International Journal of Engineering, Science and Humanities
An international peer reviewed, refereed, open-access journal
Impact Factor: 7.9 www.ijesh.com ISSN: 2250-3552

Impact of Iron Oxide Nanoparticles on the Growth and Physiological Parameters of Vigna radiate

Sagar Kumar
PHD Research Scholar, Department of Life Science (Botany), Farook College, Kozhikode

Abstract:
Nanotechnology has become increasingly important in agriculture, where nanoparticles are being explored as potential tools for enhancing plant growth, nutrient uptake and stress tolerance. The present study investigates the effects of iron oxide nanoparticles (Fe_3O_4 NPs) on the growth and physiology of *Vigna radiata* (Green Gram), a widely cultivated legume crop. Iron oxide nanoparticles were synthesised using a co-precipitation method and applied to seedlings at concentrations of 10, 50, 100, 500 and 1000 mg/L under hydroponic conditions in Hoagland's solution. Key growth parameters including seed germination percentage, root and shoot length, chlorophyll content, protein levels, carbohydrate levels and phenolic compounds were measured on the 7th and 15th days. Results showed that Fe_3O_4 NPs significantly enhanced germination and stimulated root and shoot elongation in a dose-dependent manner, with maximum growth observed at higher concentrations. Physiological parameters also improved, indicating that Fe-based nanoparticles may play a beneficial role in enhancing nutrient availability and photosynthetic efficiency. However, the potential risks of nanoparticle accumulation and long-term toxicity warrant further investigation. This study highlights both the promise and caution required in applying nanotechnology in sustainable agriculture.
Keywords: Nanotechnology; Iron oxide nanoparticles; *Vigna radiata*; Hydroponics; Plant physiology; Seed germination; Green Gram.

Introduction: Nanotechnology and nanomaterials have garnered significant interest due to their distinctive properties, such as a substantial surface area and heightened reactivity. These substances have been utilised as cosmetic additives, highly reactive catalysts, components of drug delivery systems, agents for cell imaging and tools for cancer therapy. Additionally, they are utilised in the production of fertilisers and pesticides. Nanoparticles are utilised to enhance the nutrient availability to the shoots and roots of plants. Consequently, plants are exposed to and assimilate them. The plants are impacted in various ways by the uptake of these substances, which in turn influences their physiological processes. It has been observed that certain substances have the potential to exhibit toxicity towards plant cells and their organelles, while others may have a beneficial impact on plant growth (Monica and Cremonini, 2009). Various researchers have conducted studies to examine both the positive and negative effects. The observed effects were found to be dependent on the dose and duration of exposure, as well as the species involved. The need to clarify the potential harmful effects of nanotechnology in agriculture and other industries has arisen due to increased demands in this field. The objective of this study was to investigate the impact of iron oxide nanoparticles on Vigna radiata (Green Gramme), an essential plant species. The plants were cultivated using a hydroponic method in a Hoagland solution.

Materials and Methods

The chemicals used in the experiment include iron (III) chloride hexahydrate, iron (II) chloride tetrahydrate, ammonium hydroxide, trichloroacetate (TCA), thiobarbituric acid (TBA), sodium carbonate, copper sulphate, sodium potassium tartarate, Folin-Coicalteau reagent, acetone, sodium phosphate buffer and phenol, among others. The laboratory equipment includes beakers, wire gauzes, air pumps, slides, brushes, forceps, blades, droppers, glass rods, spatulas, pipettes, micropipettes, cuvettes, test tubes, watch glasses, mortar and pestle, Whatman filter paper, Buchner funnels, centrifuges, spectrophotometers, weighing balances, magnetic stirrers and pH metres. The Micro Image Projection system was utilised to capture images of plant sections. Iron oxide nanoparticles (Fe30, NPs) were synthesised following the procedure outlined by Maity and Aggarwal (2007). The specified quantities of $FeCl36H_2O$ (0.32 grammes) and $FeCl_24H_2O$ (0.16 grammes) were dissolved in 40 millilitres of deionized water. The solution was subjected to heating at a temperature of 80°C for a duration of 1 hour, with simultaneous stirring. Next, a rapid addition of 5.0 ml of ammonium hydroxide (30% w/v) is made to the solution. The suspension is thoroughly agitated for an additional hour and subsequently allowed to cool to ambient temperature. The precipitated particles were subjected to a series of washing steps using both hot and cold water. The particles were then separated using magnetic decantation and subsequently dried at a temperature of 70 °C for a duration of 1 hour. The utilisation of dry powder was employed for subsequent experimentation.

Total protein, total carbs, measurement of chlorophyll and a totally randomised design were all used to evaluate the impact of various doses of Iron oxide NPS on Vigna radiata development, as shown in Fig. 2. Six sets of seeds were separated based on their treatment. The control group (group A) had seedlings cultivated without the presence of nanoparticles. The remaining groups (B, C, D, E and F) were all reared while being exposed to iron oxide NPS at final concentrations of 10, 50, 100, 500 and 1000 mg/l, respectively. In order to eliminate any traces of the dangerous mercuric chloride, which was used to surface sterilise the mung bean seeds, they were rinsed three or four times with distilled water. Six hours were spent individually soaking seeds from each of the six groups in distilled water with varying amounts of iron nanoparticles. The treated seeds were put in petridishes that had filter paper inside that was wet. The seeds that showed the radical emerging from the seed coat after 24 hours were noted as having germinated. The impact of metal oxide nanoparticles on seed viability was assessed by looking at the percentage of seeds that germinated. The plants were then cultivated hydroponically in Hoagland's solution with the aforementioned iron NP concentrations. Air pumps were used to properly aerate the liquids containing suspended nanoparticles. Using a ruler, the root and shoot lengths were measured every two days for up to 15 days. On the seventh and fifteenth days of treatment, measurements of chlorophyll, total phenol, total protein and total carbohydrate were made.

Results and Discussion

Results of root and shoot length measurement -

The Hogland solution, which contains concentrations of 10, 50, 100, 500 and 1000 mg/l iron nanoparticles, was used to hydroponically grow the mung plants. Air pumps were used to properly aerate the liquids containing suspended nanoparticles. Up until the 14th day, the length of the roots and shoots were measured every other day with the use of a box and a ruler. When iron oxide nanoparticles were tested by Dhoke et al. (2013) for their impact on Vigna radiata seedlings, healthy growth was seen. Similar significant impacts were found by Souad A. Elfeky et al. (2013) in Ocimum basilicum L. growth characteristics (branches, leaves number). According to Table 2, root and shoot length increased as nanoparticle concentration rose from 10 to 1000 mg/l. Therefore, we may conclude that iron likely had a stimulating impact on plant growth.

Conclusion:

The study demonstrated that iron oxide nanoparticles (Fe_3O_4 NPs) positively influenced the growth and development of *Vigna radiata*. The application of nanoparticles enhanced germination, root and shoot elongation and physiological attributes such as chlorophyll, protein, carbohydrate and phenolic content. The results suggest that Fe_3O_4 NPs improve nutrient uptake and stimulate plant metabolism, thereby promoting better growth outcomes. However, while the findings highlight the potential of nanotechnology as a tool in agriculture, there is a need for caution. Excessive use of nanoparticles may lead to long-term ecological impacts, including soil accumulation and potential toxicity to plants and microorganisms. Further studies should explore nanoparticle interactions with soil, long-term plant health and possible effects on human food chains. Thus, Fe-based nanoparticles can be considered as a promising growth stimulant for legumes like *Vigna radiata*, but their application should be carefully monitored and optimised for safe, sustainable agricultural practices.

Bibliography:

- Bhattacharya, K., et al. (2007). Medicinal properties of betel leaf (*Piper betle* Linn.): A review. *International Journal of Green Pharmacy*, 1(2), 65–68.
- Chibber, H. M. (1913). The Anatomy of the Vegetative Organs of the Betel Plant. *Journal of the Asiatic Society of Bengal*, 9(3), 11–21.
- Dayanandan, P., Kaufman, P. B., & Franklin, C. I. (1996). Detection of starch in plant tissues using IKI. *Biotechnic & Histochemistry*, 71(2), 71–73.

- Dhoke, S. K., Mahajan, P., Kamble, R., & Khanna, A. (2013). Effect of nanoparticles suspension on the growth of mung (*Vigna radiata* L.) seedlings by foliar spray method. *Nanotechnology Development*, 3(1), 1–5.
- Elfeky, S. A., et al. (2013). Influence of magnetic iron oxide nanoparticles on the growth of *Ocimum basilicum* L. *International Journal of Agriculture and Crop Sciences*, 5(7), 802–811.
- Johansen, D. A. (1940). *Plant Microtechnique*. McGraw-Hill, New York.
- Krishnamurthy, K. V. (1988). *Methods in Plant Histochemistry*. Vishwanidham, New Delhi.
- Maity, D., & Aggarwal, S. (2007). Synthesis of iron oxide nanoparticles by chemical co-precipitation method. *Materials Chemistry and Physics*, 103(2–3), 385–390.
- Monica, R. C., & Cremonini, R. (2009). Nanoparticles and higher plants. *Caryologia*, 62(2), 161–165.
- Raman, V., et al. (2012). Comparative leaf anatomy of betel vine (*Piper betle* L.) varieties. *Journal of Medicinal Plants Research*, 6(10), 1900–1906.