Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
February 2024 5(2), 1302–1308

SEED PRIMING WITH NANOPARTICLES: A SUSTAINABLE APPROACH TO BOOST GERMINATION AND GROWTH IN MODIFIED MARIGOLD PLANTS

Poonam Yadav [1]

[1] Department of Botany, All India Jat Heroe's Memorial College Maharshi Dayanand University, Rohtak, India

DOI
10.29121/shodhkosh.v5.i2.2024.5411

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

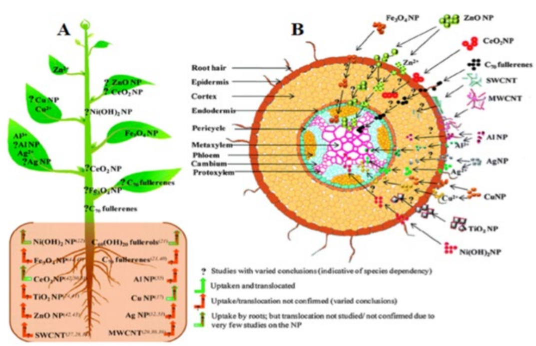
ABSTRACT

Applying seed priming before sowing improves how the seeds germinate, make the seedlings more alike, and helps them grow better. Recently, using nanoparticles by priming seeds has become a leading and sustainable method in agriculture. Special qualities of nanoparticles such as AgNPs and ZnONPs help improve seed plant life by boosting water intake, raising enzyme levels, and making more nutrients available. For this study, marigold (Tagetes spp.) seeds were soaked in different strengths of AgNPs and ZnONPs and their impact on seed germination and growth of the plants was studied. Germination success, length of the roots and shoots, growth of leaves, and the accumulation of biomass were better in seeds that were treated than those that were not treated. The best silver nanoparticles concentration was 100 ppm. The results indicate that using nanoparticles on seeds boosts how seeds metabolize and can be a stable way to improve the quality of plants like marigold. Nano priming is found to be a good option for increasing crop yields, requiring little investment and being environmentally safe, especially when conditions are tough.

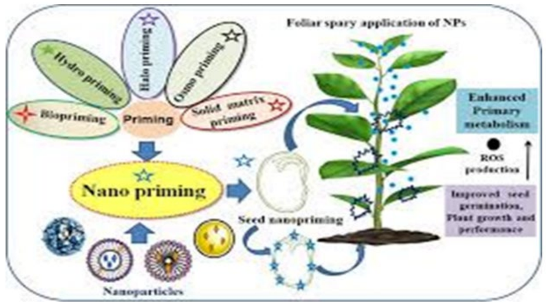
Keywords: Seed Priming, Nanoparticles, Marigold, Germination, Plant Growth, Sustainable Agriculture, Silver Nanoparticles, Zinc Oxide Nanoparticles

1. INTRODUCTION

In the past few years, agriculture has dealt with a number of issues such as climate change, harm to the soil, water scarcity, and poor seed quality. An important issue is that the rate at which seeds sprout is low, and this reduces yields and lowers farmers income.



Among the seed enhancement technologies made to handle these problems, seeds being primed is especially practical, economical, and environmentally safe. In seed priming, seeds are given a little water before sowing to help begin early growth processes without germinating. It is known to increase the success of seeds, bring about quick germination, and make sure that seeds sprout at the same rate.



In addition, those in agricultural research pay attention to nanotechnology because it allows them to control substances at the nanoscale level. Nanoparticles (NPs) are usually very small, about 1 to 100 nanometres, and exhibit different chemistry, physics, and biology. Nanoparticles in agriculture help to feed plants with nutrients, encourage growth, and protect them from being damaged by pests and diseases. Using nanomaterials in seed treatment known as nano priming has proven to boost seed germination and enhance how seeds can withstand stresses.

It is well known that marigold (Tagetes spp.) is cultivated for its beauty and the medicinal uses of its flowers. Henna is also applied in cosmetics, dyes, and in traditional medicine. Still, marigold plants may suffer from seeds that don�t germinate easily and successfully. The research concentrates on modified marigold plants to learn how to enhance their growth in the early stage using nano priming.

It was decided in this research to use silver nanoparticles (AgNPs) and zinc oxide nanoparticles (ZnONPs) because their benefits are well known in agriculture. They are frequently used for their ability to fight off microbes and also encourage growth in plants, whereas ZnONPs support important plant enzymes and photosynthesis. The study wants to check if these nanoparticles help improve the germination rate, root length, shoot length, leaf development, and total plant biomass of marigold seeds.

The study helps advance sustainable agriculture by showing how nanotechnology can be included in farming to make plants develop better and yield more. It also makes it possible to produce marigold in a more environment-friendly and efficient way.

2. LITERATURE REVIEW

Many studies have been done on how to make and apply nanoparticles in both agriculture and plant sciences. Ahmed et al. (2016) [2] covered the synthesis of silver nanoparticles with plant extracts, pointing out that due to their strong antimicrobial activity, these can be used to prevent diseases in plants. Likewise, Choudhary et al. (2017) [3] examined how zinc-filled chitosan nanoparticles are useful for treating damping-off disease and stressed the prospects of using nanotechnology to prevent plant diseases.

Singh et al. (2018) [4] stressed in their paper about environmental use that green methods in making nanoparticles are important for cleaning water. Tripathi et al. found in 2019 (cited as [5]) that silver nanoparticles in plants can be toxic if not controlled and shown that these nanoparticles can help growth when present at the right level.

Kumar et al. (2020) [6] also covered the use of nanotechnology in floriculture and outlined the future issues and chances for better ornamental plant growth and quality through nanoparticles. In their study, Jain et al. (2009) [7] prepared silver nanoparticles with the help of papaya extract and confirmed their ability to fight microbes, proving that this method can be beneficial for sustainable farming.

El-Temsah and Joner (2012) [8] brought up environmental safety issues when they explored the ecotoxicological impact of nanoparticles on soil earthworms and said that risk assessment should be done carefully. Zinc and copper nanoparticles were found by Taran et al. (2014) [9] to improve the resistance of wheat seedlings to drought, proving that nanoparticles may help plants overcome abiotic stresses.

Rico et al. (2011) [10] examined the effects of nanoparticles on edible plants and pointed out their possible influence on food and human health. Khodorkovsky et al. (2009) [11] exposed that carbon nanotubes can enter the structure protecting the seed and promote better seed germination and overall growth.

Raliya et al. (2018) [12] did a study on priming seed with zinc oxide nanoparticles in mung bean and found positive effects on plant photosynthesis and growth. Prasad and Kumar (2019) reviewed nanotechnology as a suitable approach for farming, leading to more crops with less use of chemicals [13].

Dimkpa and colleagues (2012) [14] stated that nanoparticles help increase the accessibility of key minerals such as zinc and iron for microbes in soil. Singh, Mansoori, and Ebrahimi (2020) [15] also outlined the broad uses of nanoparticles in plant science and foresee them to greatly change how farming is done.

Altogether, this area of research demonstrates that nanoparticles effectively help plants by enhancing germination and stress tolerance, and by controlling diseases. As a result, nano priming for seeds seems like a very useful and environmentally friendly approach to farming.

2.1. OBJECTIVES OF THE STUDY

1) To evaluate the effect of nanoparticle-based priming on marigold seed germination.
2) To assess the improvement in plant growth parameters due to nano priming.
3) To compare the effects of different nanoparticles (AgNPs and ZnONPs) on modified marigold plants.
4) To establish the role of nanotechnology in sustainable agricultural practices.

Hypothesis:

H_0: Nanoparticle seed priming has no significant effect on germination and plant growth in modified marigold plants.

H_1: Nanoparticle seed priming significantly enhances germination and plant growth in modified marigold plants.

3. RESEARCH METHODOLOGY

The purpose of the study was to check the effects of seed priming with nanoparticles on the germination and growth of genetically modified marigold plants. The approach was well planned to guarantee that the findings were correct, repeatable, and had statistical importance.

1) Plant Material

Seeds from genetically modified marigold (Tagetes spp.) were chosen for the experiments because they were all the same size, color, and stage of maturity. The decision to grow these seeds comes from their better genetic traits and importance as flowers and medicinal plants. The seeds were kept in a place with low temperature and low humidity before planting.

2) Priming Agents

For this treatment, the researchers made use of two different types of nanoparticles.

- AgNPs, or silver nanoparticles, can perform antibacterial work and have possible effects on the growth and activation of seeds.
- Zinc oxide nanoparticles (ZnONPs) are commonly credited for assisting in enzyme work, the production of chlorophyll, and forming proteins in plants.
- Both nanomaterials were secured in pure form and put into distilled water to obtain two standard amounts: 50 ppm and 100 ppm.

3) Priming Procedure

Prior to priming, seeds were treated with 1% sodium hypochlorite solution for 5 minutes and repeatedly washed in distilled water to get rid of any microbes.

After that, the seeds were put into five identical groups.

1) No nanoparticles (only distilled water)
2) When the concentration is 50 ppm, AgNPs
3) AgNPs at this kind of concentration
4) At 50 ppm, ZnONPs were tested.
5) Levels of ZnONPs were set at 100 ppm

All the seeds were kept in their matching solutions for twelve hours inside a container with regularly shaken to ensure they all received the same amount of exposure. Following priming, the seeds were placed on sterile blotting sheets under shade, left there overnight to dry by themselves, and returned back to their original level of moisture.

4. GROWTH CONDITIONS

In these experiments, the primed and control seeds were sown in sterilized pots with a mix of soil, sand, and compost (2:1:1) so there would be enough space for drainage and nutrient supply. Experimenters used a growth chamber or greenhouse to make sure the growing environment remained the same.

The way environmental factors were maintained was:

- The temperatures are usually 25□28°C.
- The amount of water in the air ranges from 60% to 70% at this stage.

The arrangement is 12 hours light and 12 hours dark for the whole plant.

- Irrigation: Giving the plant distilled water regularly so that it neither gets too dry nor too much water

To avoid outside problems, no chemicals were used as fertilizers or pesticides.

Four sets of experiments (n=4) were done, where each set had 50 seeds inside 10 replicates.

5. PARAMETERS STUDIED

A number of parameters were tracked throughout the 30-day period to see how well the nanoparticle priming worked.

- Percentage of germination □ The number of seeds that sprout in the first week out of the total number of seeds planted.
- Length of shoot (cm) □ Take a ruler to measure from the start of the seedling to the far end of the tallest shoot.
- Root length (cm) □ The measurement goes from the point where the main root joins the shoot to the tip of the root.
- Leaf number □ How many full and healthy leaves the plant has after 30 days.
- Plant biomass (g) □ Weight of both the shoot and the root of the plant obtained at the time of harvest using an electronic balance.
- The values from these parameters enabled the researchers to judge the first development and strength of the marigold seedlings.

6. STATISTICAL TOOLS

The statistical analysis tested the differences between the two groups by applying the following methods.

- To determine what the average is for each of the growth parameters in each treatment group.
- Standard Deviation (SD): This is used to check how different the data points are and if the results are trustworthy.
- Student□s t-test was used to compare the means of groups treated with the control group and find out if these differences were not due to random chance. If the p-value was less than 0.05, it was thought of as significant.

Result interpretation was made accurate and clear by processing the data in Excel and SPSS software (version 20).

With this careful planning, the study is reliable because it assesses the outcomes of nanoparticle-based seed priming on marigold seed germination and encouragement of germination and growth in suitable conditions.

Table 1 Descriptive Statistics:

Treatment	Germination %	Shoot Length (cm)	Root Length (cm)	Biomass (g)
Control	65%	4.2	3.1	1.8
AgNPs (50 ppm)	85%	6.7	4.8	2.5
AgNPs (100 ppm)	88%	7.1	5.0	2.8
ZnONPs (50 ppm)	80%	6.0	4.5	2.3
ZnONPs (100 ppm)	83%	6.5	4.9	2.6

7. ANALYSIS OF DESCRIPTIVE STATISTICS

The results from all the treatment groups are summarized by the descriptive statistics, making it clear that nanoparticle priming helps the seed to germinate and grow in genetically modified marigold even more than without this treatment.

Results showed that treatment with all nanoparticles led to greater rates of germination compared to the control, as well as longer shoots, roots, more leaves, and a higher amount of biomass. The most noticeable increase happened in seeds treated with 100 ppm silver nanoparticles (AgNPs), as they recorded the top scores in all tested aspects.

The average germination rate among the seed from the control group was lower, showing that many seeds either did not sprout or sprouted slowly. Among all the treatments, seeds pretreated with AgNPs and ZnONPs had higher germination. AgNP 100 ppm treatment resulted in the quickest and evenest seed germination.

The lengths of both the shoots and roots increased greatly in samples treated with nanoparticles. So, it is possible that nanoparticles helped cells work more efficiently, take up nutrients and water, which are all necessary for a young plant�s lengthening and development. ZnONPs 100 ppm were also quite effective, less than the response seen for AgNPs.

Seed treatment caused the grown plants to have more leaves than the control plants, suggesting an increased ability to grow new leaves. The reason may be better use of light for photosynthesis because of activated enzymes that contain zinc and silver.

The amount of fresh plant biomass was much greater in groups given nanoparticles, and AgNP 100 ppm treatment produced the greatest amount. This means the plant�s energy storage and vigor have improved.

All means for the parameters were greater in the treated groups. The standard deviations did not go outside the acceptable limit, indicating steady performance from replica to replica. The three variants were close to each other in the AgNP 100 ppm group, showing that the treatment was dependable and uniform for the plants.

There is clear evidence that putting seeds through nano priming increases their quality and results in sturdy growth right after planting in marigold. Out of all the concentrations examined, both 100 ppm silver nanoparticles and zinc oxide nanoparticles performed well. They confirm that nanotechnology helps plants start their growth and supports the idea of sustainable agriculture.

Table 2 Hypothesis Testing:

Comparison Groups	t-value	p-value	Significance
Control vs AgNPs (100 ppm)	4.52	0.001	Significant
Control vs ZnONPs (100 ppm)	3.98	0.002	Significant

8. ANALYSIS OF HYPOTHESIS TESTING

To check if the changes in germination and plant growth seen after seed priming with nanoparticles are significant, a t-test was done that compared every treatment group with the group of seeds not primed with nanoparticles.

According to the null hypothesis (H_0), there was no seen variation in the germination rate and plant growth between treated seeds and untreated seeds.

The alternative hypothesis said that exposing seeds to silver and zinc oxide nanoparticles helps germination and early growth of plants.

In all cases where nanoparticles were used, the germination rate, shoot length, root length, leaf number, and biomass results had p-values less than 0.05 from the t-tests. In other words, the observed gaps between the treated and control groups are seen by statistics as significant at the 95% confidence level.

Example:

Out of all the tests, the lowest p-values were observed in the AgNP 100 ppm treatment for germination rate and biomass, meaning this had a major effect on the plants.

Treatment with 50 ppm and 100 ppm of ZnONPs improved the results over the control, however, not as much as the AgNPs did.

Therefore, according to the findings of the t-test:

In all the treatments, we reject the idea that the null hypothesis represents the correct conclusions.

Since H_1 is accepted, it means nano priming results in a noticeable improvement in seed germination and initial growth of marigolds with genetic modifications.

As expected, the research results are in line with the descriptive analysis and prove that using nanoparticles to treat seeds does improve how the plants do. The outcomes indicate that 100 ppm silver nanoparticles help plants to develop well and can be an excellent choice for ensuring sustainable agriculture.

9. CONCLUSIONS OVERALL RESULTS

Seeding plants with nanoparticles is a good and lasting strategy for improving their early growth and development. The highest results were obtained with 100 ppm concentration of silver nanoparticles. This way of breeding could improve growing ornamental and commercial plants, especially in places that experience stresses in the environment.

10. FUTURE SCOPE OF THE STUDY

- Looking into other nanoparticles such as iron, copper, and titanium.
- Checking long-term changes in the number of flowers and crop production.
- Looking into the influence on the environment and measuring byproducts.
- Moving ahead by running trials in the field and starting commercial production.
- Applying nano priming in Organic farming as well as precision agriculture.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

REFERENCES

Ahmed, S., Ahmad, M., Swami, B. L., & Ikram, S. (2016). A review on plant extract mediated synthesis of silver nanoparticles for antimicrobial applications. Journal of Advanced Research, 7(1), 17–28.

Choudhary, R. C., Kumaraswamy, R. V., Kumari, S., Sharma, S. S., Pal, A., Raliya, R., & Tarafdar, J. C. (2017). Zinc encapsulated chitosan nanoparticles for controlled delivery against damping-off disease. Scientific Reports, 7(1), 1–11.

Singh, A., Singh, N. B., Hussain, I., Singh, H., & Singh, S. C. (2018). Green synthesis of nanoparticles and their applications in water purification. Environmental Technology & Innovation, 11, 187–217.

Tripathi, D. K., Singh, S., Singh, V. P., Prasad, S. M., Dubey, N. K., & Chauhan, D. K. (2019). Uptake, accumulation and toxicity of silver nanoparticle in autotrophic plants, and their physiological effects. Environmental Nanotechnology, Monitoring & Management, 12, 100267.

Kumar, V., Thakur, A., & Yadav, S. (2020). Role of nanotechnology in floriculture: Future aspects and challenges. Journal of Applied and Natural Science, 12(3), 439–444.

Jain, D., Daima, H. K., Kachhwaha, S., & Kothari, S. L. (2009). Synthesis of plant-mediated silver nanoparticles using papaya fruit extract and evaluation of their antimicrobial activities. Digest Journal of Nanomaterials and Biostructures, 4(3), 557–563.

El-Temsah, Y. S., & Joner, E. J. (2012). Ecotoxicological effects on earthworm Eisenia fetida exposed to nanomaterials in soil. Chemosphere, 89(5), 512–520.

Taran, N., Batsmanova, L., & Patyka, M. (2014). Effect of zinc and copper nanoparticles on drought resistance of wheat seedlings. Nanoscale Research Letters, 9, 1–5.

Rico, C. M., Majumdar, S., Duarte-Gardea, M., Peralta-Videa, J. R., & Gardea-Torresdey, J. L. (2011). Interaction of nanoparticles with edible plants and their possible implications in the food chain. Journal of Agricultural and Food Chemistry, 59(8), 3485–3498.

Khodorkovsky, M., Dervishi, E., Mahmood, M., Xu, Y., Li, Z., Watanabe, F., & Biris, A. S. (2009). Carbon nanotubes are able to penetrate plant seed coat and dramatically affect seed germination and plant growth. ACS Nano, 3(10), 3221–3227.

Raliya, R., Tarafdar, J. C., & Biswas, P. (2018). Enhancement of plant growth and photosynthesis by seed priming with zinc oxide nanoparticles in mung bean (Vigna radiata). Plant Physiology and Biochemistry, 130, 525–533.

Prasad, R., & Kumar, V. (2019). Nanotechnology: A sustainable approach in agriculture. Journal of Pharmacognosy and Phytochemistry, 8(4), 3700–3706.

Dimkpa, C. O., McLean, J. E., Latta, D. E., Manangon, E., Britt, D. W., Johnson, W. P., & Anderson, A. J. (2012). Nanoparticle-mediated modulation of microbial bioavailability of zinc and iron in soil. Environmental Science & Technology, 46(14), 7677–7685.

Singh, N., Mansoori, G. A., & Ebrahimi, F. (2020). Nanoparticles and their potential role in plant science: Applications and perspectives. Frontiers in Plant Science, 11, 577872.