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Toxicity of ZnO nanoparticles on germinating *Sesamum indicum* (Co-1) and their antibacterial activity

S NARENDHRAN[1,*], P RAJIV[1] and RAJESHWARI SIVARAJ[2]

[1]Department of Biotechnology, School of Life Sciences, Karpagam Academy of Higher Education, Eachanari post, Coimbatore 641 021, India

[2]Department of Chemistry, Government Arts College, Udumalpet 642 126, India

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Abstract. **A comparative study of chemically (ZnO) and biologically synthesized (nano-ZnO) nanoparticles were carried out to determine the effect on seed germination of *Sesamum indicum* (Co-1) by soaking method. Nano-ZnO is synthesized using *Lantana aculeata* aqueous extract. Chemical synthesis of ZnO nanoparticles by precipitate method and was characterized by ultraviolet–Visible spectroscopy (UV–Vis), Fourier transform infrared spectrometer (FT-IR), energy dispersive X-ray spectrometer (EDX), X-ray diffractometer (XRD), field emission scanning electron microscopy (FESEM) and high resolution transmission electron microscopy (HRTEM). Antibacterial activity against pathogens was determined using well diffusion method. All the characterization analysis revealed that ZnO and nano-ZnO nanoparticles were spherical in shape with an average particle size of 18 ± 2 and 12 ± 3 nm, respectively. Antibacterial studies conclude that nano-ZnO NPs have maximum zone of inhibition which was observed in *Pseudomonas aeruginosa* (15.60 ± 1.0 mm) at 100 μg ml^{-1} concentration when compared to other ZnO NPs. Phytomediate ZnO have no adverse effects on seed germination, root elongation on *S. indicum*. But chemically synthesized ZnO nanoparticles significantly decreased in germination of *S. indicum*-treated samples and no changes were observed in bulk ZnO. These results clearly indicate the benefits of using bio-fabricate ZnO nanoparticles, i.e., more efficient in germination of *S. indicum* and can also act as antibacterial agent. It can be used as nanofertilizer in environmental aspect of agricultural development.**

Keywords. **Antibacterial activity; seed germination; *S. indicum*; *L. aculeata*; ZnO nanoparticles.**

1. Introduction

Nanomaterials have gained increasing attention because of their novel properties, including a large specific surface area and high reaction activity [1,2]. Nanomaterials have also been used for various fundamental and practical applications [3]. The use of nanoparticles in the growth of plants and for the control of plant diseases is a recent practice studied. There are reports that nanomaterials on higher plants have both positive and negative effects [4,5].

Sesamum indicum is a member of the Pedaliaceae family and considered as a drought-tolerant crop. *S. indicum* L. is the most conservative oilseed crop cultivated for its edible oil. It is also known as the king of oil seeds due to high oil content (50–60%) of its seeds [6]. Sesame oil is used in foods (cooking and salad), medicine, soap manufacturing, etc. Its seeds and young leaves are eaten as stews and used in soaps, respectively, in Asia [7]. Sesamum oil is used as active ingredient in antiseptics, bactericides, disinfectants and antitubercular agents because it contains natural antioxidants such as sesamin and sesamolin [8].

Zinc has been considered as an essential micronutrient for metabolic activities in plants and animals including humans. Although it is required in trace amounts in plants but, if it is not available in required amount, it creates physiological imbalances and affects enzyme activities and other metabolic processes [9]. The biocidal properties of the NPs have significant practical relevance. Antibacterial and antifungal properties of metal NPs can be tapped to control bacterial and fungal organisms responsible for crop losses [10]. However, it must be very clear that these NPs should not have any adverse effect in plant systems. Hence, in the present investigation, we study the comparisons of biologically and chemically synthesized ZnO NPs on germinating *S. indicum* and their antibacterial activity (figure 1).

2. Materials and methods

2.1 *Materials*

Phytomediated ZnO nanoparticles were synthesized using *Lantana aculeata* leaf extract and an average particle size (12 ± 3 nm) of the nanoparticles was determined through high resolution transmission electron microscope (HRTEM) (JEOL JEM-3100F) (figure 2). Commercially available zinc oxide nanoparticles (bulk ZnO) with average particle size of <30 nm (99.0% purity) and experimental chemicals were purchased from Sigma-Aldrich Chemicals, Mumbai, India.

*Author for correspondence (narendhransumathi@gmail.com)