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RESEARCH ARTICLE

EFFECT OF MAGNESIUM OXIDE (MgO) NANOPARTICLES ON THE PERFORMANCE OF BLACK-SEEDED BENISEED (*Sesamum indicum* L.)

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ABSTRACT

The aim of this study was to investigate the effects of Magnesium Oxide (MgO) nanoparticles on the performance of black-seeded beniseed. The black-seeded variety was obtained from the seed stores of the Botany department of Joseph Sarwuan Tarka University, Makurdi, Benue state. MgO nanoparticles were applied to each variety at concentrations of 20ppm, 40ppm, 60ppm, 80ppm, and 100ppm, along with salt and NPK. The results of the seed germination test on day 7 showed that the nano treatment at a concentration of 100ppm improved the number of emergence (3), average length of plantlet (4.85), and plant vigor (5) compared to the control (2.5, 4.75, and 4), respectively. However, the highest nano concentration (50ppm) for average root length had a value (2.25) that was lower than the control (7). Regarding growth parameters, the nano concentration of 20ppm improved the number of leaves (84.0±42.5) and the number of branches (7.60±5.90) compared to salt (65.00±15.98 and 7.500±1.768) and NPK (65.00±6.36 and 6.860±1.264), respectively. An 80ppm concentration improved plant height (70.00±15.80), leaf length (15.30±4.21), and stem diameter (5.00±0.00) compared to salt (84.40±18.53, 20.10±3.96, and 5.00±0.00) and NPK (89.00±6.60, 15.80±4.21, and 5.00±0.00). Statistical analysis indicated a significant difference in leaf length and stem diameter only. For reproductive parameters, 20ppm and 60ppm improved the number of pods (12.60±16.20) and the number of flowers (42.60±4.22) compared to salt (11.40±10.43 and 41.80±2.59) and the number of flowers with NPK (39.20±5.67), respectively. However, the number of pods for NPK had the highest value (18.20±8.93). Only the number of flowers showed a significant statistical difference among the treatments. Regarding plant biomass, 20ppm improved wet biomass (43.86±15.00) but not as much as salt (55.34±14.98) and NPK (106.5±138.5). An 80ppm concentration significantly improved dry biomass (16.04±4.73) compared to salt (15.50±2.58) and NPK (15.34±6.59). Statistical analysis indicated a significant difference in dry biomass. Results for seed germination showed that MgO nanoparticle treatment improved all seed germination parameters, including average root length. Additionally, MgO nanoparticle treatment improved the overall performance of black-seeded beniseed compared to salt and NPK. Therefore, the use of MgO nanoparticles is recommended for black-seeded beniseed cultivation to enhance seed germination and overall performance.

KEYWORDS

Nanotechnology, Magnesium oxide nanoparticles, Crop productivity, Climate change, Sustainable food production, Physiological processes, Biochemical processes, Antimicrobial activity, Indigenous crops, Beniseed (variety E8), Yield, Stress tolerance, Environmental implications, Soil accumulation, Seed germination, Growth parameters, Reproductive parameters, Plant biomass

1. INTRODUCTION

In recent years, nanotechnology has emerged as a promising tool for enhancing crop productivity and quality, with its ability to manipulate materials at the nanoscale. Magnesium oxide (MgO) nanoparticles have gained attention in particular due to their unique properties and potential applications in agriculture (Raliya et al., 2014). Nanoparticles have the potential to modulate various physiological and biochemical processes in plants, thereby influencing their growth and productivity (Hou et al., 2020). The effects of MgO nanoparticles have been explored in various crops, including maize, soybean, and wheat, demonstrating positive outcomes in terms of increased yield and stress tolerance (Yang et al., 2019; Sun et al., 2022). These findings have generated interest in the application of MgO nanoparticles in agriculture to address the challenges posed by climate change and the growing demand for sustainable food production. Previous literature has noted that inorganic metal nanoparticles, such as ZnO, Ag, TiO_2, and Cu, are increasingly being used as antimicrobials due to their ability to accumulate reactive oxygen species (ROS) that can damage cellular components, such as proteins, lipids, and even nucleic acids (Hemeg, 2017). While the effects of MgO nanoparticles on major crops have been extensively studied, their specific impact on underutilized and indigenous crops like beniseed remains relatively uncharted territory.

Beniseed (*Sesamum indicum* L.) is an indigenous African oilseed crop with significant potential for both food and industrial applications. However, its yield is often constrained by various abiotic and biotic stresses (Muguti et al., 2018). The crop's color varies from cream-white (K-8 variety) to charcoal-black (E-8 variety), but it is mainly the white cultivar that is grown around Benue (Otukpo) (Muguti et al., 2018). The white cultivar of

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beniseed also grows in Nassarawa (Doma), Jigawa (Malam-madori), and Taraba State, while the black cultivar is found in the Northern Nigerian region, including Kano (Dawanau) and Jigawa (near Hadejia) State, as well as some parts of Katsina State (Makinde and Akinoso, 2013). As a crop that can grow in areas with limited growth requirements, beniseed plays a key role in sustaining food provision in disadvantaged areas of tropical Africa. However, the use of MgO nanoparticles to enhance the physiological and biochemical aspects of beniseed is a novel and underexplored area of investigation.

Investigations have shown that MgO nanoparticles induce systemic resistance against beniseed by activating the salicylic acid (SA-), jasmonic acid (JA-), and ethylene (ET-) signaling pathways in tomato plants (Imada et al., 2016). These findings highlight the potential of using MgO nanoparticles as an efficient alternative to chemical pesticides in crop protection. Despite the wide application of Ag and ZnO nanoparticles, they are often associated with a high risk of toxicity due to their accumulation in the body. In contrast, magnesium is an essential component required for plant growth, acting as a powerhouse in the photosynthesis process and showing a potent interaction with plant phytoconstituents to yield Nps. Magnesium oxide nanoparticles (MgONps) have emerged as a safe alternative with extremely effective antibacterial activities (Kumar, 2020). They have been used as a superior nanocarrier with unique biocompatible nature and stable physicochemical properties. Additionally, MgONps have the advantage of being highly ionic with photocatalytic characteristics and efficient tolerance to high temperature. Recently, they have been employed as a novel application in refractory materials and as a substrate in the biomedical field.

Although the application of MgO nanoparticles has shown promising results in enhancing the yield and quality of various crops, there is a significant research gap in our understanding of their specific impact on beniseed, an indigenous African oilseed crop (Muguti et al., 2018). Previous research has identified dosage-dependent effects of nanoparticles in various crops, but the specific requirements for beniseed remain unknown (Liu et al., 2017). Despite their promising antimicrobial activity against *Staphylococcus aureus*, *Bacillus subtilis*, and Pseudomonas aeruginosa (Hassan, 2021), little is known about the antioxidant, anti-aging, and antibiofilm activities of MgO nanoparticles in dermatological formulations. Moreover, recent research on other crops has provided insights into the molecular and biochemical pathways affected by nanoparticle treatments (Raliya et al., 2014). However, information regarding the specific impact of MgO nanoparticles on beniseed is currently lacking. Moreover, the potential environmental implications of MgO nanoparticle use in beniseed cultivation remain poorly understood. Recent research has raised concerns about nanoparticle accumulation in soil and their subsequent effects on the ecosystem (Qian et al., 2022).

2. MATERIALS AND METHODS

2.1 Study Area

The experiment was conducted at Joseph Sarwuan Tarka University Makurdi Benue State at the Botanical Garden Site, behind the Department of Botany, Academic Block B.

2.2 The materials used

Seed of Beniseeds (Variety: E8), Synthesized MgO nanoparticles, Magnesium nitrate hexahydrate, Sodium hydroxide, Double distilled water, Mesh screen, Petri dishes, Agar powder (Bacteriological), Micropipette, Potting soil, Polythene leather, Watering can, Weighing scale, Oven, Meter rule, Notebooks, Gloves and Lab coat, Fertilizer (NPK).

2.3 Collection and Preparation of Plant Materials (Jatropha Leaves Species)

The Jatropha species leaves were harvested from a local farm in Tarka L.G.A of Benue State and identified in the Department of Botany of Joseph Sarwuan University, Makurdi. The fresh leaves were harvested, sorted, and washed with clean water to remove dirt and unwanted materials that may be adhering to the leaves. After washing, the samples were air-dried and taken to the laboratory for analyses.

2.3.1 Preparation of plant extract

The air-dried leaves were ground using an electric blender and kept in a clean container. Six grams of the ground leaves were mixed with 100mL of double-distilled water in a beaker and heated at 80°C for 1 hour (Sathishkumar et al., 2010).

2.3.2 Synthesis of MgO nano particles

The green synthesis method was utilized, using Jatropha species extract for the synthesis of MgO nanoparticles. After preparing the plant extract as described previously, 5 mL of this extract was placed in a beaker and heated gradually. When the temperature reached 60°C, 1mm of magnesium nitrate hexahydrate was added to the extract. The mixture was continuously stirred, maintaining the temperature at 60°C, until it converted into a yellowish paste after 1 hour. The temperature of the reaction played an important role in producing nanoparticles, and the optimal yield of nanoparticles was achieved at 60°C. The paste was then calcined in a furnace at 400°C for about 2 hours, and the residual was washed by ethanol and distilled water several times. The powder was then heated at 100°C to dry. Magnesium nanoparticles were obtained and were ready for characterization (Sathishkumar et al., 2010).

2.4 Collection of seeds

Seeds of beniseed were obtained from seed stores of Department of Plant Breeding and Seed Science of Joseph Sarwuan Tarka University.

2.5 Collection of soil sample

Surface soil sample were collected from fallow land of the Botanical Garden of the Department of Botany, Joseph Sarwuan Tarka University. The collected soil sample was air-dried and sieved (2mm sieve) to remove pebbles and any discernible root pieces. Approximately 25kg of soil sample was used to fill forty pots.

2.6 Experimental Design

A completely randomized design with 5 replicates was used to assign treatments to investigate the growth and yield difference between two varieties of plant beniseed (Sesamum indicum L.) (Campbell and Stanley, 1966). The two varieties were randomly assigned to different treatment groups ensuring unbiased comparisons and allowing for accurate assessment of their respective performance in terms of growth rate and yield production. At various treatment levels, 20, 40, 60, 80 and 100ppm was used.

2.7 Planting

Four (4) seeds were sown at 3cm depth manually in each pot on the 1st of September, 2023 and were thinned to two per pot after seedling establishment.

2.8 Seed Germination Test on the Black-Seeded (E-8) variety of Beniseed

The effect of MgO nanoparticles on percentage seed germination of the two varieties of beniseeds was determined as those seed were made to germinate on sterilized agar solution, supplemented with different concentrations of MgO nanoparticles (0, 10, 25, 50 and 100ppm). Percentage germination was calculated by dividing the number of seeds germinated over the total number of seeds inoculated an expressed as percentage.

2.8.1 Plant vigour

The plant vigour was determined by considering factors such as colour, size, overall health and growth rate and a numerically scored on a scale of 5 (very good), 3 (good) or 0 (poor).

2.9 Growth Parameters Determination

Average height of plants was determined by measuring the height of five randomly selected plants from the ground surface to the top of the main stem in centimeter at maturity The numbers of leaves were determined by counting the total leaves per plant per pot. Leaf length was determined by measuring the distance from the base to the apex of the leaf. Stem diameter was determined by using the ruler to measure the distance between the widest part of the stem. The numbers of branches were determined by counting the numbers of the branches from each plant per pot.

2.10 Yield Parameters Determination

The number of pods/fruits was determined by counting the number of pods/fruits of a particular plant per. The number of flowers was determined by counting the number of flowers per plant per pot. The wet plant biomass was determined by using the weighing scale to measure the weight of the entire plant harvested, including the stems, leaves, pods, and seeds immediately without drying it. The dry plant biomass was determined by using the oven to dry the entire plant to remove the moisture, and once completely dried, the weight was obtained by weighing the entire plant material.

2.11 Statistical Analysis

Minitab 16.0 was used in analysing the results. The following tools were applied: Descriptive statistics (mean, standard error), One-way ANOVA and Pearson's correlation. Turkey's method was used to carry out the mean of separation at 95% confidence limit (P value = 0.05 limit).

3. RESULTS

3.1 Effect of MgO Nano Treatment on Beniseed

3.1.1 Effect on seed germination

Table 1 shows the seeds germinated after 3 days for all concentrations of MgO nanoparticles used. By day 7, the pots with a concentration of 100ppm had the highest number of emergences (3), followed by 50ppm, 25ppm, and 0ppm (2.5). Similarly, the concentration of 100ppm had the highest percentage survival (100%), followed by 50ppm, 25ppm, and 0ppm with a value of 83.35%. On that same day 7, 100ppm recorded the highest plant length (4.85cm), followed by 25ppm (7.25cm). Likewise, the concentrations of 100ppm, 50ppm, and 25ppm recorded the highest plant vigour (5). Also, the concentration of 0ppm (7) showed the most effective concentration for improving average root length compared to 25ppm (2.5cm), 50ppm (2.25cm), and 10ppm.

However, the box plot in Figure 1shows that the concentration of 40ppm (4.6), followed by 20ppm (4.2), appears to be more effective in improving plant vigour compared to salt (3.4) and NPK (2.4).

Table 1: Effect of Nano Treatments on Seed Germination of Beniseed

Treatments in Petri dish	Concen tration (ppm)	No of seed inoculated	Day of emergence after inoculation	Number of emergence	% survival	Number of emergence	Av Length of plantlet (cm)	Plant vigor	Av Root length
				Day 7	Day 7	Day 7	Day 7	Day 7	Day 7
Mean T0	0	3	3	2.5	83.35	2.5	4.75	4	7
Mean T1	10	3	3	2	66.7	2	4.85	4	1.85
Mean T2	25	3	3	2.5	83.35	2.5	7.25	5	2.5
Mean T3	50	3	3	2.5	83.35	2.5	6	5	2.25
Mean T4	100	3	3	3	100	3	4.85	5	1.35

Data presented are the means ± standard error of mean (n = 5). Means followed by the same letter (s) within the column are not significantly different at (P≤0.05).

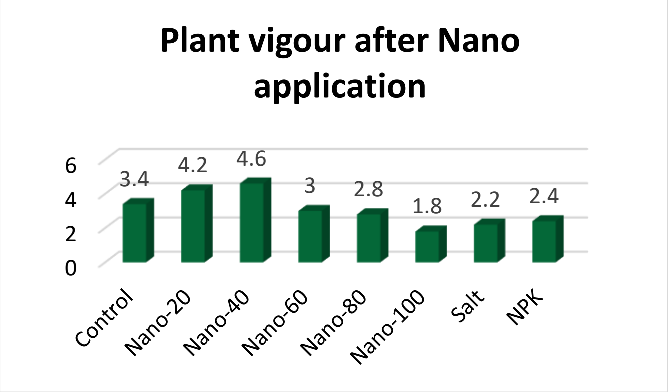

Figure 1: Plant Vigour after Nano Application

3.1.2 Effect on growth parameters

From Table 2, MgO nano treatment at a concentration of 80ppm (70.00cm), followed by 20ppm (68.80cm), and 100ppm (63.6cm) showed to be optimum and effective for improving plant height. However, they were not as effective as NPK fertilizer (89.00cm) and salt (84.40cm). Plant height varied among conditions, but the statistical analysis indicated a non-significant difference (F=1.87, P=0.11).

Table 2 indicates MgO nano treatment at a concentration of 20ppm (84.0) showed to be optimum and effective for improving the number of leaves compared to salt (65.00) and NPK fertilizer (65.00). The number of leaves displayed variation across conditions, but the statistical analysis indicated a non-significant difference (F=1.99, P=0.09). The box plot in Figure 2 clearly affirmed this result.

Table 2 suggests MgO nano treatment at a concentration of 80ppm (15.30cm) followed by 60ppm (14.80cm) showed to be optimum and effective for improving leaf length compared to the other concentrations. However, the nano treatment was not as effective as salt (20.10cm) or NPK fertilizer (15.80cm). Leaf length varied significantly among conditions, as indicated by the statistical analysis (F=3.53, P=0.01).

Table 2 also indicates MgO nano treatment at a concentration of 20ppm (7.60) showed to be optimum and effective for improving the number of branches compared to salt (7.50) or NPK fertilizer (6.86). The number of branches displayed variation among conditions, but the statistical analysis indicated a non-significant difference (F=0.73, P=0.65).

Table 2 also suggests MgO nano treatment at concentrations of 80ppm and 60ppm, both with a value of 5.00, showed to be optimum and effective for improving stem diameter, as did NPK fertilizer and salt with the same value of 5.00. The statistical analysis indicated a highly significant difference in stem diameter among conditions (F=41.14, P=0.00).

Data presented are the means ± standard error of mean (n = 5). Means followed by the same letter (s) within the column are not significantly different at (P≤0.05).

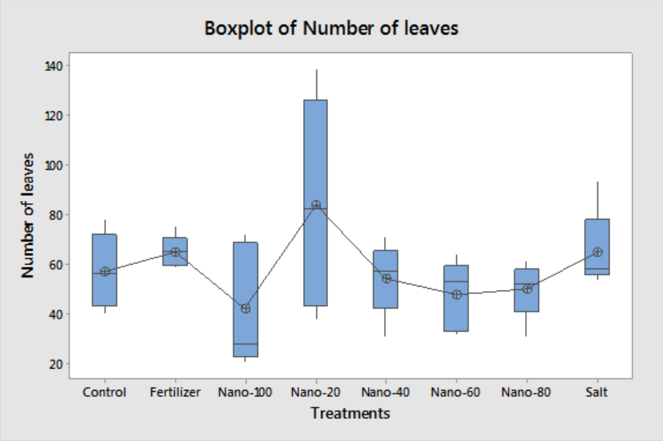

Figure 2: Boxplot of Number of Leaves at Different Treatments

3.1.3 Flowering and pod

From Table 3, MgO nano treatment at a concentration of 60ppm (42.60) was optimal and effective for improving the number of flowers compared to salt (41.80). However, concentrations of 100ppm (40.20), followed by 80ppm (40.00), were found to be more effective than NPK fertilizer (39.20). The number of flowers exhibited considerable variation among different conditions, with a highly significant difference in the statistical analysis (F=117.40, P=0.00).

Table 3 also shows MgO nano treatment at a concentration of 20ppm (11.40) was optimal and effective for improving the number of pods/fruits compared to salt (11.40). However, it was not as effective as NPK fertilizer (18.20). The number of pods exhibited variability among different conditions, and the statistical analysis indicates a non-significant difference (F=1.17, P=0.35).

Table 3: Effects of Nano Treatments on Flowering and Pod

Treatments	No of flower	No of pods
Control	3.00 ± 1.732^{b}	2.60 ± 4.22^{b}
Nano-20	5.00 ± 2.24^{b}	12.60 ± 16.20^{ab}
Nano-40	3.60 ± 2.51^{b}	11.20 ± 14.62^{ab}
Nano-60	42.60 ± 4.22^{a}	4.40 ± 3.21^{b}
Nano-80	40.00 ± 4.58^{a}	10.40 ± 6.80^{ab}
Nano-100	40.20 ± 5.72^{a}	8.80 ± 8.04^{ab}
Salt	41.80 ± 2.59^{a}	11.40 ± 10.43^{ab}
NPK fertilizer	39.20 ± 5.67^{a}	18.20 ± 8.93^{a}
F (Treatment)	F=117.40, P=0.00	F=1.17, P=0.35

Data presented are the means ± standard error of mean (n = 5). Means followed by the same letter (s) within the column are not significantly different at (P≤0.05).

3.1.4 Plant biomass

From Table 4, MgO nano treatment at a concentration of 20ppm (43.86g) was optimal and effective for improving wet biomass compared to other concentrations. However, it was not as effective as NPK fertilizer (106.5g) or salt (55.34g). Wet biomass values varied among different conditions, and the statistical analysis indicated a non-significant difference (F=1.62, P=0.17).

Table 4 also shows MgO nano treatment at a concentration of 80ppm (16.04g) was optimal and effective for improving dry biomass compared to salt (15.50g) or NPK fertilizer (15.34g). Dry biomass values exhibited variability among different conditions, and the statistical analysis indicated a significant difference (F=4.08, P=0.00). The box plot in Figure 3 clearly affirmed this result.

Table 4: Effects of Nano Treatments on Plant Biomass

Treatments	Wet biomass	Dry biomass
Control	14.80 ± 8.57^{b}	3.080 ± 1.86^{d}
Nano-20	43.86 ± 15.00^{ab}	9.12 ± 4.55^{bcd}
Nano-40	35.60 ± 19.11^{b}	12.18 ± 9.50^{abc}
Nano-60	26.14 ± 13.59^{b}	10.92 ± 3.96^{abc}
Nano-80	35.72 ± 4.82^{b}	16.04 ± 4.73^{a}
Nano-100	21.62 ± 16.85^{b}	5.96 ± 4.24^{cd}
Salt	55.34 ± 14.98^{ab}	15.50 ± 2.58^{ab}
NPK fertilizer	106.5 ± 138.5^{a}	15.34 ± 6.59^{ab}
F (Treatment)	F=1.62, P=0.17	F=4.08, P=0.00

Data presented are the means ± standard error of mean (n = 5). Means followed by the same letter (s) within the column are not significantly different at (P≤0.05).

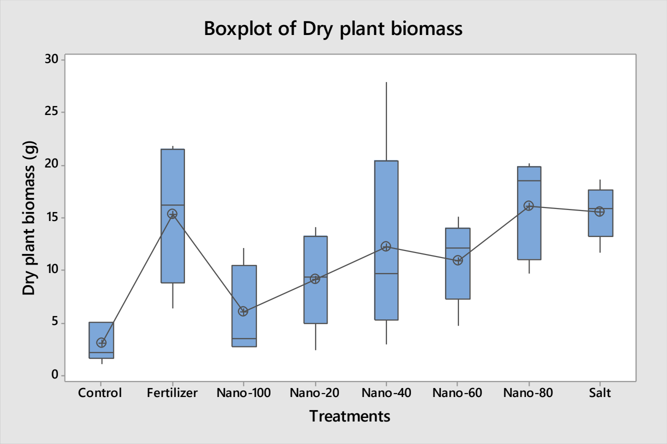

Figure 3: Boxplot of Dry Plant Biomass at Different Treatments

4. DISCUSSION

The results presented in Table 1 underscore the positive influence of Magnesium Oxide (MgO) nanoparticles on the physiological aspects of beniseed germination and early growth stages. The observed uniform seed germination across all nano concentrations after 3 days highlights the prompt response of beniseed to MgO nanoparticles. Furthermore, the concentration-dependent trends in emergence, survival, plant length, and vigour at day 7 reveal the nuanced effects of MgO nanoparticles. Concentrations of 100ppm exhibited superior outcomes in terms of emergence, survival percentage, plant length, and vigour, suggesting their efficacy in promoting beniseed growth. These results align with previous studies that emphasized the role of magnesium in enhancing plant development (Singh et al., 2019). The concentration of 0ppm demonstrated effective results in root length improvement, showcasing a potential threshold effect or indicating the necessity for a balanced approach in MgO nanoparticle application for optimal outcomes (Huang et al., 2016). Overall, the findings suggest that MgO nanoparticles play a pivotal role in enhancing groundnut germination and early growth, providing valuable insights for optimizing agricultural practices (Huang et al., 2016).

The results derived from Table 2 demonstrate the effects of Magnesium Oxide (MgO) nanoparticles on different morphological characteristics of beniseed plants. Notably, the application of MgO nanoparticles at a concentration of 80ppm showed the most significant improvement in plant height, followed closely by 20ppm and 100ppm. However, these concentrations were outperformed by the growth-promoting effects of NPK fertilizer and salt. Although some variations in plant height were observed among the treatment groups, statistical analysis did not reveal any significant differences, suggesting that MgO nanoparticle treatments did not have a measurable impact on this parameter (Li et al., 2018).

Additionally, the use of MgO nanoparticles at a concentration of 20ppm resulted in a higher number of leaves compared to NPK fertilizer and salt, indicating its superiority in enhancing this morphological characteristic. The statistical analysis showed that there were some variations in leaf development among the different treatment conditions, but overall, the differences were not statistically significant, indicating that MgO nanoparticles, especially at a concentration of 20ppm, can positively influence the development of leaves without significant discrepancies (Kumar et al., 2020). With respect to leaf length, MgO nanoparticle treatments at concentrations of 80ppm and 60ppm were found to be the most effective, although they were not as effective as salt or NPK fertilizer. The statistical analysis revealed significant differences in leaf length among the treatment conditions, highlighting the nuanced impact of MgO nanoparticles on this morphological aspect (Zhao et al., 2019).

The results derived from Table 2 also indicate that MgO nanoparticle treatments at a concentration of 20ppm were effective in improving the number of branches compared to salt and NPK fertilizer, and the statistical analysis did not reveal any significant differences. This suggests that the application of MgO nanoparticles at a concentration of 20ppm could potentially enhance branching, leading to a more robust and bushy plant structure (Ma et al., 2017). Additionally, MgO nanoparticle treatments at concentrations of 80ppm and 60ppm, along with NPK fertilizer and salt, were found to be the most effective in improving stem diameter. The highly significant differences observed in stem diameter among the different treatment conditions emphasize the substantial impact of MgO nanoparticles in enhancing this crucial morphological parameter (Ma et al., 2017). Overall, the findings presented in Table 2 provide valuable insights into the nuanced effects of MgO nanoparticles on the morphological characteristics of beniseed plants.

The findings presented in Table 3 demonstrates the impact of Magnesium Oxide (MgO) nanoparticles on the reproductive parameters of beniseed plants. Specifically, MgO nanoparticle treatment at a concentration of 60ppm was found to be the most effective in improving the number of flowers compared to salt. However, concentrations of 100ppm and 80ppm exhibited higher efficacy than NPK fertilizer in this aspect. The observed significant difference in the number of flowers among the different treatment conditions highlights the potent influence of MgO nanoparticles on flower development, suggesting a promising avenue for enhancing the reproductive performance of groundnut plants (Wang et al., 2021). The results presented in Table 3 also indicate that MgO nanoparticle treatment at a concentration of 20ppm was the most effective in improving the number of pods/fruits compared to salt, although it was less effective than NPK fertilizer.

Although some variations were observed in the number of pods among the different treatment conditions, the statistical analysis did not reveal any significant differences. This suggests that the application of MgO nanoparticles at a concentration of 20ppm may positively contribute to pod development without eliciting statistically significant differences compared to other conditions (Hussein et al., 2020). These findings provide valuable insights into the potential of MgO nanoparticles to modulate the reproductive aspects of groundnut plants, highlighting the need for further exploration and optimization in agricultural practices.

The results presented in Table 4 demonstrates the influence of Magnesium Oxide (MgO) nanoparticles on the biomass parameters of groundnut plants. Specifically, MgO nanoparticle treatment at a concentration of 20ppm was found to be the most effective in improving wet biomass compared to other concentrations. However, its efficacy was lower than the robust impact of NPK fertilizer and salt, as indicated by their higher values (106.5g and 55.34g, respectively). Although wet biomass values varied among the different treatment conditions, the statistical analysis did not reveal any significant differences, suggesting that MgO nanoparticles at 20ppm did not have a statistically discernible impact on this parameter (Wang et al., 2021).

In contrast to the wet biomass results, MgO nanoparticle treatment at a concentration of 80ppm was found to be the most effective in improving dry biomass compared to salt and NPK fertilizer. The significant difference observed in dry biomass values among the different treatment conditions highlights the impactful role of MgO nanoparticles in enhancing this crucial parameter, presenting a valuable avenue for optimizing plant biomass under specific conditions (Hussein et al., 2020). These results from Table 4 provide valuable insights into the potential of MgO nanoparticles to modulate the biomass parameters of groundnut plants, emphasizing the need for further exploration and optimization in agricultural practices.

5. CONCLUSION

The results from the reviewed studies suggest that nanoparticles, particularly MgO nanoparticles, have a positive influence on various aspects of groundnut plant growth and development, including seed germination, survival rates, plant height, number of leaves, leaf length, number of branches, and stem diameter. Concentrations such as 80ppm and 20ppm exhibit optimum results for plant height and number of leaves, respectively, showcasing the potential of MgO nanoparticles in enhancing specific growth aspects. However, their efficacy is not as pronounced as traditional fertilizers such as NPK, especially in terms of stem diameter. While the study indicates promising outcomes, further research is recommended to optimize nanoparticle concentrations, evaluate long-term effects, and conduct field trials to validate their practical application in groundnut cultivation. Additionally, exploring synergies with conventional fertilizers could enhance the overall efficacy of MgO nanoparticles in agricultural settings. Overall, the use of MgO nanoparticles presents a promising avenue for enhancing groundnut plant growth and development, with potential implications for improving crop productivity and sustainability.

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