J. Agric. Res. Technol., 50 (3) : 252-257 (2025) https://doi.org/ 10.56228/ JART.2025.50304

Role of Nano-Fertilizers in Conjuction with Conventional Fertilizer for Boosting Potential of Crop Yields- an Overview

S. B. Nandanwar*, S. C. Meena, R. S. Thakare, D. V. Dahat, R. H. Meena, D. P. Singh, K. M. Sonawane and G. B. Chaudhari
Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722 (M.S.) India
*Corresponding author E-mail : sb_nandanwar@yahoo.in
(Received : 01.01.2025 Accepted : 10.06.2025)

Abstract

The nano-fertilizers (NFs) is an emerging research field in agriculture.These are materials in the size range of 1-100 nm that support nutrition of the plant. It is a novel way to optimize the nutrient supply, either alone or in combination. Nano materials such as nano fertilizersenhance nutrient uptake efficiency, reducing environmental impact and optimizing resource utilization. Similarly, nano pesticides, exhibit increased efficacy in pest and diseases management, reducing the need for conventional fertilizers or chemicals treatments.The quantity and quality of the macro and micronutrients, nitrogen, phosphorus, potassium, calcium, sulphur, iron, zinc, boron and molybdenum are crucial for agricultural production. By using alternative fertilizers to conventional fertilizers that are both environmentally responsible and highly effective, such as nano fertilizers, it is better and important to diminish supplement misfortune during preparation and work to increment crop efficiency. It was found that the foliar sprays of nano-fertilizers at critical growth stages either alone or in combination have been found to increase yields even at reduced levels of application of their conventional fertilizers. It is also showed that, nano fertilizers in combination with conventional fertilizers to the crops stimulated and accelerated growth as well as boosted production of crop, growth attributes and yield attributing characters and content and uptake of nutrients.

Key words : Nano fertilizers, Conventional fertilizers, Foliar spray, Economics.

The application of nano-fertilizers (NFs) is an emerging research field in agriculture. These are materials in the size range of 1–100 nm that support the nutrition of the plants. It is a novel way to optimize the nutrient supply, either alone or in combination. NFs are an economical alternative to ordinary chemical fertilizers that can increase global food production in a sustainable way. NFs are made up of nutrients and micronutrients and may act as carriers for nutrients. The nanocarriers deliver the nutrients to the right place, reducing the additional amount of active chemicals deposited in the plant, besides a slow release. Although nano-coated materials manage to penetrate through the stomata with a size exclusion limit greater than 10 nm, the nanoparticles appear to be able to make holes and enter the vascular system. This review addresses the potential benefits of NFs to agriculture, synthesis, mode of entry, mechanisms of action, and the fate of nanomaterials in the soil. Finally, policy makers will have the bases to regulate the dose, frequency, and time period of NF applications for food production. (Graciela Dolores Avila-Quezada *et al*., 2022).

Nano fertilizers play a significant role in crop production up to 35 to 40% of the productivity. Nano sized active ingredients in fertilizer help to improve nutrient use efficiency and this could be due to their high specific surface area, which facilitates good absorption of the nutrients. The distribution of nano NPK element in paddy was found to be uniform and their use efficiency was 97.43 %, 98.11% and 97.03 %, respectively (Akhlesh Chouriya *et al*., 2020).

The importance of effects of foliar nano-fertilization on different crops compared to conventional nutrient sources and methods of

application. Nano science and nanotechnology research in agriculture and horticulture are still at an elementary stage but developing rapidly. Conventional bulk fertilizer or traditional fertilizers are not only expensive for the producer, but may be harmful to humans and the environment. This has led to the search for environmentally friendly fertilizers or smart fertilizer, mainly those with high nutrient-use efficiency, and nanotechnology is rising as a promising alternative. More recently, foliar feeding has been widely used and accepted as an essential part of crop production, especially on horticultural crops. Although not as widespread on agronomic crops, the benefits of foliar feeding have been well documented and increasing efforts have been made to achieve consistent responses (Pratima Ningaraddi Morab *et al*., 2020).

Nano fertilizers are more useful than conventional fertilizers. They have the ability three times as effective for nutrients to reduce chemical fertilizer requirements and make crops resistant to drought and disease and less dangerous to the environment. They easily absorbed by plants because of their high surface area to volume ratio (Al-Juthery, *et al*., 2018).

Importance of nano-fertilizers : Nano-fertilizers are important because mineral fertilizers are essential for growing foods. Nanotechnology can increase crop output and lowernutrient loss despite the low the low efficiency of nutrient uptake and significant losses. Due to this, interest in nano-fertilizers and nano supported fertilizers has increased, giving rise to the concept of fertilizer. Due to its capacity to increase soil fertility and supply nutrients, nano-fertilizers may be the best thing to happen to modern agriculture.

The nanoparticle has a dimension measured in nm (1 nm =10-9 m). nano fertilizers are known to improve solubility and dispersion of insoluble nutrients in soil. They also increase fertilizers use efficiency (three times), uptake ratio of the soil nutrients in crop production and save fertilizer resource. They extend effective duration of the nutrient supply of fertilizers into soil crops and reduce loss of fertilizers into soil by leaching. They help in improving the crop yield by 17-24 per cent, owing to their small size and higher surface area there will be more nutrient mobilization in the plants.

The science of nanotechnology has provided the feasibility for the utilization of nanoscale or nonstructural materials as fertilizer carriers or controlled-release carriers for building the smart fertilizers reduce cost of environmental protection. A nano-fertilizer possesses properties that they can fulfill plant root requirement more efficiently as compared the conventional fertilizers. Encapsulation of fertilizer nutrients within a nanoparticle can be done in the following ways-

1) The nutrient can be encapsulated inside the nano porous materials

2) The nutrient can be coated with a thin polymer film

3) The nutrient can be delivered as tiny particles or emulsions of nanoscale dimension

Nano fertilizers in crop nutrition : Supplying the required plant nutrients in the form of nano fertilizers can contribute to plant nutrition in the following two ways:

1) Nanostructured elements are incorporated in such a carrier complex that may or may not be a nanomaterial. It is incorporated by absorption or adsorption in a matrix such as a chitosan, poly acrylic acid, clay or zeolite.

2) Using the required nutrient elements in nanostructures formulations (either in suspension or encapsulated).

Nutrient use efficiency through nano-fertilizers : The nano fertilizers possess certain specific properties, which facilitate higher nutrient use efficiency. The important properties are:

1) The nano-fertilizers have a higher surface area, which is mainly due to the very smaller size of the nano particles that provide more sites to facilitate the different metabolic process in the plant system. This results in the production of more photosynthesis with less consumption of nutrient elements.

2) They have high solubility in different solvents such as water.

3) The particle size of nano fertilizers is very small (less than 100 nm), which facilitate more penetration of nano-particles into the plant system.

4) Nano fertilizer elements have the large surface area and particle size smaller than the pores of root and leaves of the plants. This increases penetration into the plant system from applied surfaces and thus improves uptake and nutrient use efficiency of the nano-fertilizers.

5) The reduced particle size of nano fertilizer results in increased specific surface area and a number of particles per unit area of fertilizer, which provide more opportunity for contact of nano-fertilizers and it leads to more penetration and uptake.

6) The fertilizer elements encapsulated in nano particles increase the availability and hence uptake of the plant nutrients to the crops.

Zeolite-basednano-fertilizesare capable of releasing the nutrients slowly to the crop plant which increase the availability of nutrient elements to the crops though out of the growth period. This prevent loss of nutrients through denitrification, volatilization, leaching and fixation in the soil especially NO_3 and NH_4 form of nitrogen.

Here some of the more recent review which will be benefitted to the researcher and

SN	Crop	Nano material	Effect of nano material	References
1	Paddy	Urea (50%) and nano urea (2 spray)	Recorded higher plant height, leaf area index, dry matter accumulation, microbial population, crop growth	Dhayalan *et al*., 2023.
2	Maize	Nano-NPK, Nano micronutrient, Nano amino acid Conventional phosphorus fertilizers and nano urea,	Increased K, Fe, Cu, Mn in grains and highest nutrient use efficiency, Higher plant height, maximum plant dry weight, maximum crop growth rate, maximum rows per cobs, grains per row, seed index, grain and stover yield, harvest index and maximum gross, net return and B:C ratio	Alzree jawi *et al*., 2021and Raj *et al*., 2024
3	Bhindi	Organic nano NPK formulations	Highest bacterial and enzymes count in post harvest soil	Nibin *et al*., 2019
4	Ground nut	15N-urea and 15 N-super-IB, Nano micronutrients (Fe, Mn and Zn), Bio soil application P and Nano P fertilizers	Nodules and acetylene reduction activity,Greatest plant height, number of branches, pods, seed weight highest content of N, P, Fe, Mn and Zn in both seeds and straw, chlorophyll, carotenoids, carbohydrates, TSS, protein and oil percentage, Higher field emergence, plant height, number of pods, pod yield, shelling and SMK, Highest Net return and B:C ratio	Khan *et al*., 2012, Deepak Sathyan, 2022, El-Metwally *et al*., 2018, Bakry *et al*., 2022, Sweta Kumari *et al*., 2017 and Manoj *et al*., 2023

SN	Crop	Nano material	Effect of nano material	References
5	Green gram	RDN and Nano urea	Higher fertility co-efficient, pods, seeds grain yields, maximum productivity and profitability	Saitheja *et al*., 2022
6	Wheat	Nano chelated super fertilizers, nano amino acids and nano K, Conventional NPK and Nano NPK and Zn	Significant response all growth and yield parameters, chlorophyll, plant height, length of spike, concentration and uptake of Fe, Cu, Zn and Mn in grain, grain yield and protein, agronomic productivity	Al-juthery et al., 2019, Singh *et al*., 2023 and Choudhary *et al*., 2022
7	Mustard	RDN and nano urea	Positive effect and higher values on plant height, number of branches, number of functional leaves and dry matter production, seed and straw yield	Pandav *et al*., 2022 and K. Navya *et al*., 2022
8	Rice	RDN with Nano N	Highest plant height, number of tillers, grain and straw yields	Midde *et al*., 2022 and Pedireddy *et al*., 2024
9	Potato	Urea, Nano-N, Band Nano Mo, Conventional NPK and Nano-N and Zn	Increase in tuber and dry vegetative , biological, starch yield and protein and ascorbic yield, Significantly increased leaf area index, plant height, dry matter production, tuber yield, enhanced the uptake of NPK and Zn and maximum net return	Al-juthery *et al*., 2020 and Neogi *et al*., 2022
10	Fodder oats	RDN and nano urea	Increase in available N, P, K in soil, soil microbial activities	Kumar *et al*., 2021
11	Fig	Nano fertilizer and conventional fertilizers	Increase growth, chlorophyll, nutrient content and enzymes activity	Mustafa *et al*., 2018
12	Tomato	Nano foliar fertilizers and commonly water soluble fertilizers	Increase in fruit, fruit per plant, fruit length, fruit girth and benefit cost ratio	Panda *et al*., 2020
13	Grape-vine	Calcium phosphate nano particles doped with urea and U-ACP	Increase the quail-quantitative parameters of vine	Gaiotti *et al*., 2021
14	Sun-flower	Conventional NPK and Nano urea	Improved growth and yield	Goud *et al*., 2022

agricultural innovative farmers for boosting their farm income with reducing conventional fertilizers doses and cost on fertilizers inputs without increasing soil and water pollution through conventional fertilizers and to protect environmental imbalance for sustainable agriculture.

References

Akhlesh Chouriya, Arti Choure and Sarita Singh, 2020. Nano Fertilizers Use for Field Crop in Chhindwara District of Madhya Prades. Indian Journal Pure Applied Bioscience 8(5), 462-465.

Akshay Mehta, Alkesh Yadav, Aman Kumar, Kanika and Manish. 2024. Role of nanotechnology in horticulture:an overview: International J. of Advanced Biochemistry Research. 8(1):702-708.

Al-juthery, H. W. A., Habeeb, K. H., Altaee, F. J. K., AL-Taey K. A. and Al-Tawaha, A. R. M. 2018. Effect of foliar application of different sources of nano fertilizers on growth and yield of wheat.Bioscience Research 15(4): 3988-3997.

Al-juthery, H. W. A., Hardan, H. M., Al-Swedi, F. G. A., Obaid, M. H. and Al-Shami, Q. M. N. 2019. Effect of foliar nutrition of nano fertilizers and amino acids on growth and yield of wheat. International conference on Agricultural Sciences, Earth and environmental Sciences 388 012046.

Al-juthery , Hayyawi W. A., Estabraq and Hilal Obaid Al-Maamouri. 2020. Effect of urea and nano-nitrogen fertigation and foliar application of nano boron and molybdenum on some growth and yield parameters of potato. QJAS Al-Qadisiyah Journal for Agriculture Sciences: 10(1): 253-263.

Alzreejawi, A. M. Safa, and Hayyawi, W. A. Al-juthery. 2021. Effect of foliar application of nano nutrients and amino acids as a complementary nutrition on quality and quality of maize grains IOP Conf. Earth and Environmental Science: 735 (012060).

Bakry, B. A., S. S. El-Nwehy, R. R. Afify, O. M. Ibrahim and M. E. Abd El-Aziz. 2022. Preparation, characterization and evaluation of nano phosphorus foliar application on peanut production under sandy soil. Asian Journal of Plant Sciences. 21: 423-431.

Choudhary, Kannoj J., Jain, Devendra, Tomar, Manish, Patidar, Ritesh and Choudhary, Ruchika. 2022. Effect of nano urea vs conventional urea on the nutrient content, uptake and economics of black wheat (*Triticum aestivum* L.) along with biofertilizers. Biological Forum-An international Journal, 14(2a): 499-504.

Dhayalan, S. Anoor, Davamani, V., Maheshwari, M., Maragatham, S. and Sharmila Rahale, C. 2023. Influence of nano urea on growth and microbial population in paddy ecosystem. International Journal of Environment and Climate Change.12(10): 1239-1247.

El-Metwally, I. M., Doaa M. R. Abo-Basha and M. E. Abd El-Aziz. 2018. Response of peanut plants to different foliar applications of nano-iron, manganese and zinc under sandy soil conditios. Middle East Journal of applied Sciences. 8(2):474-482.

Gaiotti Federica, Marco Lucchetta, GiacomoRodeggher, Daniel lorenzoni, Edardo Longo, Emanuele Noselli, Stefano Cesco, Nicola Belfiore, Lorennzo Lovat, Jose ManuelDelgado-Lupez, Francisco J. Carmona, antaonietta Guagliardi, Norbetrto Masciocchi and Youry Pii. 2021. Urea doped calcium phosphate nano particles as sustainable nitrogen for viticulture: Implicationson yield and quality of Pinot gris Grapevines. Agronomy. 11061026.

Goud G. Manoj Kumar, Kasbe Sudhanshu Sudhakar, Md Latheef Pasha and A. Madhavi. 2022. Evaluation of the foliar application of nano urea 0n the performance of rabi sunflower (*Helianthus annus* L.). International Journal of Environment and Climate Change, 12(11):2700-2706.

Graciela Dolores Avila-Quezada, Avinash P. Ingale, Patrycja Golinska, Mahendra Rai. 2022. Strategic application of nano-fertilizers for sustainable agriculture: benefits and bottlenecks; DE Gruyter-Nanotechnology Review. 11: 2123-2124.

Khan Monowar Karim, and Tomio Yoshida (1995). Nitrogen fixation in peanut at various concentrations of 15N-Urea and slow release 15N- fertilizer. Soil Sci. Plant Nutr., 41(1):55-63.

Kumar Rakesh, Manoj Kumar, Ravi Kumar Meena, Kuldeep Singh, Vijendra Kumar and Dinesh Kumar. 2021. Soil microbial and enzymatic responses as influenced by various sources through nano nitrogen in fodder oats. Frontiers in Crop Improvement:9, 3668-3672.

Mandi, S. P., Byadgi, Sumalata, Jyoti, B.L., Siddharaju, R., Ramanappa, T. M. 2023. Influence of nano-fertilizers on crop growth, seed yield and quality in groundnut (*Arachis hypogaea* L.)Mysore J. Agric.Sci., 57 (4):183-192.

Manoj S. P., Sumalata byadgi, B. L. Jyoti, R. Siddaraju and T. M. Ramanapaa. 2023. Influence of nano- fertilizers on crop growth, seed yield and quality in groundnut (*Arachis hypogaea* L.). Mysore J. Agric. Sci., 57(4):183-192.

Midde, Kumar Sai., M. Sarvavana Perurnal, G. Murugan, R. Sudhagar, Vikram sai Mattepally and Maheshswara reddy Bada. 2022. Evaluation of nano urea on growth and yield attributes of rice (*Oryza sativa* L.). Chemical Science Review and Letters 11(42): 211-214.

Mustafa, N. S., Shaarawy, H. H., El-Dashouri, M. F. and Sherin A. Mahfouze. 2018. Impact of nano fertilizer on different aspects of growth performance, nutrients and some enzymes activities of (Sultani) fig cultivar: Bioscience Research: 15(4): 3429-3436.

Navya, K, Sai Kumar R., Krishna Chaitanya A. and Sampat O. 2022. Effect of nano nitrogen in conjuction with urea on growth and yield of mustard (*Brassica juncea* L.) in Northern Telangana Zone. Biological forum- An International Journal, 14(3):95-99.

Neogi, S. and Das, S. K. 2022. Effect of nitrogen and zinc in nano forms on growth and productivity of potato (*Solanum tuberosum* L.) in inceptisols. Journal of Crop and Weed 18(1):32-38.

Nibin, P. M., K. Ushakumari and P. K.Ishrath (2019).Soil microbial and enzymatic responses as influenced by various sources through nano nitrogen in fodder oats: International Journal of Current Microbiology and Applied Sciences:8(4):1814-1819.

Nitumoni Mahanta, Ashok Dambale, Montrishna Rajkhowa

2019. Nutrient use efficiency through nano fertilizers: InternationalJ. of Chemical Studies: 7(3): 2839-2842.

Panda Janmejaya, Alok nandi, Siba Prasad Mishra, Asist Kumar Pal, Ajoy Kumar Pattnaik and Nitish Kumar Jena. 2020. Effect of nano fertilizer on yield, yield attributes and economices in tomato (*Solanun lycopersicum* L.). International Journal of current microbiology and Applied Science: 9(5):2583-2591.

Pandav, D. M., Talathi, M. S., Bodakhe, P. S., Chavan, V. G. More, S. S., Pethe, U. B., Rajmahadiik, V. A., Ghodake, S. S. and Mote, G. K. 2022. Response of nitrogen level and nano urea on mustard (*Brassica juncea* L.) under Konkan condition. The Pharma Innovation, 11(12): 2055-2061.

Pedireddy Sneha., Manish Kumar, Soumya Saha, Narendra Kumar Nag, Chandrakar, T. P. and Singh, D. P. 2024. Effect of nano urea on growth, productivity and economics of transplanted rice. International Journal of Economic Plants. 11(3):217-221.

Raj Rahul, Umesha, C. and Pranav Kumar. 2024. Effect of phosphorus and nano urea on growth and yield attributes of maize (*Zea mays* L.). International Journal of Advanced Biochemistry Research, 8(7): 665-669.

Saitheja Vaddi, Senthivelu, M., Prabhukumar, G. and Rajendra Prasad. 2022. Maximizing the productivity profitability of summer irrigated green gram (*Vigna radiata* L.) by combining basal nitrogrn dose and foliar nutrition of nano and normal urea. International Journal of plant and soil Science: 34(22): 109-119.

Sathyan Deepak. 2022. Effect of nano nutrients on pea growth and yield (*Pisum sativum* L.). The Pharma Innovation Journal. (11(9): 1895-1898.

Singh, Bal Veer, Rana, N. S., Kurdekar, Akshay Kumar, Verma, Anupama, Saini, Yonika, Dhruvendra Singh Sachan, Singh, Barinderjit and Tripathi, Amol M. 2023. Effect nano and non-nano nutrients on content, uptake and NUE of wheat (*Triticum aestivum* L.). International Journal of Environment and Climate Change, 13(7): 551-558.

Sweta Kumari, M., Rao, P. C., Padmaja, G., Ramalu, V., Saritha, J. D. and Ramakrishna, K. 2017. Effect of bio and nano phosphorus on yield, yield attributes and oil content of groundnut (*Arachis hypogaea* L.). Environment Conservation Journal, 18(3):21-26.

Waleed, K.S., Al-Juheishy, Salim A. Y, Ghazal. 2023. Role of nano fertilizers in improving productivity of peanut crop: A review: Mesopotamia J.of Agriculture. 51(4); 13-17.