

Nanoparticles as a Tool for Environmentally Conscious Farming

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Tiny is beautiful and tiny is potential this statement holds well when we talk about nanoparticles. Nanoparticles generally are considered as particles with a size of up to 100 nm, exhibit completely new or improved properties as compared to the larger particles of the bulk material.

Climate change, the loss of resources, and the extinction of biodiversity all pose threats to our agriculture. In order to boost crop output and guarantee the quality and safety of food in a sustainable manner, a new agricultural revolution is required and this could be facilitated by nanotechnology. At present, different types of metal nano-materials are being produced using copper, potassium, iron, zinc oxide, titanium, magnesium, gold, alginate and silver *etc.* The effective process of seed nano-priming can alter the metabolic and signalling pathways of seeds, which has an impact on all stages of plant life, including germination and seedling establishment. Studies have demonstrated a number of advantages of seed nano-priming, including enhanced plant growth and development, increased productivity, and better food quality in terms of nutrients.

Nanoparticles as Foe and a Friend

Recent research has demonstrated that seeds and plants are affected by nanoparticles. Some nanoparticles may disrupt germination or cause phytotoxicity in seedlings, among other adverse consequences. Others, however, can operate as stimulants by influencing cellular signalling pathways, which enhance seed metabolism, seedling vigour, and plant development. These effects are influenced by the physical-chemical characteristics of nanoparticles, which include their size, zeta potential, and concentration.

In order to protect seeds during storage, enhance germination and germination synchronisation, boost plant growth, and increase crops' resistance to biotic or abiotic stress

conditions, nano-priming can be applied to seeds. This can help to lower the amounts of pesticides and fertilisers needed. According to recent studies, seed nano-priming can activate a variety of genes during germination, particularly those involved in plant stress resistance. Even while studies have previously produced encouraging results, the use of nanotechnology for seed priming is a relatively new field of study. Since many nanoparticles have antimicrobial properties and can load antimicrobial compounds, seed nano-priming can also be employed to protect seeds. Additionally, bio fortification of seeds by nano-priming can be employed to encourage an improvement in food quality and production.

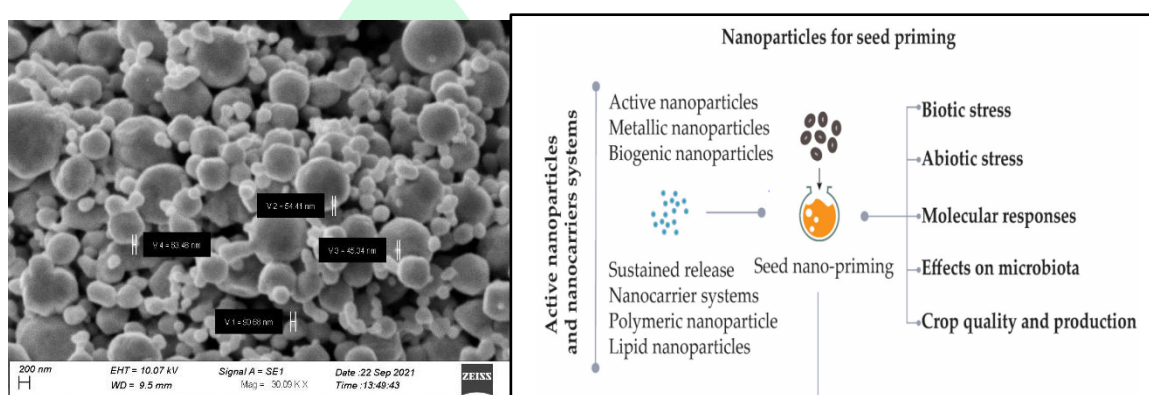


Fig. a) SEM image of silver nanoparticles at 200nm scale

b) Potential benefits of seed nano priming (image source: Anderson do Espirito Santo Pereira *et al.*, 2021)

Conclusion

One method that can be used to increase sustainability in agriculture is seed nanopriming, which is a promising application of nanotechnology. Once these systems are able to promote plant establishment and provide protection against biotic and abiotic stresses, resulting in improvements of productivity and food quality, they have the potential to transform traditional agriculture based on the use of agrochemicals towards a more sustainable agriculture. Together, these elements may provide a system that is safer for farmers and consumers while minimising environmental harm from conventional agriculture. The future studies should also be initiated at genomics and proteomics level with an objective to understand various changes in seeds at cellular level and examine the cellular mechanisms.