RESEARCH ARTICLE

Green Synthesis of MgO Nanoparticles from *Eicchornia crassipes* Aqueous Leaf Extract and its Phytotoxic Effect on *Triticum aestivum*

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Abstract

Nano-biotechnology has a profound impact on various fields. The photo-mediated green approach of structuring the oxide nanoparticles from metal has become exigent due to helping to circumvent the adverse effects on the environment as compared to other methods of synthesis like chemical and physical. For synthesis of Nano-composites by plant material was initiated due to the material containing an enormous number of bio-reductants and surfactants, useful formation of nanoparticles. The formation of phytofacile metal nanoparticles is due to the presence of phyto-components which an efficacious substitutes as bio-reductants and surfactants. The green synthesis of MgO_2 is eco-friendly towards the creation of inorganic metal oxide nanoparticles. The magnesium oxide metal nanoparticles act as a very stable and safest component of the human body. In the present work, the preparation of magnesium oxide nanoparticles (MgO_2NPs) was initiated by using an aqueous leaf extract of *Eicchornia crassipes*. The synthesized MgO_2 nano-composites were characterized through UV–vis spectroscopy. The nanoparticles showed absorbance at 314 nm. The phytotoxicity of synthesized MgO_2 NPs was tested against the *Triticum aestivum*. The results indicate that increase in all aspects of essential components exposed to the MgO_2 nanoparticles in comparison to the control treatment which showed better content for root and shoot growth of the *T. aestivum*. This is a fruitful outcome of this research work that the exposure of nanoparticles to *T. aestivum* leads to grow the plant vigorously and did not show any adverse effect. This claimed that the MgO_2 NPs are eco-friendly for the environment.

Highlights

- Utilization of aquatic weed for preparation of magnesium oxide nanocomposites.
- Effect of MgO_2NP_S on growth of *T. aestivum*
- Effect studied in terms of root and shoot growth of *T. aestivum*

Keywords: *Eichhornia crassipes,* Nanoparticles, Phytotoxicity, Green synthesis, *Triticum aestivum*

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Introduction

Green synthesis of nanomaterial gained a lot of attention due to its sustainability, reliability as well as its eco-friendly approach in various fields (Selim, Y. A. 2020). Advanced development in the nano-biotechnology field reaches its point on the verge of preparing nanoparticles, nanotubes and nanowires by using novel biomaterials (Sankar, R. 2014).

One of the undesirable materials is the common aquatic weed *Eichhornia crassipes* (water hyacinth) in an ecosystem spread vastly and widely distributed all over the world (Elenwo, E. I. and Akankali, J. A. 2016). Recent perspective showed that *E. crassipes* have tremendous growth, environmental adaptability and inter-locking shoot pattern with impenetrable mat. *E. crassipes* also have an enormous ability to expand over the water body and form a dense mat over it (Sharma, A. *et al.*, 2016; Mitchell, D. S. 1985).

The invariable growth of *E. crassipes* has an adverse impact on an aquatic ecosystem by taking nutrients directly from water bodies in terms of organic contaminants, heavy metals and necessary nutrients (Tiwari, S. *et al.*, 2007., Aoi, T. and Hayashi, T. 1996). *E. crassipes* nearly absorbs 30% Potassium, 15% Nitrogen, 5% Protein. The rate of absorption of Nitrogen is 5 to 10 times greater than phosphorous (Makhanu, K. S. 1997; Roger, H. H. and Davis D. E. 1972; Osumo, M. W. 2001). The *E. crassipes* show very harmful effects on the flora and fauna of aquatic ecosystems. It acts as one of the most serious destructing agents for the native aquatic fauna, posing a threat to aquatic diversity. It also reduces the growth of phytoplankton in aquatic body systems and causes for collapse of the food chain invariably (Gichuki, J. 2012; Patel, S. 2012; Villamagna, A. and Murphy, B. 2010). *E. crassipes* is considered as an invasive danger to the world's aqueous diversity (Mack, R. N. *et al.*, 2000). More complex coverage of *E. crassipes* on the water surface increases higher

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sedimentation rate and evapotranspiration rate by creating anaerobic conditions through various lethal gases. When a large number of these lethal gases are introduced into an aquatic ecosystem they will cause adverse effects on fish by reducing the dissolved oxygen state of the water body (Dereje, T. *et al*., 2017; Gerry, H. *et al*., 1997; Gopal, P. 1987).

E. crassipes has profound harmful impacts on the ecosystem from all sides. But its leaves showed some important applicable constituents. Nowadays, green synthesis of nano-composites takes a vast array by using various plant parts extract as having more accessibility, productivity, and eco-friendly impact (Martirosyan, A. 2014; Bonomo, M. 2018). Regarding this, it has been ascertained that the plants extracted in collaboration with the present natural resources form exceptional substitute agents in the preparation of nanocomposites (Okitsu, K. 2007; El-Ansary, A. 2009).

However, the synthesis of Ag and ZnO nanocomposites is largely implemented in nano-biotechnology. The continuous accumulation of nano-composites creates a harmful impact on the human body system. Despite this, magnesium is considered a crucial element for stimulation in terms of plant expansion as well as reducing the risk of danger to any flora and fauna of an ecosystem. Additionally, Magnesium helps to catalyze the process of photosynthesis very swiftly. Following the Food and Drug Administration, the Magnesium Oxide nano-composite set a safe alternative against various microbe strains. The magnesium element is involved rapidly with phytoconstituents to enhance the photosynthesis process and initiate plant growth.

This study introduces a novel, eco-friendly approach to synthesizing magnesium oxide (MgO) nanoparticles using *Eichhornia crassipes* aqueous leaf extract. The green synthesis method employed in this research offers several advantages over traditional chemical synthesis. Furthermore, this research investigates the phytotoxic effects of the synthesized MgO nanoparticles on *Triticum aestivum* (wheat), a crucial crop for global food security. The findings of this study provide valuable insights into the potential risks and benefits associated with the use of MgO nanoparticles in agricultural applications. This study provides a comprehensive assessment of the phytotoxic effects of MgO nanoparticles on *T. aestivum*, highlighting the potential risks and benefits associated with their use in agriculture.

Overall, this research contributes to the development of sustainable, eco-friendly methods for nanoparticle synthesis and provides valuable insights into the phytotoxic effects of MgO nanoparticles on agriculturally important crops.

Material and Methodology

Plant Material

The *Ecchornia crassipes* used for this work were collected from a stagnant water body located in Annasaheb Awate College, Manchar.

Preparation of Aqueous extract of *E. crassipes*

Eicchhornia crassipes leaves were washed once with tap water and later on twice by using deionized water to remove all the impurities and dust particles. The leaves were oven-dried at 50°C and then crumbled into a fine powder. Then, 5 g of the leaves powder was homogenized with plenty amount of deionized water and made a final volume of up to 200 mL. The mixture was boiled for 1-hour at 50°C in a boiling water bath. After cooling it to room temperature, filtered the mixture to obtain the aqueous form of extract. The aqueous extract was stored at 5 to 10°C for further use.

Preparation of MgO2 Nanoparticles from aqueous extract of *E. crassipes*

Over 30 mL of *E. crassipes* aqueous leaf extract was mixed with 150 mL of 0.1 M magnesium nitrate hexahydrate on a constant stirred condition at 50°C. After a half hour add to the above mixture 10 mL of 0.1 M NaOH in a dropwise manner. The time taken for the formation was 2 hours. Now, the 2-layer dispersion was obtained which was centrifuged at 5000 rpm for 15 minutes. Here, the buoyant was disposed and the settings were washed out with deionized water to detach excessive $Mg(NO_3)·6H2O$. Later, the content was dried in the oven at 50°C for 4 hours (Fig. 1).

Phytotoxicity

The phytotoxicity was tested against seeds of *T. aestivum*. Before use the seeds were treated with 60 to 70% ethanol for up to 2 minutes. Thereafter, seeds were washed off through deionized water to avoid any interference of the Ethanolic part in upcoming

Fig. 1: Schematic representation for the generation of magnesium nanoparticles in aqueous leaf extract from *E. crassipes* (MgNPs-Ec).

results (Pokhrel, L.R, 2013). Subsequently, the seeds of *T. aestivum* were plunged into metallic oxide Nanoparticles for 1h. Every 10 seeds of *T. aestivum* were transferred to a plastic glass jar filled with 70% black soil with a distance between each seed nearly 1-cm. Concentration 10 mL solutions like 20, 40, 60, 80, and 100 mg were added in respective plastic glass jars containing 10 seeds each and one set of plastic jars blank without nanoparticle solution. Routinely, the above set was exposed to sunlight and regularly MgONps was added. The germination was conducted for 10 days. After 10 days rate of germination was measured by the root and shoot of control and exposed seeds (Rico, C.M, 2013; Atha, D.H, 2012).

Statistical Data Analysis

The statistical analysis was depicted by the one-way ANOVA method independently for root and shoot growth of *T. aestivum* with standard deviation. It helped to determine the variability and validity of observed data sets of the work.

Result

Synthesis of Magnesium Oxide Nanocomposites by *E. crassipes* leaf extract

Throughout, the formation of magnesium oxide nano-composites by phyto-facile method with the help of *E. crassipes* aqueous leaf extract the colorless solution of magnesium nitrate turned to the dark brownish color shown in Fig. 2 c. The mixture continued on stirring for 2 hours and then kept aside for 24 hours to settle down the nanoparticles. The prepared nanoparticles Fig. 2 (a-c) were confirmed by UV-vis spectroscopy. The absorption peak of nanoparticles was observed at 314 nm indicating the MgO-NPs are synthesized by reducing Mg $(NO_3)_2$ to MgO.

Seed Germination

As shown in Fig. 3a-b, the magnesium oxide nanoparticles showed tremendous remarkable impacts on the germination rate of *T. aestivum* seedlings. Similar to other NPs (Clement, L, 2013), The Magnesium Oxide Nanoparticles did not show any probable adverse effect on the biological system. MgONPs induced the germination of *T. aestivum*. However, the response was totally reliant on the concentration of MgONPs in *T. aestivum* seed germination. In *T. aestivum* plant, results revealed that the highest and lowest growth percentages of 100 and 80%, respectively, were observed in 100 mg concentration of MgO Nanoparticles as well as in control (Ma, X. 2010). The outcomes possibly state the positive relation between nano-MgO to the seed germination of *T. aestivum*. Consequences, of germination on plants, showed that the resultant growth percentage varied significantly. However, the increasing concentration of synthesized nanomaterial impacts to increase in the rate of seed germination. Extreme seedling growth is found in the highest concentration of 100 mg.

Effect of MgNPs on *T. aestivum* Growth

As shown in Fig. 3, when the *T. aestivum was* treated with variable concentrations of MgO-NP's ranging from 20 to 100 mg, the

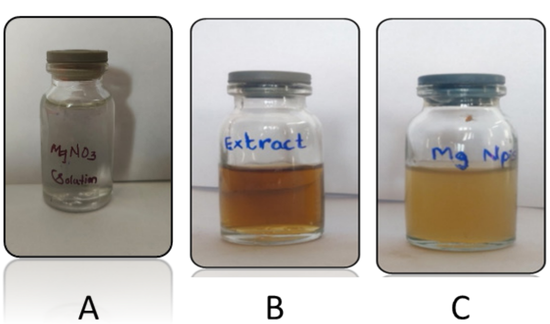


Fig. 2: (A) Magnesium nitrate solution **(B)** Before the synthesis of nanoparticles **(C)** After synthesis of nanoparticles.

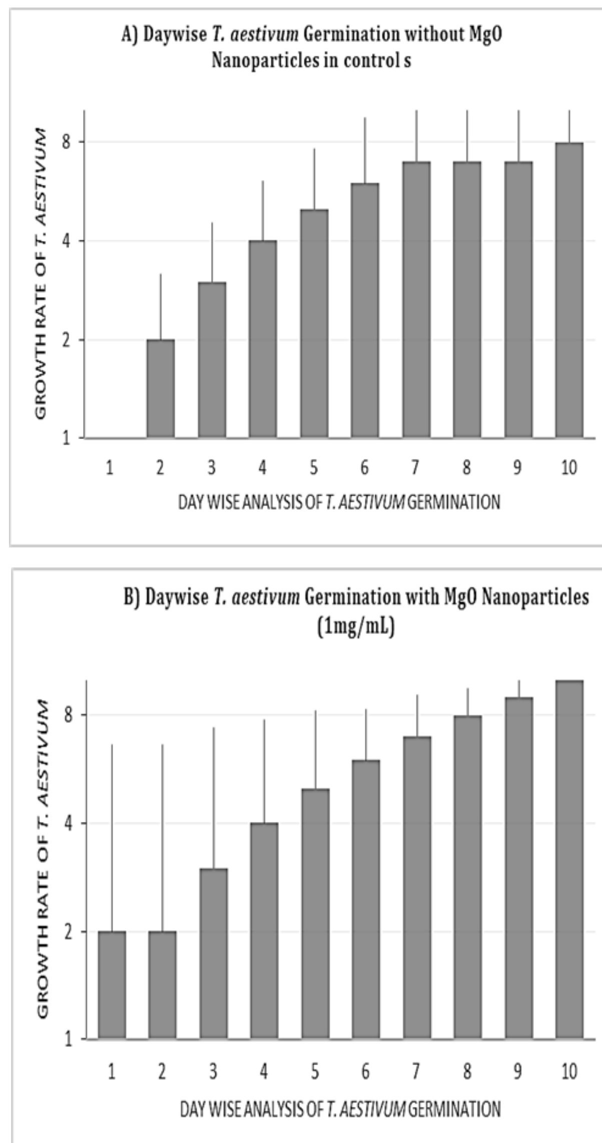
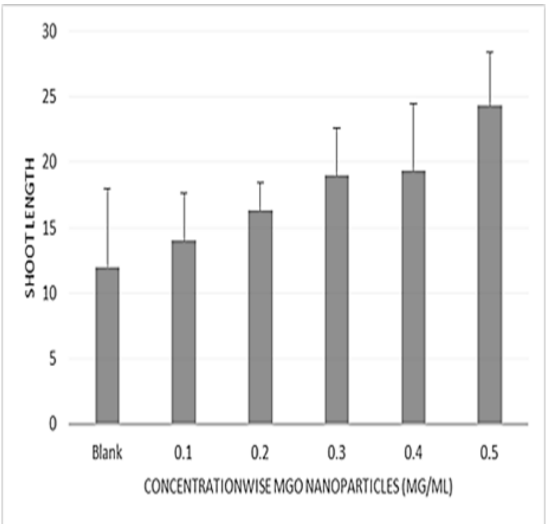
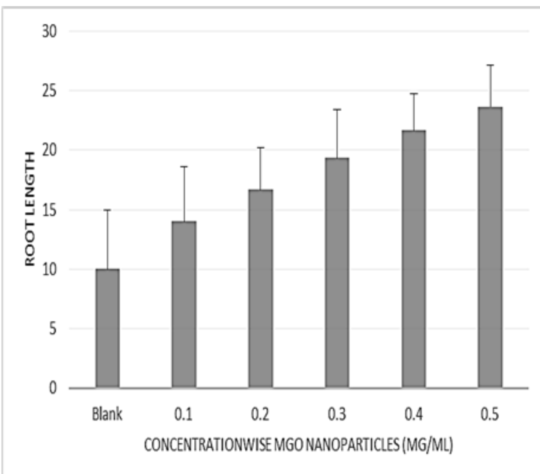


Fig. 3: (A) The statistical day-wise analysis of the growth of *T. aestivum* without exposure of Nanoparticles in a control set by using values are mean (n=3) ± SD **(B)** The statistical day-wise analysis of the effect of MgO NPs (1-mg/mL) on germination of *T. aestivum* by using values are mean (n = 3) ± SD (Adjei. M. O, *et al*., 2021).



A



B

Fig. 4: Impact of MgO NPs (mg/mL) on shoot length (A) and root length (B) of *T. aestivum* plants. Values are mean (n = 3) ± SD. One-way ANOVA performed separately for shoot and root length was significant at $p < 0.05$ Different superscripts on bars for each pigment denote significant differences between means according to DMRT ($p < 0.05$) (Kumar S. 2015).

MgO-NPs increased the root and shoot length remarkably after 10 days of treatment. The spectacular raised in the growth of root and shoot length is important for the overall growth of plants. It also helps to increase the quality of *T. aestivum*. The profound results showed that the exposure of MgONPs was impacted positively on the root development of the *T. aestivum*. It might be due to the maximum absorption of MgONPs by the roots of *T. aestivum* rather than the shoot.

Discussion

Increasing zinc and magnesium in the soil can also help plant growth, germination, and development because these elements are among the microelements needed for plant growth (Roger H. H, 1997).

For the growth and development of seedlings, microelements are needed like zinc and magnesium. Increasing the amount of zinc and magnesium absorbed moreover by soil and assisted for plant growth and development along with seed germination (Harris, D. *et al*., 2007).

In the present study, we used *E. crassipes* extract to reduce the magnesium nitrate. The absorption peak of MgO-NPs at 314 claimed that the synthesis was by green method, apart from these by visualization in color change occurs from colorless to brown (Fig. 4a-b) (Jeevanandam, J. 2017). The color change observed with the *E. crassipes* aqueous extract of magnesium nitrate indicates successful phyto-reduction, demonstrating effective photosynthesis of nanoparticles. This color alteration serves as a visual marker for the formation of nanoparticles, reflecting the chemical processes involved in their synthesis. The reductive elements present in the *E. crassipes* extract were able to form the MgO-NPs. As the UV-vis indicates the absorption peak lies accordingly in the range of 200 to 800 nm.

Jayarambabu *et al*., (2016) showed that the effect of formed MgONPs on the germination of maize seeds impacted fruitful outcomes that in terms of the highest and lowest germination percentages retained by the seeds were 95 and 80%, respectively. Similar results were found in the above research that the MgO-NPs of *E. crassipes* also stimulate the highest growth of the *T. aestivum* than the control plant set. The treatment of maize seeds with MgO nanoparticles significantly influenced their germination percentage. This suggests that MgO-NPs may enhance or inhibit germination, depending on the concentration and exposure conditions. Further investigation is needed to understand the underlying mechanisms and optimize treatment for improved seed performance. Whereas, the concentration of MgO-NPs raised up to 150 mg impacted greatly the growth ratio of Maize (Jayarambabu, N. 2016).

In the present study, similar results were found as we applied 20, 40, 60, 80 and 100 mg concentrations of magnesium nanoparticles in *T. aestivum* showed a greater growth ratio in terms of root and shoot development.

In *Ananas comosus var. bracteatus* the impact of MgONP showed that the root growth decreases influencing the depletion of the growth rate of leaf and plant biomass. In another study, performed on the tomato plant, the high doses of titanium and zinc oxide nanomaterials impact the suppression of root length as well as changes in some characteristics of the physiology of tomato (Raliya, *et al*., 2014).

Some Studies revealed that the initial mode of MgO-NP introduction also leads to induced stress levels in elongation as well as the development of roots (Ma, Y. *et al*., 2010). Pugazhendhi *et al*., 2019 also concluded that *Sargassum wightti* also showed a decreasing ratio of root and shoot length after exposing to the utmost concentration of MgO nanocomposites (Pugazhendhi, A. *et al*., 2019). While our findings vary dramatically, the exposure of MgO-NPs will affect positively the growth and development of roots of *T. aestivum* it favorably impacts the root development more than the shoot development of *T. aestivum*.

According to, Marusenko *et al*. the tomato seeds are not affected by the concentration of TiO2 and ZnO nanoparticles (0–750 μg/mL) (Raliya, R. 2015). Another report concluded that nano-TiO2 can induce spinach seed germination with seedling vigor and growth, which helps to trigger antioxidative mechanisms (Zheng, L. 2005). These all variations are reliable over the type of nanomaterial, plant species, and Substrate used for the synthesis of nanoparticles. Besides that, the soil type and culturing media also impacted the overall growth of plants and seedlings (Capaldi, A. 2015).

Conclusion

The study suggested that MgO-NPs synthesized from the aquatic weed *E. crassipes* aqueous extract showed fruitful impacts on the growth and development of *T. aestivum*. The MgO-NPs assisted the growth of leaves and roots of wheat plants. The highest amount of exposing the MgO-NPs to *T. aestivum* induces the maximum absorption in the roots and leaves of wheat. At the 100 mg concentration of nanoparticles, the 100% growth of *T. aestivum* was observed. Based on the results, the work itself terminates that, the MgO-NPs synthesized from *E. crassipes* aqueous extract will be used in the agricultural field along with biofertilizers to initiate prominent growth and development of plants. In the future, the relevant research will focus on the characterization of nanocomposites and analysis of biochemical components of roots and shoots of the treated plants.

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Author contributions

Shabnam Sayyed, Aamina Khan, Tejal Jangale and Misbah Inamdar: Ideology, Methodology, Affirmation, Exploration, Data structuring, Authenticate draft preparation; Sanjay Pokale, Snehal Kale, Dr. Yasmeen Shaikh and Reshma Shaikh: Investigation, Data curation, Statistical analyses, Funding acquisition, Conceptualization, Supervision review.

Conflict of Interest

No competing financial Interests and personal relationships have been reported in the present paper proclaimed by the authors.

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