# Effect of *Mimosa pigra* conjugated zinc nanoparticles on seed germination and seedlings growth of *Solanum lycopersicum*

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**Zinc plays a vital role as a micronutrient in plant development, but its low availability in soil often hampers crop yield. Zinc oxide nanoparticles (ZnO NPs) are gaining attention as an effective substitute for traditional zinc fertilisers, due to their improved solubility and efficient nutrient delivery. In the present study, ZnO NPs synthesised through an eco-friendly method using *Mimosa pigra* leaf extract were evaluated for their effects on the germination and early growth of tomato seeds. Characterised at 81 nm, the ZnO NPs significantly influence growth parameters. Under controlled laboratory conditions, the impact of varying concentrations of ZnO nanoparticles (ranging from 0 to 1000 ppm) on seedling development was assessed. The findings indicated that ZnO NPs had a notable effect on several growth-related traits. Statistical analysis of root length indicated that the differences between the treatments were highly significant ($P < 0.0001$, $F = 20.64$), with the 1, 5 and 10 ppm treatments resulting in significantly greater root length than the control group (48.22 ± 24.19, 55.76 ± 29.71, 63.26 ± 24.14 mm vs 35.97 ± 28.97 mm respectively). The seed vigour index was highest at a concentration of 10 ppm, and statistical analysis revealed highly significant differences between treatments ($P < 0.0001$, $F = 36.81$), with the 10 ppm treatment showing a significantly higher seed vigour index than the control group (73.64 mm% vs 31.14 mm% respectively). The findings suggest that 10 ppm of green-synthesised ZnO NPs from *M. pigra* can act as a nano-nutrient source and positively impact the growth and development of tomato seedlings. Beyond 10 ppm, growth declines, likely due to induced stress responses. The present article showcases the positive effects of *M. pigra*-synthesised ZnO NPs on tomatoes, offering an eco-friendly approach to boosting crop productivity.**

**Keywords:** Growth parameters, *Mimosa pigra*, seed germination, tomato seedlings, ZnO nanoparticles.

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NANOTECHNOLOGY involves controlling and altering matter at the nanoscale, typically within the range of 1 to 100 nanometers[1], with a particular focus on handling individual atoms and molecules[2]. At this scale, materials have unique properties that are not possessed in their bulk form. Nanotechnology can also be used to develop new agricultural products, such as fertilisers and pesticides, that are more efficient and less environmentally harmful. For example, nanoparticles (NPs) can be used to deliver nutrients directly to plant roots, or as foliage application by reducing the need for chemical fertilisers and thereby conserving the environment[3]. Nanotechnology-enabled delivery systems for fertilisers, pesticides and fungicides offer a promising approach to sustainable agriculture by mitigating environmental impacts and reducing health risks[4].

NPs can influence plants in multiple ways, affecting their structure and physiological functions. These effects vary based on the characteristics of the NPs, including their chemical makeup, size, surface modifications, and reactivity, as well as the plant's own physical and biological traits. The effectiveness of NPs also depends on how well they are able to interact with plant cells and tissues[5]. NPs have a high surface area to volume ratio, high reactivity, and high solubility, which allows them to easily interact with cell membranes and other cellular components, such as proteins and lipids. This interaction can influence multiple physiological processes in plants, both directly and indirectly, such as seed germination, growth, and development, ultimately contributing to enhanced crop productivity[6]. Once absorbed by the plant, these nanoparticles can translocate throughout the plant's tissues and become available for various cellular processes[7].

The biosynthesis of metallic nanoparticles by plant extracts, microorganisms, algae, and yeast extracts is a green and eco-friendly technology that uses biological sources as reducing and stabilising agents in green NP synthesis. Phytochemicals are natural compounds produced by plants that contribute to their overall health and protection. Phytochemicals do this by protecting plants from a variety of environmental stresses, including pollution, stress, drought, UV exposure and pathogenic attack[8]. Reducing agents in plant extract help to convert metal ions into nanoparticles.