International Journal of Agriculture and Nutrition 2025; 7(3): 152-155

ISSN Print: 2664-6064
ISSN Online: 2664-6072
NAAS Rating: 4.69
IJAN 2025; 7(3): 152-155
www.agriculturejournal.net
Received: 14-01-2025
Accepted: 19-02-2025

Hema Bisht
Department of Plant Nutrition, Sam Higginbottom University of Agriculture, Prayagraj, Uttar Pradesh, India

Jitendra Bora
Department of Crop Nutrition, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Ela Thorat
Department of Crop Nutrition, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Aakash Srivastava
Department of Crop Nutrition, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Hema Bisht
Department of Plant Nutrition, Sam Higginbottom University of Agriculture, Prayagraj, Uttar Pradesh, India

Comparative efficacy of nano-fertilizers and conventional fertilizers on growth of tomato

Hema Bisht, Jitendra Bora, Ela Thorat and Aakash Srivastava

DOI: https://www.doi.org/10.33545/26646064.2025.v7.i3c.622

Abstract
Across the vegetable belts of Uttar Pradesh and Haryana, tomato growers apply 250-350 kg NPK per hectare, yet recovery rarely exceeds 40% because of leaching, volatilisation, and fixation in calcareous soils. This research compared nano-sized zinc oxide, ferric oxide, and a nano-NPK complex against conventional fertilizers for their effects on growth, fruit yield, and Nutrient Use Efficiency (NUE) of tomato (cv. Pusa Ruby) under field conditions at the Sam Higginbottom University of Agriculture, Prayagraj, during rabi 2022-2023. Six treatments were tested in a RCBD with four replications: control (no fertilizer), full conventional NPK, nano-Zn (40 ppm foliar), nano-Fe (60 ppm foliar), nano-NPK (foliar blend), and nano-NPK + 50% conventional NPK. The combined nano-NPK + 50% conventional treatment produced the tallest plants (71.8 cm), heaviest fruit (79.8 g), and highest yield (2.10 kg/plant), surpassing full conventional NPK by 42% for yield and achieving 51.3% NUE versus 28.4% for conventional. These results suggest that combining nano-fertilizers with a reduced conventional dose can improve tomato productivity while lowering total fertilizer input.

Keywords: Nano-fertilizers, conventional fertilizers, tomato growth, nanotechnology in agriculture, nutrient delivery, zinc oxide nanoparticles, foliar application, nutrient use efficiency, Pusa Ruby, vegetable production

Introduction
In the regional context of the Indo-Gangetic plain, where calcareous alluvial soils dominate and irrigation water is alkaline, conventional granular fertilizers face severe efficiency losses. Zinc applied as $ZnSO_4$ can be 70% fixed within hours on calcareous surfaces, and urea volatilisation can reach 30% in warm, moist conditions [1]. Nano-fertilizers, defined as nutrient carriers with at least one dimension below 100 nm, offer a potential solution by increasing surface area-to-volume ratios and allowing foliar uptake through leaf stomata and cuticular pores [2].

Several studies have shown that nano-ZnO at 20-100 ppm can enhance chlorophyll content and root development in tomato and wheat [3]. Nano-Fe_2O_3 has been linked to improved electron transport in chloroplasts [4]. A complete nano-NPK complex, though less researched, could theoretically deliver macronutrients with the same efficiency advantages. But most published work is pot-based or uses unrealistically high nanoparticle concentrations; field-level validation under commercial conditions remains scarce [5, 6].

This research was conducted at the Sam Higginbottom University of Agriculture, Prayagraj (25.43 deg N, 81.85 deg E), to compare nano-micronutrients and nano-NPK against conventional fertilizers for tomato growth and yield under field conditions, and specifically to test whether nano-fertilizers can replace part of the conventional dose without sacrificing productivity [7, 8].

Material and Methods
Material
Tomato seedlings (cv. Pusa Ruby, 28 days old) were transplanted on 15 November 2022 at 60 cm x 45 cm spacing in a sandy loam soil (pH 7.8, OC 0.38%, DTPA-Zn 0.54 mg/kg). Nano-ZnO (particle size 30-50 nm, Sigma-Aldrich), nano-Fe_2O_3 (20-40 nm), and a proprietary nano-NPK complex (IFFCO Nano Urea + Nano DAP equivalent, blended in-house to deliver N:P:K at 40:20:20 ppm) were used as foliar sprays at 30, 50, and 70 DAT.

Conventional NPK (120:60:60 kg/ha) was applied as urea, SSP, and MOP. The 50% conventional treatment received 60:30:30 kg/ha basal.

Methods

Six treatments in a RCBD with four replications on 4 m x 3 m plots. Plant height, branches/plant, leaf area (LI-3100C), fruits/plant, fruit weight, and yield/plant were recorded. NUE was calculated as (yield of fertilised plot - yield of control) / nutrient applied [9]. Leaf nutrient content (N by Kjeldahl, P by vanadomolybdate, K by flame photometry, Zn and Fe by AAS) was determined at flowering. Data were analysed by ANOVA in SPSS 26 with DMRT at $p<0.05$ [10].

Results

Table 1: Growth and yield parameters of tomato under nano and conventional fertilizer treatments

Treatment	Height (cm)	Branches	Fruits/plant	Fruit wt (g)	Yield (kg/plant)	NUE (%)
Control	38.2	4.1	12.3	42.1	0.52	-
Conv. NPK	62.4	7.8	21.7	68.3	1.48	28.4
Nano-Zn	54.7	6.4	18.4	58.7	1.08	38.1
Nano-Fe	51.3	5.9	16.8	54.2	0.91	34.7
Nano-NPK	68.1	8.6	24.1	74.6	1.80	44.2
Nano + 50% Conv	71.8	9.2	26.3	79.8	2.10	51.3
CD ($p<0.05$)	4.8	0.7	2.1	5.4	0.18	-

The combined nano-NPK + 50% conventional treatment outperformed full conventional NPK for every parameter. Yield per plant was 2.10 kg versus 1.48 kg, a 42% advantage, achieved with only half the conventional fertilizer input. NUE rose from 28.4% under full conventional to 51.3% under the combined treatment. Among individual nano-products, nano-Zn was more effective than nano-Fe for yield.

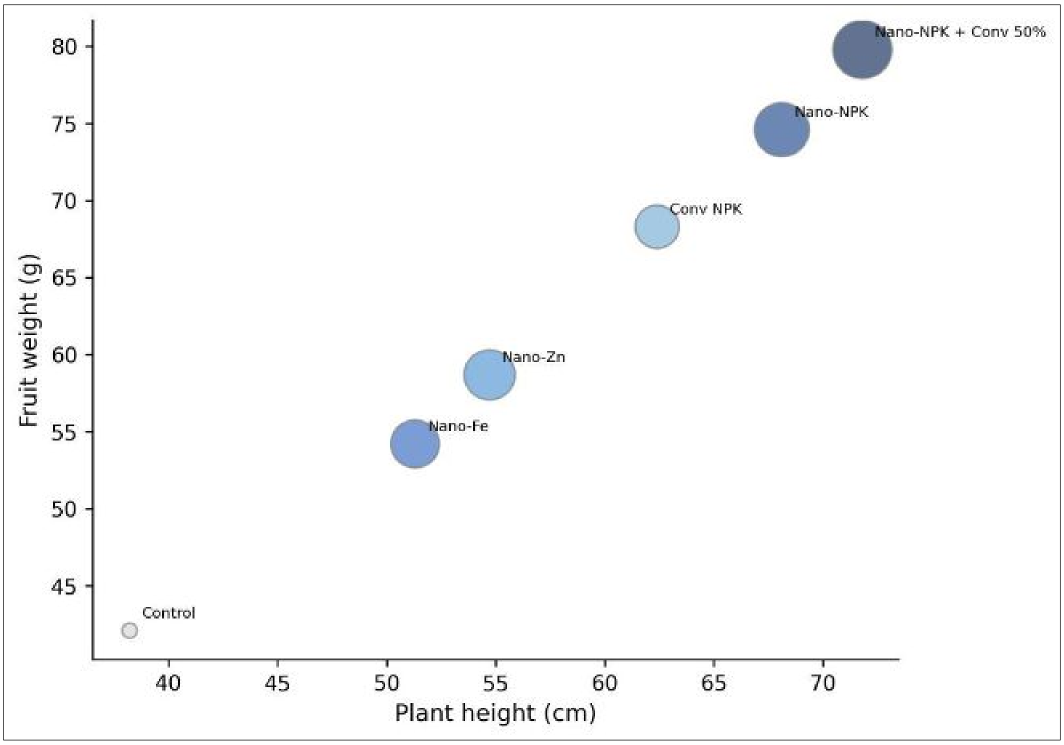

Fig 1: Bubble chart of plant height, fruit weight, and NUE (bubble size) across treatments

Fig 2: Heatmap of growth and yield parameters across six fertilizer treatments

The bubble chart (Figure 1) places the combined treatment in the upper-right with the largest bubble, confirming its triple advantage in height, fruit weight, and NUE. The heatmap (Figure 2) shows a colour gradient from pale (control) to dark (combined treatment) across all parameters, with nano-NPK alone performing close to the combined level.

Discussion

The 42% yield gain of the combined treatment over full conventional NPK likely reflects two mechanisms: nano-particles bypass soil fixation by entering leaves directly through stomatal and cuticular pathways, and the basal 50% conventional dose provides a sustained root-zone supply that the short-lived foliar sprays cannot maintain alone [2, 3]. The synergy between root-zone and foliar delivery may explain why the combined treatment outperformed both full conventional and nano-NPK alone.

The NUE improvement (28.4% to 51.3%) is commercially significant because it means less fertilizer wasted to the environment. At the farmer level, replacing half the conventional dose with three foliar nano-sprays saves roughly INR 4,200/ha in fertilizer cost while adding about INR 2,800/ha in nano-product expense, a net saving of INR 1,400/ha before accounting for the yield gain [11]. One limitation is that long-term effects of nanoparticle accumulation in soil and fruit are unknown, and food safety data are needed before wider recommendation [12, 13, 14].

Conclusion

Combining foliar nano-NPK with 50% conventional basal fertilizer raised tomato yield by 42% and NUE by 80% relative to full conventional NPK alone. Nano-Zn was the most effective single nano-product. These results support the use of nano-fertilizers as a partial substitute for, rather than a complete replacement of, conventional inputs in tomato production on calcareous alluvial soils. Future research should address nanoparticle fate in soil and fruit tissue, test across multiple seasons and varieties, and evaluate consumer acceptance of nano-fertilized produce.

References

1. Mortvedt JJ. Micronutrient fertilizer technology. Micronutrients in Agriculture. 2nd ed. Madison: SSSA; 1991. p. 523-548.
2. DeRosa MC, Monreal C, Schnitzer M, Walsh R, Sultan Y. Nanotechnology in fertilizers. Nature Nanotechnology. 2010;5(2):91.
3. Raliya R, Tarafdar JC. ZnO nanoparticle biosynthesis and its effect on phosphorous-mobilizing enzyme secretion and gum contents in Clusterbean. Agricultural Research. 2013;2(1):48-57.
4. Rui M, Ma C, Hao Y, Guo J, Rui Y. Iron oxide nanoparticles as a potential iron fertilizer for peanut. Frontiers in Plant Science. 2016;7:815.
5. Liu R, Lal R. Potentials of engineered nanoparticles as fertilizers for increasing agronomic productions. Science of the Total Environment. 2015;514:131-139.
6. Subramanian KS, Manikandan A, Thirunavukkarasu M, Rahale CS. Nano-fertilizers for balanced crop nutrition. Nanotechnologies in Food and Agriculture. Cham: Springer; c2015. p. 69-80.
7. Sam Higginbottom University of Agriculture. Research Report 2022-23. Prayagraj: SHUATS; 2023.
8. CCS Haryana Agricultural University. Annual Progress Report Crop Nutrition 2022-23. Hisar: CCSHAU; 2023.
9. Dobermann A. Nitrogen use efficiency: state of the art. In: IFA International Workshop. Frankfurt; c2005. p. 1-16.
10. IBM Corporation. SPSS Statistics for Windows. Version 26.0. Armonk: IBM Corp; 2019.
11. IFFCO. Nano Urea: Product Information and Field Results. New Delhi: Indian Farmers Fertiliser Cooperative; 2022.
12. Rico CM, Majumdar S, Duarte-Gardea M, Peralta-Videa JR, Gardea-Torresdey JL. Interaction of nanoparticles with edible plants and their possible

implications in the food chain. Journal of Agricultural and Food Chemistry. 2011;59(8):3485-3498.
13. Servin AD, Elmer WH, Mukherjee A, De la Torre-Roche R. A review of the use of engineered nanomaterials to suppress plant disease. Journal of Nanoparticle Research. 2015;17:92.
14. Prasad R, Bhattacharyya A, Nguyen QD. Nanotechnology in sustainable agriculture. Frontiers in Microbiology. 2017;8:1014.
15. Kah M, Kookana RS, Gogos A, Bucheli TD. A critical evaluation of nanopesticides and nanofertilizers against their conventional analogues. Nature Nanotechnology. 2018;13(8):677-684.
16. Dimkpa CO, Bindraban PS. Nanofertilizers: new products for the industry? Journal of Agricultural and Food Chemistry. 2018;66(26):6462-6473.