



## Nano Sparks: Igniting Precision Farming's Nutrient Revolution

\*Anita Choudhary, Rakesh Choudhary, Hemlata Gurjar, Manisha, Priyanka, Tanuja and Sanju Choudhary

M.Sc. Scholar, CoA, Nagaur, AU Jodhpur-341001, Rajasthan, India

\*Corresponding Author's email: [anitachoudhary8562@gmail.com](mailto:anitachoudhary8562@gmail.com)

Nano fertilizers represent a cutting-edge advancement in agriculture, utilizing particles sized 1-100 nanometers to deliver nutrients with unprecedented efficiency. These formulations enhance nutrient uptake by plants, often boosting utilization rates by 20-30% compared to conventional fertilizers, while minimizing losses through leaching or volatilization.[1]

### Key Characteristics

Nano fertilizers feature high surface area and reactivity, enabling controlled release tailored to crop needs throughout the growth cycle.[1] Common types include nano-urea, nano-phosphorus, nano-ZnO, and nano-Fe, often encapsulated or coated with nanomaterials like metal oxides.[1][8] Their nanoscale design allows deeper soil penetration and targeted delivery, reducing overall fertilizer application by synchronizing with plant physiology.[2]

### Benefits for Crop Yield

Studies demonstrate nano-ZnO at 10-20 mg/L increases wheat grain yield, maize shoot growth, and cluster bean nutrient content.[1] Nano-SiO<sub>2</sub> combined with nano-TiO<sub>2</sub> at 100-500 ppm significantly boosts capsicum seed germination.[1] Overall, these inputs improve chlorophyll levels, biological yield, and fruit quality, supporting sustainable output amid rising global food demands.[1][5]

Nano -Fertilizer	Dose Range	Crop Example	Key Effects
ZnO NPs	10-20 mg/L	Wheat (Triticum aestivum)	Enhanced grain production
ZnO NPs	10 mg/L	Maize (Zea mays)	Improved height, chlorophyll
Nano-SiO <sub>2</sub> + TiO <sub>2</sub>	100-500 ppm	Capsicum	Higher germination
Nano-N	25-100%	Rice (Oryza sativa)	More tillers, dry weight

### Environmental and Sustainability Gains

By optimizing nutrient use, nano fertilizers curb soil degradation and pollution from excess runoff, promoting eco-friendly practices.[1][2] They align with precision agriculture, lowering input costs and chemical footprints for long-term soil health.[5] Field trials confirm reduced environmental losses, making them ideal for sustainable farming in regions like India.[7]

### Challenges and Future Outlook

Despite promise, issues like production standardization, long-term toxicity assessments, and scalability persist.[1] Ongoing research focuses on green synthesis methods using plant

extracts for safer nano-fertilizers.[10] Widespread adoption could transform global agriculture, especially for specialty crops, by 2030.[3]

## References

1. The Role of Nano-Fertilizers in Sustainable Agriculture <https://pmc.ncbi.nlm.nih.gov/articles/PMC11859090/>
2. Nanofertilizers: A Smart and Sustainable Attribute to ... <https://pmc.ncbi.nlm.nih.gov/articles/PMC9573764/>
3. Editorial: Agro-nanotechnology: advancements and ... <https://www.frontiersin.org/journals/nanotechnology/articles/10.3389/fnano.2025.1668484/full>
4. What Are Nano Fertilizers? <https://arccjournals.com/blog/what-are-nano-fertilizers>
5. Towards smart agriculture through nano-fertilizer-A review <https://www.sciencedirect.com/science/article/pii/S2589234725000296>
6. Nanotechnology in agriculture: Innovations for ... <https://www.sciencedirect.com/science/article/pii/S004896972501705X>
7. Nanofertilizers for agricultural and environmental ... <https://www.sciencedirect.com/science/article/abs/pii/S0045653521039254>
8. Nanofertilizers for Sustainable Agriculture <https://austinpublishinggroup.com/agriculture-crop-sciences/fulltext/aacs-v9-id1159.pdf>
9. Nanofertilizers: New Products for the Industry? [https://portal.ct.gov/-/media/CAES/DOCUMENTS/USDA\\_Center\\_of\\_Excellence/CeNAPS/PDF2DimkpaandBindraban2017.pdf.pdf](https://portal.ct.gov/-/media/CAES/DOCUMENTS/USDA_Center_of_Excellence/CeNAPS/PDF2DimkpaandBindraban2017.pdf.pdf)
10. Green synthesis of nanomaterials used as nano-fertilizer ... <https://www.sciencedirect.com/science/article/pii/S2773111125000105>