SUNSHINE AGRICULTURE
e-Newsletter

ISSN (E): 2583 – 0821

Sun. Agri.:e- Newsletter, (2026) *6*(10), 100-103

Article ID: 696

NANO FERTILIZERS - NANO LOSSES

Kayitha Vilakar[1]
Rathod Sridhar[2]
Prem kumar[3]

[1]Teaching Associate, Department of Soil Science & Agricultural Chemistry, Agricultural College Jagtial, PJTAU, 505529 - India
[2]Ph.D. Scholar, Department of Agronomy, School of agricultural sciences, Nagaland University Medziphema, 797106 - India.
[3]Ph.D. Scholar Division of Soil Science and Agriculture Chemistry, ICAR-Indian Agricultural Research Institute New Delhi-110012.

Open Access

*Corresponding Author
Kayitha Vilakar*

Available online at

Article History
Received: 13.10.2026
Revised: 17.10.2026
Accepted: 21.10.2026

This article is published under the terms of the Creative Commons Attribution License 4.0.

INTRODUCTION

Nanotechnology offers an alternative solution to overcome the disadvantages of conventional agriculture. Therefore, recent developments in using nanoparticles (NPs) in agriculture should be studied. Nano fertilizers are more reactive, can penetrate the epidermis allowing for gradual release, targeted distribution and thus reducing nutrient surplus, enhancing nutrient use efficiency (Verma *et al.*, 2022).

2. Components of nano-fertilizer

a) The surface

Functionalised with a range of metal ions, small molecules, surfactants or polymers. It is base catalysed hydrolysis of tetraethyl orthosilicate, which results in particles of 10-350 nm that have a charged surface. Monofunctional long chain molecules, such as amines, phosphines, carboxylates and thiols, which bind to specific sites on the surface of the nanoparticle and have long chains that extend into the dispersion medium, thereby imparting stability. Generally, these are applied to the surface of the particle during preparation and can be later modified.

b) The shell

This is a layer of chemically different material from the core material. e.g. Quantum dots, Zinc sulphide.

c) The core

This is essentially the centre of the nanoparticle and is usually used to refer to the nanoparticle itself.

3. How do nano-fertilizers control nutrient release pattern?

Some carriers should hold a large amount of the nutrient of interest, sustain a suitable release rate and minimize nutrient runoff and/or conversion into forms that are not bioavailable to the plant. Some nanostructured materials as nutrient carriers:

i Nano clays ii Hydroxyapatite nanoparticles iii Mesoporous silica iv Carbon based nanomaterials v Polymeric nanoparticles vi Other nanomaterials.

i. Nano clays: Among the six categories, nano-clays are the most frequently used carriers and contain the widest range of materials. These are suitable as nutrient carriers generally have an ability to protect nutrient molecules through physical barriers provided by their structural components and intercalation of nutrients into the layers of nano-clays through ion exchange or non-electrostatic interactions. e.g. Hydrogen bonding.

ii. Hydroxyapatite nanoparticles: The moderately strong bonds, formed with hydroxyapatite nanoparticles through its carbonyl and amine groups ensured sufficient release of nutrients to meet the plant demand.

iii. Mesoporous silica: Generally, silica is important for plant nutrition, as its deficiency makes plants weaker and more vulnerable to environmental stresses.

iv. Carbon based nanomaterials: These are to be encapsulated the nano fertilizer would promote the nano formulation stability.

v. Polymeric nanoparticles: Polymers that are not nanostructured can be used as bonding agents or as secondary protective layers for nano enabled fertilizers (Mohamed *et al.*, 2021).

vi. Other nanomaterials: These help in terms of release from the nanomaterial was reported to be slow and controlled by plant demand. e.g. Nanosized Mn carbonate hollow core shell loaded with $ZnSO_4$.

4. Role of nano-fertilizers

- Plant cell walls are negatively charged and act as a surface for ion exchange, perhaps promoting the penetration of cationic rather than anionic NPs. Thus, negatively charged Nano particles have higher transport efficiency, with improved rate of internalization and translocation. In this scenario, positively charged NPs strongly adsorbed onto the root surfaces (Negatively charged), whereas negatively charged NPs demonstrated limited root accumulation but increased shoot internalization, mostly by overcoming electrostatic resistance.
- Antioxidants are secondary metabolites produced by plants under adverse situations, *i.e.,* drought, salt and nutritional deficiency. Nano fertilizers supply enough nutrients to improve antioxidant activity in plant cells due to an enhancement in photosynthetic responses generated by foliar use, with enhanced capacity of photo assimilation by leaves and grain yield.
- Nano particles, once delivered inside the cytosol, may interact with cellular machinery such as chloroplasts (Guo *et al.*, 2018). Mesoporous silica nanoparticles (MSNs) enhance photosynthesis by acquiring adequate light harvesting chlorophyll-II protein complexes and also do not cause stress in plants, indicating that they may be safe in such a type of smart delivery.

5. Biological mechanisms of nano fertilizers action

Roots, which act as the gateways for nutrients, have been reported to be significantly porous to nanomaterials compared to conventional manuring materials. The uptake of nano-fertilizers can be improved by utilizing root exudates and molecular transporters through the ionic channels and the creation of new micropores. Nanopores and stomatal openings in leaves have also been reported to facilitate the uptake and their penetration deep inside leaves. These have also been shown to have higher NUE owing to higher transport and delivery of nutrients through plasmodesmata, which are nanosized (50–60 nm) channels for the transportation of ions between cells.

Table 1: Some of the available nano fertilizers & their trade names in India

Name of Nano-fertiliser	Trade name
Nano Micro Nutrient	Eco Star
NPK, Phos, Zinc, Cal, etc.	Tag Nano
NPK	Nanofert

6. Advantages

- Due to considerably smaller losses of nano fertilizers, these can be applied in smaller amounts in comparison to synthetic fertilizers, which leads to a lower risk of environmental pollution.
- Comparatively higher solubility and diffusion impart superiority to nano-fertilizers over conventional synthetic fertilizers.
- Smart nano-fertilizers such as polymer coated fertilizers avoid premature contact with soil and water owing to thin coating encapsulation of nanoparticles, leading to negligible loss of nutrients. On the other hand, these become available as soon as plants are in a position to internalize the released nutrients (Christian *et al*., 2008).

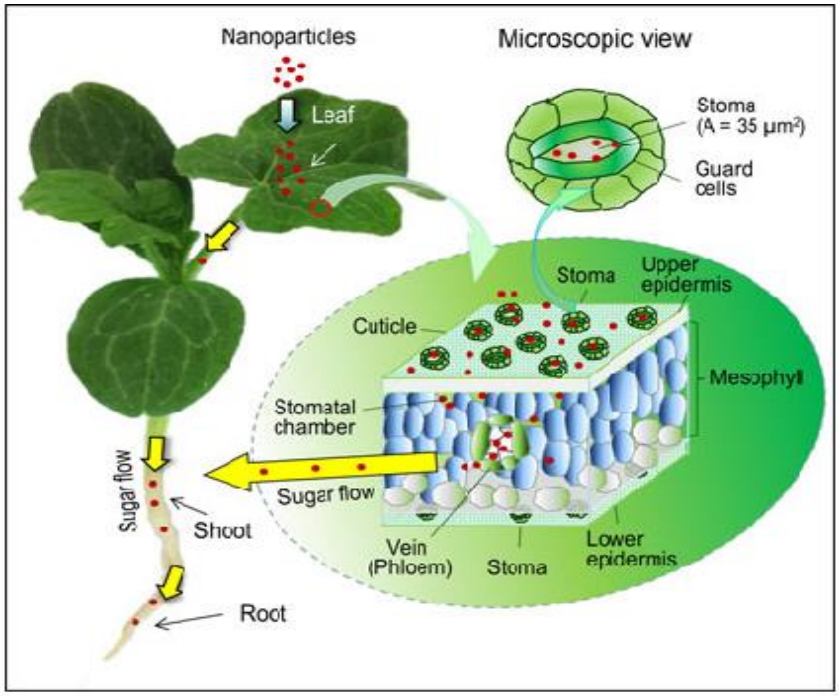


Fig 1. Uptake of nano fertilizer particles through stomata

7. Disadvantages

- The major and all-encompassing disadvantage is cost.
- In Iraq, there are many challenges faced in plant production, such as pollution, mitigation and salinity, so a lot of farmers found that nano-fertilizers is a good technique to reduce their loss, while there are many studies cautioned of bad use of nanomaterials which is more dangerous than chemicals due to its ability to permeability and accumulation.
- Lack of nano fertilizer risk management system and standardization in the formulations.

CONCLUSION

At the nano scale, physical and chemical properties of nano fertilizers are dynamic and different from their counterpart. Due to a higher surface area to volume size ratio and nano size, they have high availability and absorption, which facilitates better uptake from soil or leaves, resulting in the production of more photosynthates and biomass required for healthy crops. Nano fertilizers have benefits in terms of application and small requirement, slow-release mechanism, reduction in transportation, application cost and cause comparatively low salt accumulation in soil *vis- a-vis* conventional fertilizers.

REFERENCES

Mohamed, T., Almoshadak, A.S., Shafi, M.E., Albaqami, N.M., Saad, A.M., El-Tahan, A.M., Desoky, E.S.M., Elnahal, A.S., Almakas, A., Abd El-Mageed, T.A. and Taha, A.E., 2021. Vital roles of sustainable nano-fertilizers in improving plant quality and quantity-an updated review.

Verma, K.K., Song, X.P., Joshi, A., Tian, D.D., Rajput, V.D., Singh, M., Arora, J., Minkina, T. and Li, Y.R., 2022. Recent Trends in Nano-Fertilizers for Sustainable Agriculture under Climate Change for Global Food Security. *Nanomaterials*, *12*(1), 173.

Guo, H., White, J.C., Wang, Z. and Xing, B., 2018. Nano-enabled fertilizers to control the release and use efficiency of nutrients. *Current Opinion in Environmental Science & Health*, *6*,77-83.

Christian, P., Von der Kammer, F., Baalousha, M. and Hofmann, T., 2008. Nanoparticles: structure, properties, preparation and behaviour in environmental media. *Ecotoxicology*, *17*(5), 326-343.