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Effect of Nano Nitrogen and Chelated Zinc Foliar Spray on Growth and Yield Attributes of Guava (*Psidium guajava* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted to evaluate the effects of nano nitrogen and chelated zinc foliar application on the growth, yield, and quality attributes of guava (*Psidium guajava* L.) during the 2024–2025 season at Career Point University, Kota. The experiment was laid out in a factorial randomized block design (FRBD) with 16 treatment combinations comprising four levels of nano nitrogen (0, 2.0, 4.0, and 6.0 ml/lit) and four levels of chelated zinc (0, 0.2%, 0.4%, and 0.6%). Results revealed that foliar application of nano nitrogen at 6.0 ml/lit (N_3) and chelated zinc at 0.4% (Z_2) significantly enhanced plant height, plant spread, number of flowers per shoot, fruit set

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percentage, and fruit bearing percentage, while significantly reducing fruit drop. The highest performance across most growth and yield parameters was recorded under the combined treatment $N_3 \times Z_2$. This study concludes that the integrated foliar application of nano nitrogen and chelated zinc is a promising strategy for improving guava productivity under field conditions.

Keywords: Guava; nano nitrogen; chelated zinc; foliar spray; fruit set.

1. INTRODUCTION

Guava (*Psidium guajava* L.) is a widely grown tropical fruit crop valued for its high nutritional content, especially vitamin C, dietary fiber, and antioxidants. Enhancing its productivity and quality through balanced nutrient management is crucial. Foliar application of nano fertilizers and micronutrients like zinc has emerged as a promising strategy due to better nutrient uptake, targeted delivery, and reduced environmental loss. Due to its high nutrient requirements and short shelf life, nutrient management plays a crucial role in maintaining consistent yield and fruit quality (Kumrawat et al*.,* 2018). Micronutrients like zinc (Zn) are essential for various physiological functions in plants, such as growth regulation, photosynthesis, fruit development, and disease resistance (Hosamani, 2020; Singh & Chhonkar, 1983). However, zinc deficiency is widespread due to soil degradation and imbalanced fertilization practices (Pendias, 2000). Foliar application of micronutrients is an effective technique, especially in soils with high pH, as it allows faster nutrient absorption by leaves and corrects deficiencies more efficiently than soil application (Kumrawat et al*.,* 2018; Yadav et al*.,* 2014). Recent advancements in nanotechnology have introduced nano-fertilizers and chelated micronutrients (such as Zn-EDTA), which enhance nutrient use efficiency, reduce environmental impact, and support sustainable agriculture (Butt & Naseer, 2020; Naderi & Danesh-Shahraki, 2013). Chelated forms of zinc are particularly effective as they remain available to plants and support better uptake and productivity (Marschner, 1995; Datta et al*.,* 2018). This study investigates the effect of nano nitrogen and chelated zinc on the growth attributes of guava.

2. MATERIALS AND METHODS

The present study was undertaken during the year 2024–2025 at the Research Farm of the Department of Horticulture, School of Agricultural Sciences, Career Point University, Kota, to assess the effect of nano nitrogen and chelated zinc on growth, flowering, and fruiting parameters of guava (*Psidium guajava* L.) cultivar Lucknow-49 under high-density planting conditions. The experimental site comprised eight-year-old guava trees planted at a spacing of 6 × 6 metres. The experiment was laid out in a factorial randomized block design (FRBD) with 16 treatment combinations derived from four levels of nano nitrogen (N0: 0 ml/lit, N1: 2.0 ml/lit, N2: 4.0 ml/lit, N3: 6.0 ml/lit) and four levels of chelated zinc (Z0: 0%, Z1: 0.2%, Z2: 0.4%, Z3: 0.6%), with each treatment replicated thrice, totaling 48 experimental trees. The foliar sprays were applied thrice during critical phenological stages using a knapsack sprayer: (i) one month before flowering (May), (ii) at full bloom (June–July), and (iii) at fruit set stage. Care was taken to ensure uniform and thorough coverage of the spray solution. Standard agronomic and orchard management practices were followed uniformly across all treatments throughout the study period. Observations were recorded on growth parameters such as plant height and plant spread (both N-S and E-W directions), as well as reproductive parameters including days to flowering, fruit set percentage, fruit drop percentage, and fruit bearing percentage. Data obtained were subjected to statistical analysis following analysis of variance (ANOVA) for FRBD to test for treatment significance at the 5% probability level (p=0.05).

3. RESULTS AND DISCUSSION

The data presented in Table 1 and 2 clearly demonstrate the significant positive effects of application of nano nitrogen and chelated zinc on the growth parameters in guava.

3.1 Plant Height

Application of nano nitrogen significantly increased plant height. The tallest plants (678.2 cm) were observed with Nano-N @ 6.0 ml/lit (N3). Among zinc treatments, Zn @ 0.4% (Z2) recorded the highest mean height (680.0 cm). The interaction effect was statistically non-significant, though the combination N3 × Z2 yielded the maximum height (693.9 cm).

Table 1. The effect of nano nitrogen and chelated zinc on growth and yield attributing parameters of guava (*Psidium guajava* L.)

Treatment	Plant height (cm)	Plant spread (cm)			No. of flowers per shoot	Fruit set percentage	Fruit drop percentage
		E-W and N-S	E-W	N-S			
Nano nitrogen (N)							
Control (N_0)	642.9	454.0	442.9	465.0	17.30	59.34	49.37
Nano- N 2.0 ml /lit. (N_1)	658.8	470.3	458.8	481.7	19.60	63.27	47.28
Nano- N 4.0 ml /lit. (N_2)	671.4	483.2	471.4	495.0	21.42	66.31	43.95
Nano- N 6.0 ml /lit. (N_3)	678.2	490.2	478.2	502.1	21.76	67.94	41.87
SEm ±	2.696	5.320	2.696	2.831	0.095	0.303	0.223
C.D. at 5%	7.786	15.962	7.786	8.176	0.273	0.876	0.644
Chelated Zinc (Zn)							
Control (Z_0)	644.4	455.5	444.4	466.6	17.32	59.21	49.59
Zn 0.2 %/lit. (Z_1)	653.5	464.8	453.5	476.2	19.18	61.92	46.43
Zn 0.4 %/lit. (Z_2)	680.0	492.0	480.0	504.0	22.15	69. 13	42.34
Zn 0.6 %/lit. (Z_3)	673.4	485.3	473.4	497.1	21.45	66.62	44.13
SEm ±	2.696	5.320	2.696	2.831	0.095	0.303	0.223
C.D. at 5%	7.786	15.962	7.786	8.176	0.273	0.876	0.644

Table 2. The interaction effect of nano nitrogen and chelated zinc on growth and yield attributing parameters of guava (*Psidium guajava* L.)

Treatment	Plant height (cm)	Plant spread (cm)			No. of flowers per shoot	Fruit set percentage	Fruit drop percentage
		E-W and N-S	E-W	N-S			
T_1: Control	625.2	435.8	425.2	446.5	14.23	54.83	52.44
T_2: Nano N 2 ml/lit.	638.3	449.3	438.3	460.3	16.75	59.26	50.58
T_3: Nano N 4 ml/lit.	654.5	465.9	454.5	477.2	18.91	60.45	48.47
T_4: Nano N 6 ml/lit.	659.6	471.0	459.6	482.5	19.37	62.29	46.85
T_5: Chelated Zn 0.4%	630.3	441.0	430.3	451.8	16.32	57.96	49.14
T_6: Nano N 2 ml/lit.+ Chelated Zn 0.2 %/lit.	647.4	458.6	447.4	469.8	18.14	60.12	48.94
T_7: Nano N 4 ml/lit.+ Chelated Zn 0.2 %/lit.	661.6	473.1	461.6	484.6	20.88	63.69	44.30
T_8: Nano N 6 ml/lit.+ Chelated Zn 0.2 %/lit.	674.7	486.6	474.7	498.4	21.36	65.90	43.32
T_9: Chelated Zn 0.8%	660.6	472.1	460.6	483.6	19.69	62.75	46.98
T_{10}: Nano N 2 ml/lit.+ Chelated Zn 0.4 %/lit.	677.7	489.7	477.7	501.6	22.28	68.61	43.41
T_{11}: Nano N 4 ml/lit.+ Chelated Zn 0.4 %/lit.	687.8	500.0	487.8	512.2	23.13	71.69	41.03
T_{12}: Nano N 6 ml/lit.+ Chelated Zn 0.4 %/lit.	693.9	506.2	493.9	518.6	23.48	73.45	37.92
T_{13}: Chelated Zn 1.2%	655.5	466.9	455.5	478.3	18.96	61.83	48.92
T_{14}: Nano N 2 ml/lit.+ Chelated Zn 0.6 %/lit.	671.7	483.5	471.7	495.3	21.24	65.10	46.20
T_{15}: Nano N 4 ml/lit.+ Chelated Zn 0.6 %/lit.	681.8	493.8	481.8	505.9	22.75	69.42	42.01
T_{16}: Nano N 6 ml/lit.+ Chelated Zn 0.6 %/lit.	684.8	496.9	484.8	509.0	22.84	70.12	39.39
SEm ±	5.393	5.527	5.392	5.661	0.189	0.607	0.446
C.D. at 5%	NS	NS	NS	NS	0.546	1.752	1.288

This result aligns with earlier findings that nitrogen promotes vegetative growth by supporting chlorophyll production and cell division (Sarker et al., 2009), while zinc enhances auxin synthesis and enzyme activation, contributing to elongation and vigor (Alloway, 2008; Singh et al., 2018).

3.2 Plant Spread

3.2.1 East–west spread

The maximum spread (478.2 cm) was recorded with Nano-N @ 6.0 ml/lit. Zinc at 0.4% resulted in the highest lateral expansion (480.0 cm). Again, the N3 × Z2 treatment showed the best results (493.9 cm), albeit not statistically significant. While the interaction between nano nitrogen and zinc was not statistically significant, the highest plant spread (493.9 cm) in the $N_3 \times Z_2$ treatment indicates a potential synergistic effect, in line with previous findings in pomegranate and mango where combined nutrient treatments enhanced canopy growth (Phanindra et al., 2022; Srivastava et al., 2021).

3.2.2 North–south spread

A similar trend was observed in N–S spread. N3 and Z2 treatments recorded maximum values of 502.1 cm and 504.0 cm, respectively. The best interaction effect (518.6 cm) was seen in N3 × Z2, showing a synergistic potential. Nano nitrogen at 6.0 ml/lit (N3) resulted in the highest mean spread (502.1 cm), likely due to improved nitrogen use efficiency and enhanced chlorophyll content, promoting cell expansion and canopy development (Subba *Rao* et al., 2013). Similarly, foliar application of chelated zinc at 0.4% (Z_2) produced the greatest lateral spread (504.0 cm), which can be attributed to zinc's role in auxin synthesis, membrane integrity, and enzyme activation (Alloway, 2008).

3.3 Number of Flowers Per Shoot

Both nano nitrogen and chelated zinc treatments significantly increased flower numbers. The highest average number (21.76) was noted in N3, and among zinc levels, Z2 (22.15) performed best. A significant interaction was observed, with N3 × Z2 yielding the highest number of flowers per shoot (23.48). The superior performance of Nano-N @ 6.0 ml/lit (N_3), yielding the highest mean value (21.76), aligns with its known role in boosting nitrogen uptake efficiency and stimulating vegetative and reproductive growth (Singh et al., 2023). Similarly, chelated zinc at 0.4% (Z_2) exhibited the greatest effect (22.15), Notably, the significant interaction between N_3 and Z_2, resulting in the maximum fruit weight or size (23.48), suggests a synergistic impact when both nutrients are optimally supplied. This reinforces earlier findings by Chandana et al., (2021), who reported enhanced fruit size in guava through integrated foliar nutrition.

3.4 Fruit Set Percentage

Fruit set improved significantly with increasing doses. Nano-N @ 6.0 ml/lit resulted in the highest mean set (67.94%), while Zn @ 0.4% gave the highest (69.13%). The interaction effect was significant; the combination of N3 × Z2 had the highest fruit set (73.45%). The statistically significant interaction effect between nano nitrogen and zinc further supports the combined application approach, with the $N_3 \times Z_2$ treatment resulting in the highest fruit set (73.45%). This synergistic response may be attributed to the complementary functions of nitrogen and zinc in enhancing floral development and fertilization, consistent with the observations of Pansuriya et al. (2024) in guava.

3.5 Fruit Drop Percentage

Both treatments significantly reduced fruit drop. Nano-N @ 6.0 ml/lit recorded the lowest drop (41.87%), while Zn @ 0.4% recorded 42.34%. The most effective treatment. Similarly, chelated zinc, particularly at 0.4% (Z_2), effectively minimized fruit drop (42.34%), which can be attributed to its role in stabilizing auxins and strengthening cell walls (Alloway, 2008). The interaction between the two treatments was also significant, with the $N_3 \times Z_2$ combination recording the lowest fruit drop (37.92%), indicating that balanced nutrition involving both zinc and nano nitrogen enhances fruit retention mechanisms. These findings are in line with the work of Pansuriya et al., (2024)

4. CONCLUSION

The foliar application of nano nitrogen and chelated zinc significantly enhanced the growth and reproductive parameters of guava. Nano nitrogen @ 6.0 ml/lit and chelated zinc @ 0.4% were the most effective doses individually. The combination of these two T11@ (N3 × Z2) showed a synergistic effect in improving plant height, spread, flowering, fruit set, and yield parameters. Therefore, foliar application of Nano-

N @ 6.0 ml/lit combined with Zn @ 0.4% is recommended for optimum guava cultivation in similar agro-climatic conditions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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