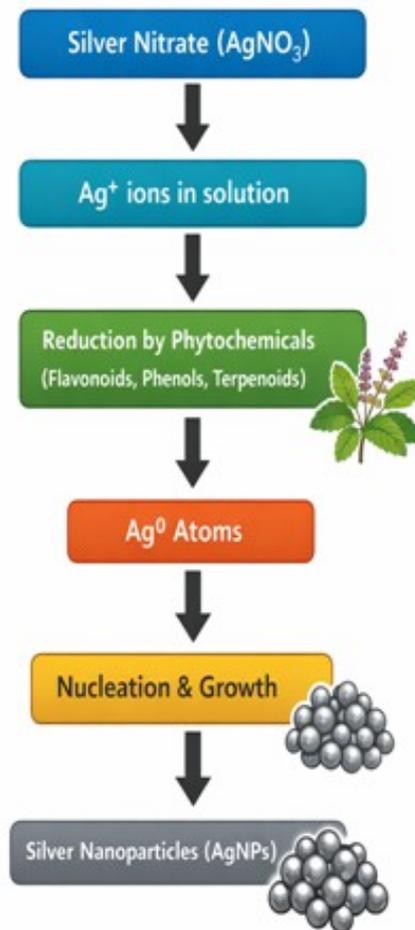


Figure 1: Green Synthesis Mechanism of AgNPs

Plant phytochemicals act as both reducing agents and stabilizing agents, enabling nanoparticle formation without additional chemicals.

CHARACTERIZATION OF SILVER NANOPARTICLES

Various analytical techniques are used to confirm nanoparticle formation and properties.

UV-Visible Spectroscopy

AgNPs exhibit a characteristic surface plasmon resonance peak around 400–450 nm, confirming nanoparticle formation.

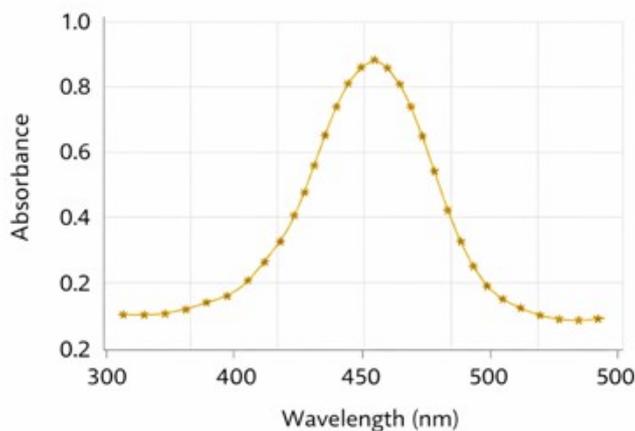


Figure 2: Example UV-Vis Spectrum

X-Ray Diffraction (XRD)

XRD analysis confirms the crystalline nature of silver nanoparticles.

Typical diffraction peaks occur at:

- 38° (111)
- 44° (200)
- 64° (220)

These peaks correspond to the face-centered cubic structure of silver.

Transmission Electron Microscopy (TEM)

TEM images reveal:

- Particle size: **10–50 nm**
- Shape: mostly **spherical**

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR identifies functional groups from plant biomolecules responsible for reduction and stabilization.

Typical peaks indicate:

- OH groups (phenolics)
- C=O groups
- Amide groups from proteins.

ANTIFUNGAL ACTIVITY AGAINST CROP PATHOGENS

Method

The antifungal activity was tested using the agar well diffusion method.

Table 1: Zone of Inhibition

Pathogen	Control (mm)	AgNPs (50 ppm)	AgNPs (100 ppm)
<i>Fusarium oxysporum</i>	0	12	18
<i>Alternaria solani</i>	0	14	20
<i>Rhizoctonia solani</i>	0	10	16

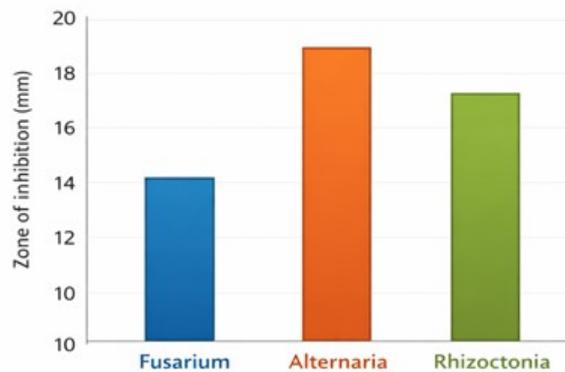


Figure 3: Antifungal Activity Chart

Silver nanoparticles disrupt fungal cell membranes and interfere with metabolic pathways, leading to fungal cell death.

DISCUSSION

The green synthesis of silver nanoparticles using *Ocimum tenuiflorum* leaf extract demonstrates an eco-friendly alternative to chemical synthesis. The phytochemicals present in Tulsi leaves serve dual roles as reducing and stabilizing agents, enabling efficient nanoparticle formation.

The characterization techniques confirmed the successful synthesis of stable and crystalline nanoparticles. UV-Vis spectroscopy revealed surface plasmon resonance peaks, while TEM images indicated spherical nanoparticles with sizes typically below 100 nm.

The antifungal assays revealed strong inhibitory effects of AgNPs against major crop pathogens. Similar studies have shown that Tulsi-mediated AgNPs can effectively control fungal diseases such as purple blotch in onion caused by *Alternaria porri*.

The mechanism of antifungal activity includes:

- Disruption of fungal cell membranes
- Generation of reactive oxygen species (ROS)
- Interaction with fungal DNA and proteins
- Inhibition of spore germination

These mechanisms make silver nanoparticles highly effective antimicrobial agents.

RESULTS

- Successful biosynthesis of silver nanoparticles using Tulsi leaf extract.
- Visible color change confirmed nanoparticle formation.
- Characterization techniques confirmed nanoscale size and crystalline structure.
- Synthesized nanoparticles showed strong antifungal activity against crop pathogens.

FINDINGS

- Green synthesis using plant extracts is environmentally friendly and cost-effective.
- Tulsi leaf extract efficiently reduces silver ions into nanoparticles.
- Biosynthesized AgNPs show strong antifungal properties.
- The nanoparticles can potentially replace chemical fungicides in agriculture.

ADVANTAGES OF GREEN SYNTHESIZED AGNPS

- Eco-friendly synthesis
- Low toxicity
- Cost-effective production
- High antimicrobial efficiency
- Potential applications in sustainable agriculture

CONCLUSION

The present study demonstrates the successful biosynthesis of silver nanoparticles using *Ocimum tenuiflorum* leaf extract through a green synthesis approach. Characterization studies confirmed the formation of stable, crystalline nanoparticles with nanoscale dimensions. The synthesized AgNPs exhibited significant antifungal activity against crop pathogens such as *Fusarium*, *Alternaria*, and *Rhizoctonia*.

Therefore, Tulsi-mediated silver nanoparticles have promising potential as eco-friendly nano-fungicides for sustainable crop protection. Further research involving field trials and toxicity assessment is recommended to evaluate their large-scale agricultural applications.

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