DOI: https://doi.org/10.70749/ijbr.v3i1.491

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

Assessing Magnesium Oxide Nanoparticles (MgONPS) for Improving Growth and Related Parameters of Chilli Plant Varieties

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ARTICLE INFO

Keywords

MgO Nanoparticles, Chilli, Ginger, Garlic.

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Declaration

Author's Contributions: All authors equally contributed to the study and approved the final manuscript.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History

Received: 25-10-2024
Revised: 26-12-2024
Accepted: 07-01-2025

ABSTRACT

Nanotechnology, among the most technological advances in the field of agriculture, holds a prominent role in reshaping agriculture and food production to meet demand efficiently and cost-effectively. The use of nanotechnology in crop protection has increased resulting in high agricultural yield by the application of nanoparticles in agriculture. The main goal of nanotechnology in agriculture is to reduce the use of spread chemicals, minimize nutrient loss during fertilization, and increase crop yield through nutrient and pest management. In this research, magnesium oxide nanoparticles (MgONPS) were prepared by using the green extract of ginger and garlic under room conditions. The prepared MgONPS were characterized by Fourier transform infrared spectroscopy, ultra-violet visible spectroscopy, x-ray diffraction, and scanning electron microscopy. The UV.vis absorption showed a maximum absorption peak at 280nm, which is in the range of 260 to 280 specific for MgONPS. The XRD pattern showed the characteristic peaks and an average particle size of 20.6nm, FTIR spectrum was found in the range of 600 to 3500cm-1 determined the presence of different bonds present on the nanoparticles. These bonds absorb I.R radiation and the transition occurs from a ground vibrational state to an excited vibrational state. This research determined the assessment of synthesized MgONPS in chilli varieties. The synthesized nanoparticles were applied to chilli plants in three concentrations. The effect of each concentration was measured compared to control. The foliar applications of the prepared MgONPS were shown to increase the plant's height, shoot length, number of leaves, number of flowers, and number of fruits compared to control.

INTRODUCTION

Nanotechnology, among the most technological advances in the field of agriculture, holds a prominent role in reshaping agriculture and food production to meet demand efficiently and cost-effectively(Rai, Ingle et al. 2012). The use of nanotechnology in crop protection has increased resulting in high agricultural yield by the application of nanoparticles in agriculture. The main goal of nanotechnology in agriculture is to reduce the use of spread chemicals, minimize nutrient loss during fertilization, and increase crop yield through nutrient and pest management(Ndlovu, Mayaya et al. 2020). Nanotechnology has tremendous potential, as it can enhance the quality of life through its applications in various fields, i.e, in agriculture and food chain. Today and in the future, nanoscience and technology have tremendous ability to find solutions to problems facing agriculture and society (Ditta and Nanotechnology 2012).

For developing countries, agriculture is the foundation of their economy, including over 60% of the population who depend directly or indirectly on agriculture to earn money(Ali, Rehman et al. 2014). The application of nanotechnology will increase crop production by enhancing the productivity of agricultural inputs like fertilizers and pesticides that alleviate crop losses. Besides this, nano biosensors lead to the production of technologically based farming systems that can identify the requirements of crops and soil. Nano biosensors also enable crop management timely(Panpatte and Jhala 2019). Nanotechnology additionally has exceptional potential for worldwide food production, upgrading food quality, and decreasing harmful waste. Food processing and farming are consequently among the main regions for the use of nanotechnology. Important areas of nanotechnology in the food sector include food protection (by the use of nanosensors for microbial detection), smart food packaging systems, protection and delivery of food ingredients by Nanoencapsulation(Jampílek, Kráľová et al. 2015).

The nanoscale carriers can anchor plant roots to the soil and organic matter around them. As a result, the environmental stability will increase, and the amount needed to be implemented will be reduced(Rai, Ingle et al. 2012). To increase the insecticidal value, a nanotechnology technique known as "nanoencapsulation" can be used. The nano-encapsulation technology encloses the active pesticide ingredient in a thin-walled sac or shell (protective coating). Another development in this area could be the availability of nanostructured catalysts, which will improve pesticide and insecticide efficacy while lowering the dose required for plants. Nanotechnology has the ability to eliminate weeds in an environmentally sustainable manner by using Nano-herbicides that do not leave harmful residues in the soil or ecosystem. Developing a target-specific herbicide chemical encapsulated in a nanoparticle that reaches the roots of target weeds and translocates to sections that impede glycolysis of food reserves in the root system, causing the weed plant to become hungry and die(Liu, Wen et al. 2006). Other key variables that cause food to spoil include the accumulation of moisture, gases, and fats. Nano lamination is another promising option for safeguarding food from harmful toxins. Nano lamination is applied to foods by spraying them on the surface or coating them with nano laminates. In addition to preserving food, they can improve its texture, flavour, and colour(Cagri, Ustunol et al. 2004).

One of the most popular techniques for nano nutrient supplementation is nano-coating. Traditional fertilizers are coated with nanoparticles in this process to improve their soil stability and plant absorption coefficients. Due to their low dissolution rates in the soil nanocoated fertilizers have a longer soil lifetime and are more available for plant uptake. Slow-soluble Released Fertilizers are a good example of a nanocoated fertilizer (SRFs). Traditional fertilizer granules are covered with nanomaterials that facilitate the slow release of nutrients for plant uptake, resulting in SRFs(Duhan, Kumar et al. 2017). Nanotechnologies have been integrated into pest (i.e., insects and weeds) and plant disease management research schemes aimed at detecting and controlling pests and diseases in major crops promptly. Nanomaterials in various forms are effective in the control of pests and diseases. Nanotechnology is used in crop pest and disease management in two ways: (a) as the primary control agent (complete pesticides or component formulations), or (b) as a carrier for conventional pesticides(Ndlovu, Mayaya et al. 2020).

Environmentally friendly fertilizers are also being developed using nanomaterials to reduce greenhouse gas emissions during crop cultivation. Despite their effectiveness, carbon-based fertilizers such as ammonium bicarbonate and urea are prone to breakdown and hydrolysis, resulting in higher quantities of byproducts such as nitrogen, ammonium carbonate, and ammonia in soils. Using ammonium bicarbonate, the nano fertilizer composition decreases gas emissions while also increasing fertilizer production. The nanoparticles fill the cavities in the loosely assembled structure of ammonium bicarbonate, resulting in a more compact structure with improved thermal and water stability. The extra rigidity provided by the carbon Nano molecules reduces ammonium bicarbonate's susceptibility to evaporation, resulting in increased use of the material in the soil (Sonkaria, Ahn et al. 2012).

Completely, the use of nanotechnology in plant protection items has risen, resulting in higher agricultural yields. In many cases, agro-nanotech advances provide quick technological fixes to the challenges in recent industrial agriculture. The current assessment covers nanotechnology's applications in agriculture, which may help to ensure agriculture's and the environment's long-term viability(Shang, Hasan et al. 2019).

Nanostructured materials have got a lot of attention in recent years because of their unique properties including higher damping, mechanical flexibility, high power, and strong thermal conductivity. Because of their large variety of applications, such as optical sensors, sensing instruments, and nano electronics, nanostructured metal oxides with smaller crystallite size and large surface area have sparked a lot of interest. Non-toxic magnesium oxide nanoparticles are used in crucibles, flame retardant materials, refractory materials, and coating materials. Variables such as pH, ionic strength, and calcination temperature will alter the size and morphology of oxide particles. The MgO nanoparticles are synthesized using a variety of processes, including sol-gel, hydrothermal, spray, pyrolysis, oxidation, microwave, and co-precipitation.

Each process has its own set of benefits and drawbacks(Nico and Fischer 2010). One of the most extensively researched is magnesium oxide (MgO) MONPs, drawing the attention of various studies and industrial studies, because of its interesting properties, such as nontoxicity, antibacterial activity, high thermal conductivity, stability, low dielectric constant, low dielectric loss, and excellent capacity for adsorption. MgONps have numerous applications in many important fields i.e agriculture, industries, water purification, antimicrobial materials, paints and superconductor materials, cosmetics etc(Mirtalebi, Almasi et al. 2019). The absorbance capacity of MgO nanoparticles is always less than Zno-Mgo nanocomposites because Zno-Mgo nanocomposites have high specific area(Fakhri, Behrouz et al. 2015).

Zingiber offcinale is the scientific name for ginger, which belongs to the Zingiberaceae family, which contains 800 species. The active components of ginger are curcrumin 6-gingerol, 6-shogaol, and 6-paradol. Antibacterial activity of ginger extracts against pathogens such as Staphylococcus aureus, *Staphylococcus pyogenes*, *Staphylococcus pneumoniae*, and *Haemophilus influenzae*. Furthermore, ginger extracts may contain chemicals that have a therapeutic effects. *Allium sativum*, also known as garlic, is a species of onion that belongs to the Alliaceae family and the Liliales plant order. Garlic (Allium sativum L.) has antibiotic activity against a wide range of Gram-negative and Gram-positive bacteria, including Escherichia coli, Salmonella, Staphylococcus aureus, Streptococcus aureus, and others(El-Refai, Ghoniem et al. 2018).

An Economic Analysis of Chilli (Capsicum annum L.) Production in Punjab Pakistan

Chilli is a common crop and is cultivated all over the world. It is reported that Chilli is raised over an area of 1776 thousand hectares in the world, with a production of 7182 thousand tonnes. Chilli is regarded as Pakistan's most important and lucrative cash crop. It, including potatoes, onions, and eggplants, is a member of the Solanaceae family. Capsicum annum/ C is the botanical name for it. In Pakistan, chilli is grown as a vegetable and spice crop with considerable economic value. It is a valuable cash crop in Pakistan. There are two species that are commonly cultivated in Pakistan are C.annum and C.frutescens. Chillies are cultivated on 38.4 million hectares, with a harvest of 53.7 million tonnes and an average yield of 1.7 tonnes per hectare, accounting for 1.5 percent of GDP. Sindh is the leading chilli manufacturer, followed by Punjab and Balochistan. Gulf countries, the United States, Canada, Sri Lanka, the United Kingdom, Singapore, and Germany are major importers of Pakistani chillies. During the 2003-2004 fiscal year, Pakistan received Rs 1.127 billion from red chilli powder exports, compared to Rs 5.912 billion from all fruits. This demonstrates the nonstaple crop's promise. Despite its value, the yield has dropped from 86.5 thousand tonnes in 1994-95 to 55.8 thousand tonnes this year (2003-04). Low-quality crops, bad cultural habits, and diseases like viruses, collar rot, and Phytophthora root rot are all contributing to the drop in yield. According to a report by the Pakistan Agriculture Research Council (PARC), the area and yield of chillies in Pakistan has been steadily decreasing. The region under chilli crop has decreased from 86.8 to 48.7 thousand hectares, and the production has decreased from 115.5 to 90.5 thousand tonnes between 1999-00 and 2004-05. In Pakistan, the yield of chilly is less than the potential that exists(Sarpras, Ahmad et al. 2019).

MATERIAL AND METHOD

The magnesium oxide nanoparticles were prepared from ginger and garlic extract under room conditions. For the preparation of MgO Nps, a green extract of ginger and garlic was prepared. For this 75g, fresh ginger and 75g garlic were purchased from the market. Then ginger and garlic were washed with tap water. After peeling off the finger and garlic, it was cut into very small pieces and was boiled in 1500ml water. When water remained 750 ml after boiling, the stove was switched off and was allowed the green extract to cool. The green extract was filtered by using filter paper. In this way, a green extract was prepared. For the preparation of 150ml Tsc solution, two beakers named 1 and 2 was taken. Each having 75ml distilled water.750g citric acid and 429g NaOH was added to a beaker 1 and 2, respectively. NaOH in beaker 2 was heated and citric acid from beaker 1 was added slowly, then this solution was boiled. In this way, TSC solution was prepared. Then the Tsc solution was heated for some time and then was allowed to cool. After that, 90g magnesium sulphate was added in 750 ml prepared green extract. After dissolving magnesium sulphate in the green extract, it was poured into the prepared 150 ml Tsc solution and was allowed to stirrer in an electric shaker for 6 to 7 hours. In this way, MgO Nps were prepared and was allowed to settle for 24 hours. Next step was centrifugation for obtaining pellets of nanoparticles for the purpose of characterization (Yang, Li et al. 2017, El-Refai, Ghoniem et al. 2018, Jeevanandam, San Chan et al. 2020).

Volume of TSC solution= 150ml

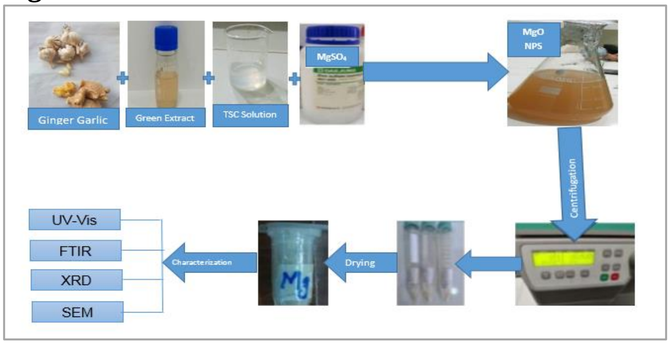
Volume of Green extract= 750ml

Total volume= Volume of TSC solution +volume of green extract

150ml + 750ml = 900ml

Three concentrations 200ppm, 400ppm, and 600ppm were prepared from prepared 900ml mgo nps solution.

Figure 1



Experimentation

To measure the impact of magnesium oxide nanoparticles on plant growth, i.e, height of the plant, leaf length, stem diameter, number of leaves, number of flowers, and number of fruit, pre-synthesized MgONPS were applied to two different species of chilli plant varieties. Seeds of two species of chilli and pots were purchased from the market. Fertile loam were purchased and was filled in pots. Two species, namely, chilli F1 hybrid, and sky seeds (BR- 763) were sown in pots in March. After one week, seed germination was observed. There were three concentrations, i.e, 200ppm, 400ppm, 600ppm were applied to two species, namely, chilli F1 hybrid and sky seed species. These three concentrations were sprayed on plants and their effect was evaluated. The concentrations were chosen according to the effectiveness against insects and bacteria. These concentrations were separately sprayed and measured for each plant. There were three replicates of plants, with one plant for each concentration of each species. One plant of each species is considered a control plant.

The seedlings were shifted into large pots after 15 days and the concentrations of MgO NPS were sprayed. The average height of each plant was measured before treatment.

After that, the dosage of nanoparticles in three different concentrations was applied to the plants after regular intervals of 15 days and their effect was measured. The height (cm) of all plants was measured. After 8 weeks, leaf number, flower, and fruit number were counted for all plants and their effect was compared with control plants.

Figure 2

15 Days Plant (Sky Seeds)

Figure 3

30 Days Plants (Sky Seeds)

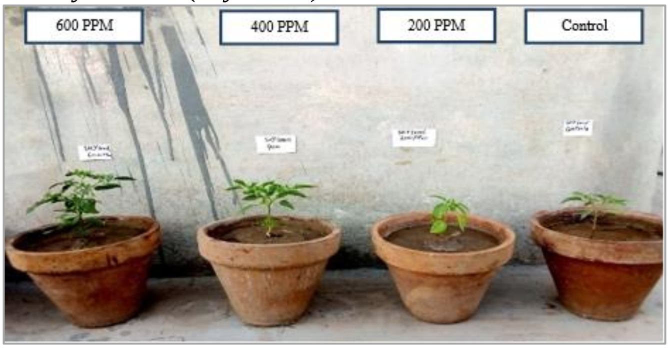


Figure 4

45 Days Plants (Sky Seeds)

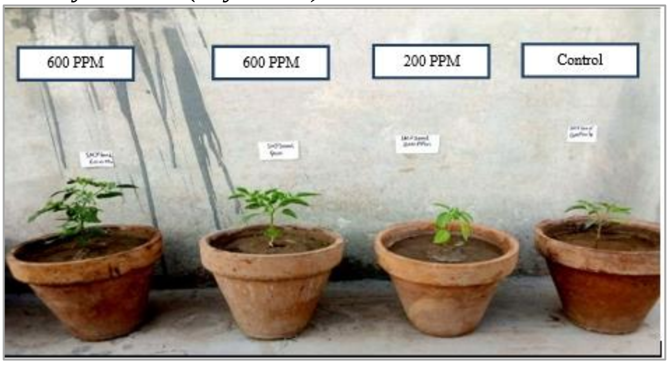
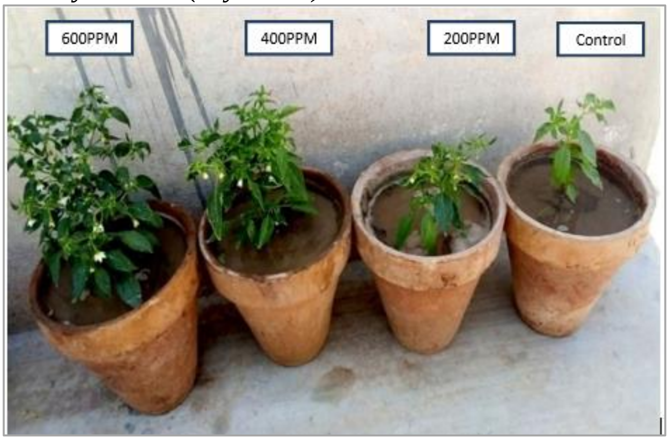


Figure 5

60 Days Plants (Sky Seeds)



F1 Hybrid Species

Figure 6

15 Days Plant

Figure 7
30 Days Plant

Figure 8
45 Days Plant

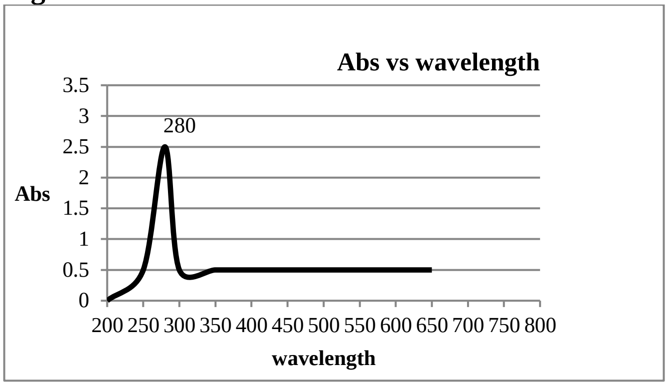
Figure 9
60 Days Plant

RESULTS

UV - Visible Spectroscopy

To confirm the preparation of MgO nanoparticles, UV-visible spectroscopy was performed in the department of biotechnology and biochemistry at Women University, Multan by using Double Beam UV-Visible Spectrophotometer [C-7200s (Peak Instruments Inc. USA]. For this purpose, Magnesium Oxide nanoparticles suspension was characterized through UV-visible spectroscopy using glass cuvettes and water served as a blank. Figure 10 shows the important absorption peak at 280 nm which is in the range of 260- 280nm specific for MgONPs confirming the synthesis of MgONPs that relates to literature(Vergheese and Vishal 2018).

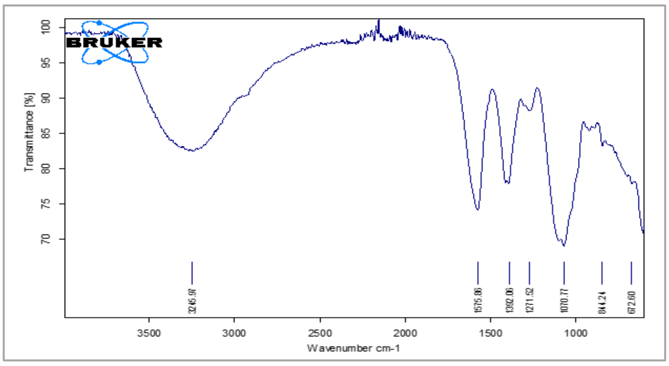
Figure 10



Fourier Transform Infrared Spectroscopy (FTIR)

The FTIR was performed at the chemistry department of Women University, Multan. The FTIR spectrum of MgONPS is shown in figure 11. The important peak of I.R spectra were shown at 3245c/m, 1575c/m, 1392c/m, 1271c/m, 1070c/m, 844c/m and 672c/m. These peaks represented the existence of different functional groups i.e O-H, C=C, O-H bending, C-O stretching, C-O stretching, S-O stretching, Mg-O respectively. These functional groups help to detect the basic chemical properties of MgONPs because each functional group contains certain bonds. When these bonds absorb I.R radiation of specific frequencies, they show stretching vibrations(Singh, Joshi et al. 2019).

Figure 11
FTIR



X-Ray Diffraction (XRD)

MgONPS were incubated after obtaining pellets. White coloured powder of MgONPS was obtained after incubation. To confirm the synthesis of MgONPS, XRD was performed. The white colored powder of MgO nanoparticles was characterized through X-ray Diffraction through Women University Lahore. The XRD pattern shows characteristics peaks that confirmed the synthesis of MgO nanoparticles. XRD analysis was performed in the range of 200 to 800 (2 Theta) using x-rays. The XRD spectra of MgO NPS are shown in figure 12. Figure 30 exhibits the peaks at angles 13.16, 31.92, 34.24, 37.72, and 46.16 that relates to 145, 80, 71, 65 and 63. The intense peaks of the XRD spectrum determine the little impurities. All these peaks are near to the literature report. The average grain size of 20.6nm was calculated using Scherrer Equation(Moorthy, Ashok et al. 2015).

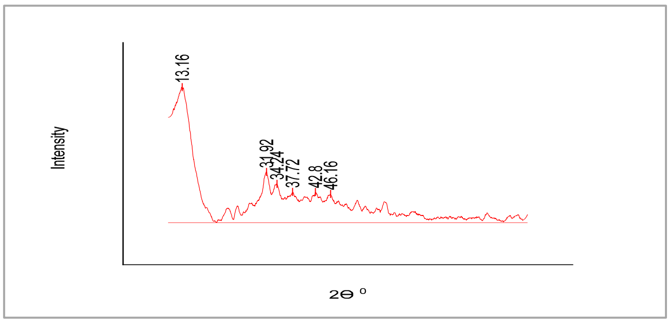
$$D = \frac{K\lambda}{\beta Cos\theta}$$

Where K=0.9 (Constant), λ = Wavelength, β = FWHM (Full Width Half Maximum)

$$Cos\theta = 2\theta^{0}$$

Figure 12

XRD

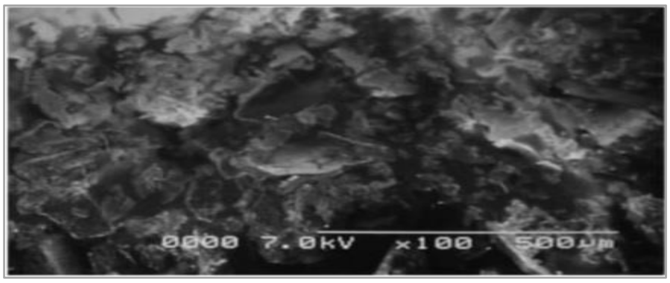


Scanning Electron Microscopy

SEM was performed to study the surface morphology of MgONPS. The SEM image in Figure 13 shows the morphology of the prepared MgONPS. The MgONPS were distributed over the entire surface as shown in fig 13. The SEM micrograph indicated that the prepared MgONPS were consisted of some fine, small, and some large grains of nanoparticles with irregular size and shape that are somewhat related to reported literature(El-Sayyad, Mosallam et al. 2018).

Figure 13

SEM



Statistical analysis

The data gathered during these findings were subjected to appropriate statistical analysis using instate software. Significant differences between mean values and standard deviation values were determined by performing Tukeys HSD test. The difference of P value <0.0001 show the results are significant. Data in Table 1 shows the foliar applications of MgONPS on plant height, shoot length, number of leaves, number of flowers, and number of fruits. The results explained that plants of Sky Seed species treated with 400ppm and 600ppm recorded a significant increase in plant height, shoot length, number of leaves, flowers, and fruits compared to control. Data in Table 2 shows the foliar treatment of MgONPS on plant height, shoot length, number of leaves, number of flowers, and number of fruits. The results explained that plants of Chilli F1 hybrid treated with 400ppm and 600ppm recorded a significant increase in plant height, shoot length, number of leaves, flowers and fruits compared to control. A significant increase in growth parameters of chilli species Sky Seed BR-763 was observed as shown in Figures 14 and 15. Figures 16, 17 exhibit the significant results regarding the growth parameters of chilli species Chilli F1 hybrid compared to control plant.

Table 1

Effect of Magnesium Oxide Nanoparticles (MgONPS) on growth and related parameters of Chilli plant species (Sky Seed BR-763) after 60 days

Concentration (ppm)	Mean ± Standard Deviation (SD)				
	Height	Shoot Length	Leaves Number	Flowers Number	Fruits Number
600ppm	24.7±0.28	15.5±0.47	70.5±0.47	17.4±0.45	5.3±0.47
400ppm	17.8±0.14	9.3±0.35	65.4±0.45	11.3±0.36	4.3±0.35
200ppm	13.6±0.42	7.2±0.37	45.2±0.37	7.2±0.32	2.2±0.26
Control	11.7±0.21	1.4±0.45	10.2±0.25	3.3±0.40	1.2±0.25
P Value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Table 1 shows the significance increase in plant height, shoot length, number of leaves, number of flowers and number of fruits

Figure 14

SD of concentrations (PPM) of MgONPS in different growth parameters of Chilli Sky Seed Species BR-763

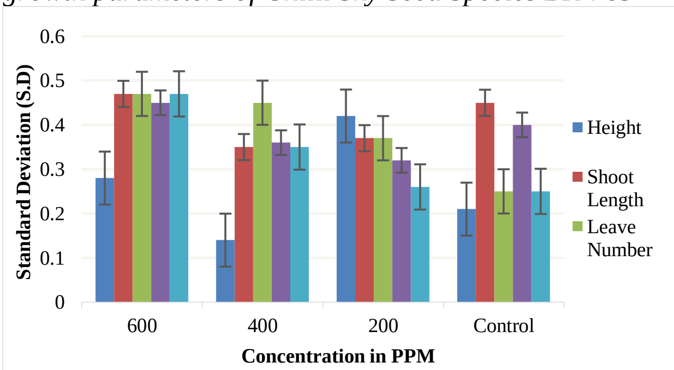


Figure 15

Mean of concentration (PPM) of MgONPS in different growth parameters of Chilli Sky Seed Species BR-763.

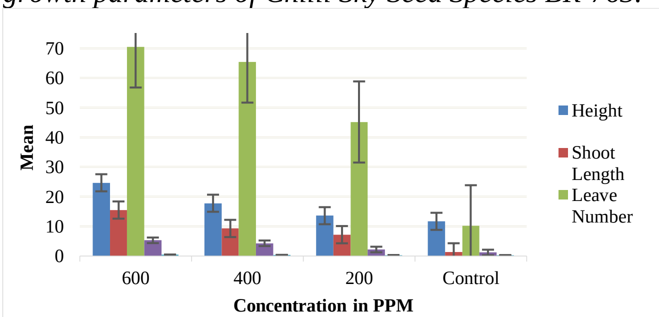


Table 2

Effect of Magnesium Oxide Nanoparticle (MgONPS) on growth and related parameters of Chilli plant species (F1 Hybrid) after 60 days

Concentration (PPM)	Mean ± Standard Deviation (SD)				
	Height	Shoot Length	Leaves Number	Flowers Number	Fruits Number
600ppm	30.5±0.35	19.7±0.28	30.5±0.56	11.4±0.49	7.5±0.56
400ppm	27.6±0.25	14.2±0.21	25.5±0.42	8.4±0.35	4.4±0.35
200ppm	26.4±0.32	7.5±0.35	15.5±0.28	4.4±0.21	2.4±0.21
Control	11.6±0.20	4.7±0.14	11.5±0.14	3.4±0.07	1.3±0.28
P. Value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0003

Table 2 shows the significance increase in plant height, shoot length, number of leaves, number of flowers, and number of fruits in chilli F1 hybrid

Figure 16

S.D of concentration (PPM) of MgONPS in different growth parameters of Chilli F1hybrid.

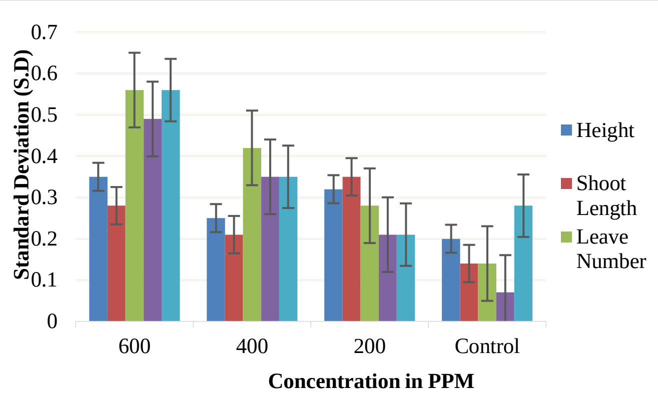
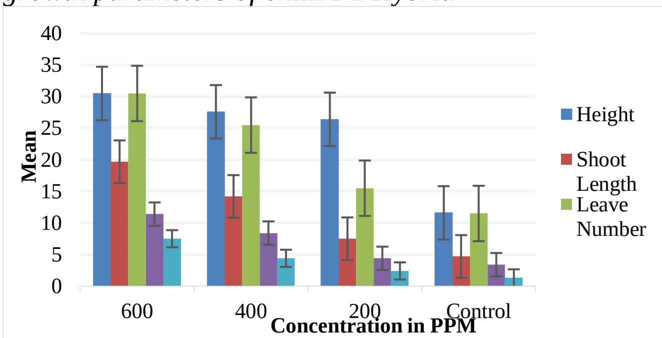


Figure 17

Mean of concentrations (PPM) of MgONPS in different growth parameters of chilli F1 Hybrid



DISCUSSION

Recently, the use of nanotechnology in the development of novel antimicrobials for combating phytopathogenic diseases that damage agricultural crops has expanded. Nanomaterials could be used to directly reduce pathogen infection, resulting in an increase in plant growth and crop yield. Surprisingly, several of the nanoparticles may be effective against a variety of bacteria, and they are also required by plants as micronutrients. Among the many different nanomaterial's, magnesium oxide NPs (MgONPs), which have the advantages of being nontoxic, safe, and easy to obtain, perform admirably as a bactericide and hold significant promise in the prevention of root and stem diseases. MgONPs have the potential to be great alternatives to chemical bactericides in crop protection, but more research into their impact on plants is needed (Cai, Liu et al. 2018). MgO has considerable antibacterial Nano microbial activity as a result of probable interactions between MgO NPs and bacterial spore negative surface membranes (Shoala 2018).

Assessing the effect of magnesium oxide nanoparticles on chilli plant varieties

The effect of synthesized MgONPS on pepper plant was evaluated. Their effect was measured on different parameters of plants. The effect of each concentration was measured separately. There were three concentrations of the prepared nanoparticles 200ppm, 400ppm, and 600ppm. A significant increase in nanoparticles absorption was recorded in 400-600ppm MgONPS concentration compared to the control plant.

The height (cm) of all plants of Sky Seed species was measured from the growing media level to the top of the apical bud with the help of a 50cm ruler. A significant increase in plant height was also recorded in 400ppm and 600ppm MgONPS compared to control as shown in Figure 18. The number of leaves was counted for the plants. Figure 20 shows a significant increase in the number of leaves of 400 and 600ppm plants compared to the control plant. There were greener leaves observed in plants applied with 400 and 600ppm of MgO NPS. These observations are due to the interaction of MgONPS absorbed by the leaves of plants treated with nanoparticles concentrations as well as tissue with organic compounds of green pepper forming organic mg compounds that help in the building of chlorophyll and nitrogen content in the leaves. There was nothing to report regarding phytotoxicity observations (Ghidan, Al-Antary et al. 2018). The shoot length of all plants was estimated. The substantial expansion in shoot length was seen at the grouping of 400ppm and 600ppm of MgO NPS. The shoot length of the plant of 200pmm was additionally higher than that of the control as shown in Figure 19.

The number of flowers per plant was counted and a significant increase in the number of flowers was noted in 200ppm, 400ppm, and 600ppm, respectively, compared to control as shown in Figure 21. A similar increase in fruit number was observed in the case of 200ppm, 400ppm and 600ppm. The fruit number for all plants was counted. The number of fruits in 600ppm was greater than all plants as illustrated by Figure 22.

In the case of Chilli F1 Hybrids, the effect of each concentration was evaluated on similar growth parameters. The significant effect of each parameter was observed as shown in Figures 23, 24 25, 26, and 27.

Figure 18
Height and Shoot length of Plant (Sky Seed BR-763)

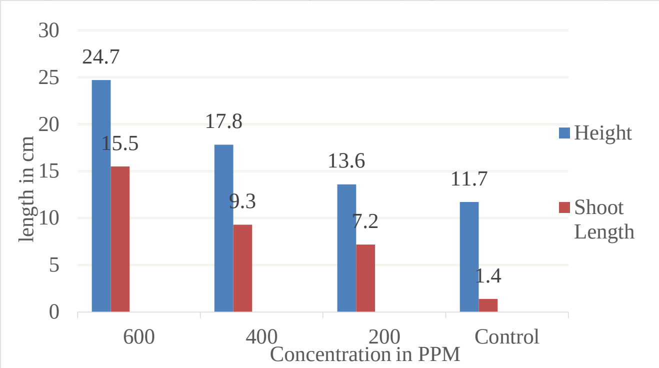


Figure 19
Number of Leaves, Flowers and Fruits of Plant Sky Seed BR-763

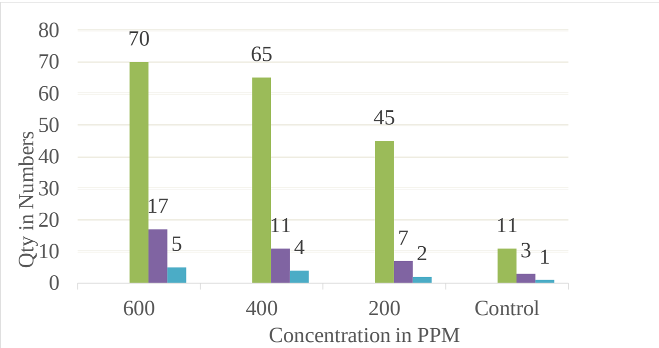


Figure 20
Height and Shoot length of plant (Chilli F1 Hybrid)

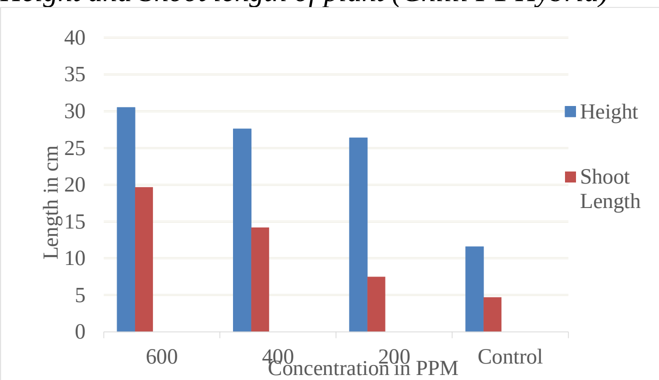
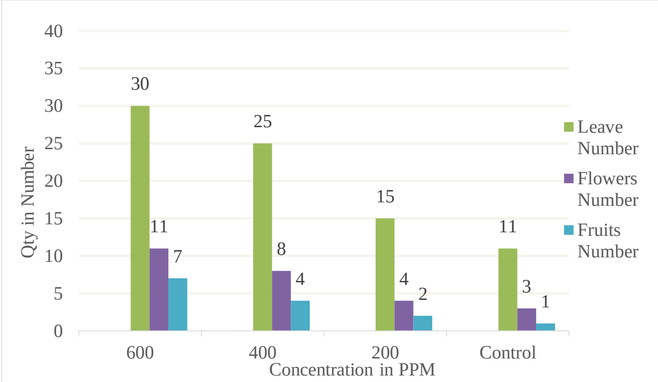


Figure 21
Number of Leaves, Flowers and Fruits of Plant (Chilli F1 Hybrid)



CONCLUSION

Nanotechnology in agriculture is primarily used to reduce pesticide and fertilizer use, reduce nutrient losses during fertilization, and increase the overall yield margins of cultivated crops by better nutrient management. The main goal of nanotechnology in agriculture is to reduce the number of spread chemicals, reduce nutrient losses during fertilization, and increase crop yield through nutrient and pest management by the use of synthesized nanoparticles.

This research proved beneficial to study the effects of synthesized MgONPS on chilli varieties. The MgONPS were prepared by using ginger and garlic extract under room conditions. The prepared MgONPS were characterized by Fourier transform infrared spectroscopy (FTIR), UV-Visible spectroscopy, and X-ray diffraction (XRD) to confirm the synthesis of MgONPS. The application of manufactured MgONPS on chilli plants at the concentration of 400ppm and 600ppm showed a significant increase in `height, shoot length, several leaves, flowers, and fruit settings compared to control. The toxic effects of nanoparticle residues were about zero.

REFERENCES

Ali, M. A., Rehman, I., Iqbal, A., Din, S., Rao, A. Q., Latif, A., ... & Husnain, T. (2014). Nanotechnology, a new frontier in Agriculture. *Adv life sci*, *1*(3), 129-138.

ayanthi, R., & Muthukrishnan, P. (2023). Green synthesis of magnesium nanoparticles and magnesium Chitosan composite using Eichhornia Crassipes leaf extract and its antibacterial activity. https://doi.org/10.21203/rs.3.rs-2755765/v1

Cagri, A., Ustunol, Z., & Ryser, E. T. (2004). Antimicrobial edible films and coatings. *Journal of Food Protection*, *67*(4), 833-848. https://doi.org/10.4315/0362-028x-67.4.833

Cai, L., Liu, M., Liu, Z., Yang, H., Sun, X., Chen, J., Xiang, S., & Ding, W. (2018). MgONPs can boost plant growth: Evidence from increased seedling growth, morpho-physiological activities, and mg uptake in tobacco (Nicotiana tabacum L.). *Molecules*, *23*(12), 3375. https://doi.org/10.3390/molecules23123375

de Mol, N.J., Fischer, M.J.E. (2010). Surface Plasmon Resonance: A General Introduction. In: Mol, N., Fischer, M. (eds) Surface Plasmon Resonance. Methods in Molecular Biology, vol 627. Humana Press. https://doi.org/10.1007/978-1-60761-670-2_1

Ditta, A. (2012). How helpful is nanotechnology in agriculture? *Advances in Natural Sciences: Nanoscience and Nanotechnology*, *3*(3), 033002. https://doi.org/10.1088/2043-6262/3/3/033002

Duhan, J. S., Kumar, R., Kumar, N., Kaur, P., Nehra, K., & Duhan, S. (2017). Nanotechnology: The new perspective in precision agriculture. *Biotechnology Reports*, *15*, 11-23. https://doi.org/10.1016/j.btre.2017.03.002

El-Refai, A. A., Ghoniem, G. A., El-Khateeb, A. Y., & Hassaan, M. M. (2018). Eco-friendly synthesis of metal nanoparticles using ginger and garlic extracts as biocompatible novel antioxidant and antimicrobial agents. *Journal of Nanostructure in Chemistry*, *8*(1), 71-81. https://doi.org/10.1007/s40097-018-0255-8

El-Sayyad, G. S., Mosallam, F. M., & El-Batal, A. I. (2018). One-pot green synthesis of magnesium oxide nanoparticles using penicillium chrysogenum melanin pigment and gamma rays with antimicrobial activity against multidrug-resistant microbes. *Advanced Powder Technology*, *29*(11), 2616-2625. https://doi.org/10.1016/j.apt.2018.07.009

Fakhri, A., & Behrouz, S. (2015). Comparison studies of adsorption properties of MgO nanoparticles and zno–mgo nanocomposites for linezolid antibiotic removal from aqueous solution using response surface methodology. *Process Safety and Environmental Protection*, *94*, 37-43. https://doi.org/10.1016/j.psep.2014.12.007

Ghidan, A. Y., Al-Antary, T. M., Awwad, A. M., & Ayad, J. Y. (2018). Physiological effect of some nanomaterials on pepper (Capsicum annuum L.) plants. *Fresenius Environmental Bulletin*, *27*(11), 7872-7878. https://www.cabidigitallibrary.org/doi/full/10.5555/20193213807

Jampílek, J., & Kráľová, K. (2015). Application of nanotechnology in agriculture and food industry, its prospects and risks. *Ecological Chemistry and Engineering S*, *22*(3), 321-361. https://doi.org/10.1515/eces-2015-0018

Jeevanandam, J., San Chan, Y., Jing Wong, Y., & Siang Hii, Y. (2020). Biogenic synthesis of magnesium oxide nanoparticles using aloe barbadensis leaf LaTeX extract. *IOP Conference Series: Materials Science and Engineering*, *943*(1), 012030. https://doi.org/10.1088/1757-899x/943/1/012030

Liu, F., Wen, L., Li, Z., Yu, W., Sun, H., & Chen, J. (2006). Porous hollow silica nanoparticles as controlled delivery system for water-soluble pesticide. *Materials Research Bulletin*, *41*(12), 2268-2275. https://doi.org/10.1016/j.materresbull.2006.04.014

Mirtalebi, S. S., Almasi, H., & Alizadeh Khaledabad, M. (2019). Physical, morphological, antimicrobial and release properties of novel mgo-bacterial cellulose nanohybrids prepared by in-situ and ex-situ methods. *International Journal of Biological Macromolecules*, *128*, 848-857. https://doi.org/10.1016/j.ijbiomac.2019.02.007

Moorthy, S. K., Ashok, C., Rao, K. V., & Viswanathan, C. (2015). Synthesis and characterization of Mgo nanoparticles by neem leaves through green method. *Materials Today: Proceedings*, *2*(9), 4360-4368. https://doi.org/10.1016/j.matpr.2015.10.027

Ndlovu, N., Mayaya, T., Muitire, C., & Munyengwa, N. (2020). Nanotechnology applications in crop production and food systems. *Int. J. Plant Breed*, *7*(1), 624-634

Panpatte, D. G. & Y. K. Jhala (2019). *Nanotechnology for Agriculture: Crop Production & Protection*, Springer.

Rai, M., & Ingle, A. (2012). Role of nanotechnology in agriculture with special reference to management of insect pests. *Applied Microbiology and Biotechnology*, *94*(2), 287-293. https://doi.org/10.1007/s00253-012-3969-4

Sarpras, M., Ahmad, I., Rawoof, A., & Ramchiary, N. (2019). Comparative analysis of developmental changes of fruit metabolites, antioxidant activities and mineral elements content in Bhut jolokia and other capsicum species. *LWT*, *105*, 363-370. https://doi.org/10.1016/j.lwt.2019.02.020

Shang, Y., Hasan, M. K., Ahammed, G. J., Li, M., Yin, H., & Zhou, J. (2019). Applications of nanotechnology in plant growth and crop protection: A review. *Molecules*, *24*(14), 2558. https://doi.org/10.3390/molecules24142558

Shoala, T. (2018). Positive impacts of nanoparticles in plant resistance against different stimuli. *Nanotechnology in the Life Sciences*, 267-279. https://doi.org/10.1007/978-3-319-91161-8_10

Singh, A., Joshi, N. C., & Ramola, M. (2019). Magnesium oxide nanoparticles (MgONPs): Green synthesis, characterizations and antimicrobial activity. *Research Journal of Pharmacy and Technology*, *12*(10), 4644. https://doi.org/10.5958/0974-360x.2019.00799.6

Sonkaria, S., Ahn, S., & Khare, V. (2012). Nanotechnology and its impact on food and nutrition: A review. *Recent Patents on Food, Nutrition & Agriculture*, *4*(1), 8-18. https://doi.org/10.2174/1876142911204010008

Yang, N., Li, F., Jian, T., Liu, C., Sun, H., Wang, L., & Xu, H. (2017). Biogenic synthesis of silver nanoparticles using ginger (Zingiber officinale) extract and their antibacterial properties against aquatic pathogens. *Acta Oceanologica Sinica*, *36*(12), 95-100. https://doi.org/10.1007/s13131-017-1099-7