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Assessment of the response to foliar application of nano fertilizers on the growth and flowering attributes of rose (*Rosa Hybrida* L.) cv Taj

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ABSTRACT

An investigation was undertaken to assess the response of foliar application of nano fertilizers on growth and flowering attributes of Rose (*Rosa hybrida* L.) cv. 'Taj' under protected cultivation conditions. The experiment was conducted during 2025–26 at Balaji Krishi Farm, Patan, Durg (Chhattisgarh), while laboratory observations were recorded at the College of Horticulture and Research Station, Sankara, Patan. The experiment was arranged in a Completely Randomized Design (CRD) consisting of ten treatments with three replications. Different concentrations of Nano DAP and Nano Zinc were applied individually and in combination through foliar spraying. The application of nano fertilizers significantly improved various growth and flowering attributes of rose plants. Among the evaluated treatments, the combined application of Nano DAP 6 ml L⁻¹ + Nano zinc 0.075 ml L⁻¹ (T₈) exhibited the most favourable response by recording the highest plant height at 30 and 60 days after treatment (127.67 and 136.10 cm, respectively), maximum number of branches (7.97), stem diameter (6.02 mm), number of leaves (70.67), leaf area (28.97 cm²) and total shoot production (9.67). Furthermore, T₈ resulted in early flower bud appearance (35.33 days) and minimum duration for flower bud opening (5.30 days). The enhanced growth and flowering performance under combined nano fertilizer application may be associated with improved nutrient availability, efficient nutrient absorption and enhanced physiological functioning of plants. The findings suggest that foliar application of Nano DAP at 6 ml L⁻¹ combined with Nano zinc at 0.075 ml L⁻¹ can be effectively used to improve growth and flowering potential of rose cv. Taj under protected cultivation.

Keywords: Nano DAP, Nano Zinc, Foliar nutrition, *Rosa hybrida*, Growth attributes, Flowering characteristics

1. Introduction

Floriculture is an important branch of horticulture that focuses on the cultivation, production and commercialization of flowering and ornamental plants. Flowers possess significant aesthetic, cultural and economic value and are extensively used for landscape development, floral decoration, religious activities, social events, perfumery and pharmaceutical industries. In recent years, floriculture has emerged as a promising sector in India owing to increasing domestic consumption and growing export potential. According to APEDA (2025) [1], India exported 21,024.41 metric tonnes of floricultural products valued at ₹749.17 crore (USD 88.58 million) during 2024–25, reflecting the increasing economic significance of the floriculture industry. Among various ornamental crops, rose (*Rosa hybrida* L.) occupies a prominent position in the global cut flower industry and is widely recognized as the “Queen of Flowers”. Due to its attractive flower colours, pleasant fragrance, diverse forms and excellent consumer acceptance, rose has gained considerable importance in both domestic and international flower markets (Ritz *et al.*, 2005; Fanourakis *et al.*, 2013) [3, 2]. However, the production of high-quality flowers with desirable growth and flowering characteristics largely depends on efficient nutrient management and balanced fertilization practices. Optimum nutrient availability is essential for maintaining vigorous vegetative growth, enhancing flowering behaviour and improving flower quality in rose. Adequate supply of macro and micronutrients promotes photosynthetic efficiency, cell division, metabolic activities and overall plant growth (Manimaran *et al.*, 2017) [4]. Among the major nutrients, phosphorus plays a crucial role in root development, energy transfer, nucleic acid synthesis and initiation of reproductive processes. However, the availability of phosphorus in soil is often restricted due to fixation with soil components, resulting in reduced nutrient use efficiency (Al-Taey *et al.*, 2019) [5]. Diammonium phosphate (DAP), containing 18% nitrogen and 46% phosphorus, is one of the most commonly used phosphatic fertilizers. The development of Nano DAP has gained importance due to its potential

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to enhance phosphorus availability, improve nutrient absorption efficiency and minimize nutrient losses (Chamuah *et al.*, 2023) [6]. Zinc is an essential micronutrient involved in various physiological processes such as enzyme activation, chlorophyll synthesis, protein metabolism and auxin biosynthesis, which influence plant growth and flowering (Alloway, 2004; Cakmak, 2000) [7, 8]. Zinc deficiency adversely affects plant productivity, while foliar application of nano zinc improves nutrient absorption and utilization due to its higher surface area and enhanced penetration ability (Sharma *et al.*, 2013; Elemike *et al.*, 2019) [10, 9]. Nano fertilizers further enhance nutrient use efficiency through controlled nutrient release and reduced nutrient losses, supporting sustainable crop production (Gade *et al.*, 2023) [11]. The combined application of Nano DAP and Nano Zinc may enhance nutrient availability and improve growth and flowering performance of rose plants. However, limited information is available regarding their combined foliar application in rose under protected cultivation. Therefore, the present investigation was undertaken to evaluate the effect of foliar application of Nano DAP and Nano Zinc on growth and flowering attributes of rose (*Rosa hybrida* L.) cv. 'Taj' under protected cultivation conditions and to identify the most effective nutrient combination for improving crop performance.

2. Materials and Methods

The study entitled "Assessment of the Response to Foliar Application of Nano Fertilizers on Growth and Flowering Attributes of Rose (*Rosa hybrida* L.) cv. 'Taj'" was conducted during 2025–26 under polyhouse conditions at Balaji Krishi Farm, Patan, Durg, Chhattisgarh, India, in collaboration with the College of Horticulture and Research Station, Sankara, Patan. The experiment comprised ten treatments involving different concentrations of Nano DAP and Nano Zinc, applied individually and in combination, to evaluate their effects on growth and flowering attributes of rose cv. 'Taj'.

2.1 Experimental details

The experiment was laid out in a Completely Randomized Design (CRD) with 10 treatments and three replications under protected cultivation conditions. rose plants were randomly assigned to the respec-

tive treatments. Nano DAP and Nano Zinc were applied as foliar sprays at different concentrations, either individually or in combination, along with an untreated control. The details of the treatments are presented in Table 1.

2.2 Treatment details

2.3 Statistical analysis

The recorded observations were subjected to analysis of variance (ANOVA) following the procedure applicable to CRD. The significance of treatment effects was tested at the 5% level of probability. Where the *F*-test was significant, the critical difference (CD) was calculated for comparison of treatment means.

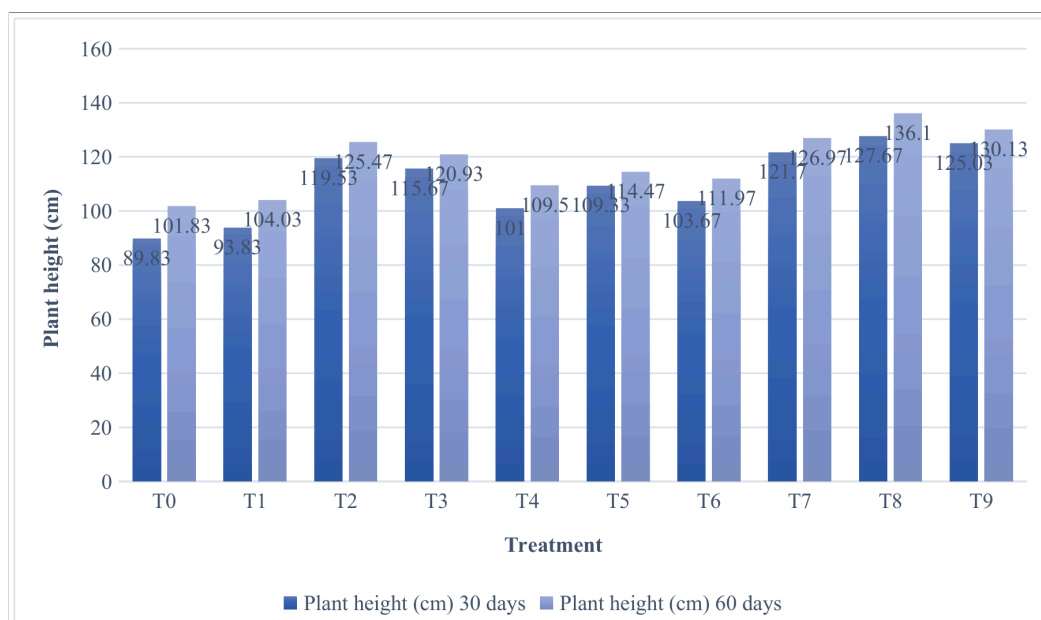
3. Results and Discussion:

The results obtained from the experiment are presented and discussed under the following headings.

3.1 Vegetative parameters

3.1.1 Plant height (cm) at 30 and 60 days after treatment

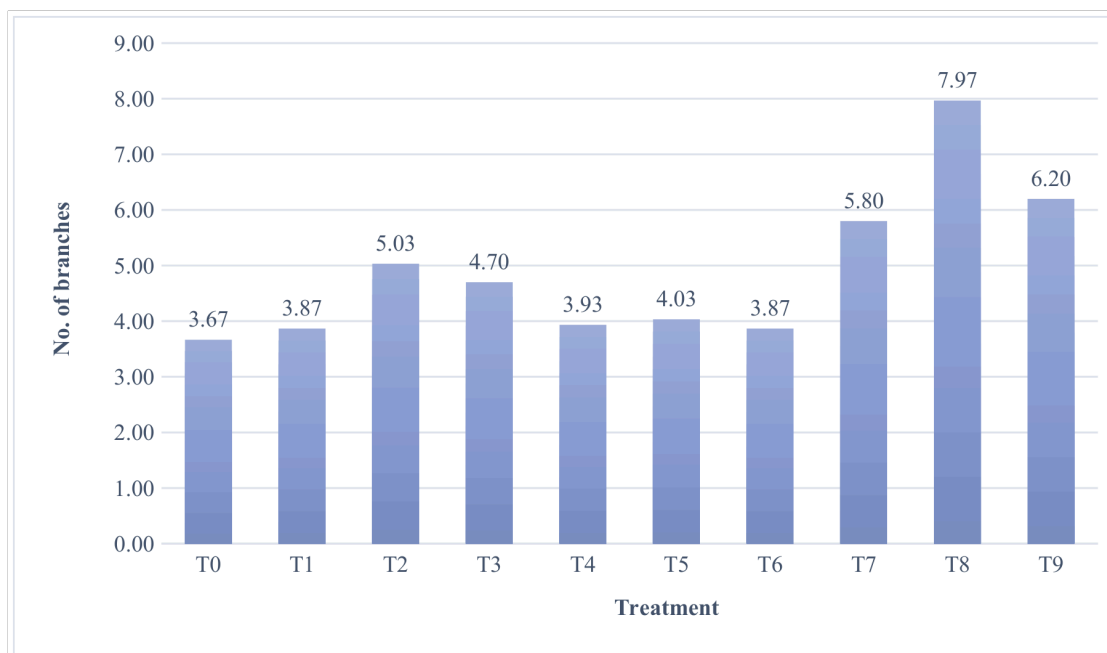
The application of Nano DAP and Nano Zinc significantly influenced plant height of rose at 30 and 60 days after treatment (DAT) (Table 3.1). At 30 DAT, the maximum plant height (127.67 cm) was recorded in T₈ (Nano DAP 6 ml L⁻¹ + Nano Zinc 0.075 ml L⁻¹), followed by T₉ (125.03 cm), while the minimum (89.83 cm) was observed in the control (T₀). A similar trend was observed at 60 DAT, where T₈ recorded the maximum plant height (136.10 cm), followed by T₉ (130.13 cm), whereas the minimum (101.83 cm) was recorded in T₀. The enhanced plant height under T₈ may be attributed to improved nutrient availability and utilization, owing to the complementary effects of nitrogen, phosphorus and zinc on plant metabolism and vegetative growth. These findings are in accordance with Joseph *et al.* (2019) [12] in China aster (*Callistephus chinensis*) and Meena *et al.* (2019) in rose (*Rosa hybrida* cv. Ganganagri).



3.1.2 Number of branches

The effect of Nano DAP and Nano Zinc application on number of branches in rose plants is presented in Table 3.1. Significant differences were recorded among treatments. The maximum number of branches (7.97 plant⁻¹) was observed in T₈, followed by T₉ (6.20 plant⁻¹), whereas the minimum (3.67 plant⁻¹) was recorded in control

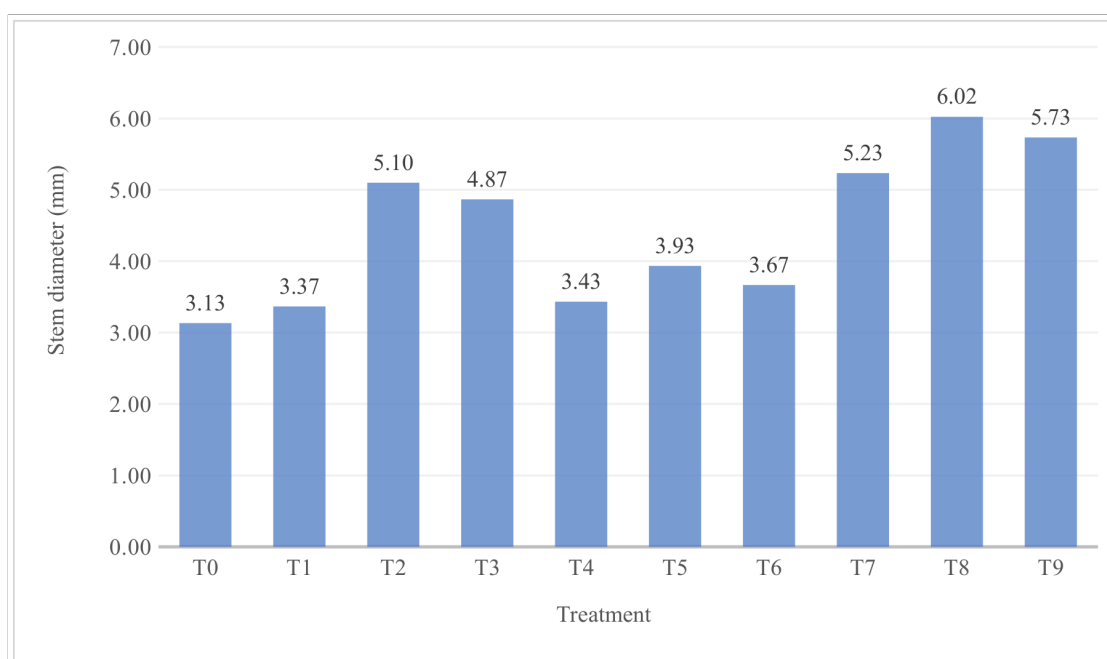
(T₀). The increased branching response may be due to better nutrient availability, enhanced enzymatic activity and the role of zinc in auxin metabolism, which promotes shoot initiation and development. Similar observations were reported by Singh (2019) [13] in *Calendula* (*Calendula officinalis* L.) where zinc application improved branching and vegetative growth.



3.1.3 Stem diameter (mm)

The effect of Nano DAP and Nano Zinc application on stem diameter of rose plants is presented in Table 3.1. Significant variation was observed among the treatments. The maximum stem diameter (6.02 mm) was recorded in T₈ (Nano DAP 6 ml L⁻¹ + Nano zinc

0.075 ml L⁻¹), followed by T₉ (5.73 mm), whereas the minimum (3.13 mm) was recorded in control (T₀). The increased stem thickness may be attributed to improved nutrient availability, better nutrient uptake and enhanced vegetative growth. These findings are supported by Raj *et al.* (2016) [14] in carnation (*Dianthus caryophyllus*), where micronutrient application improved stem growth and floral attributes.



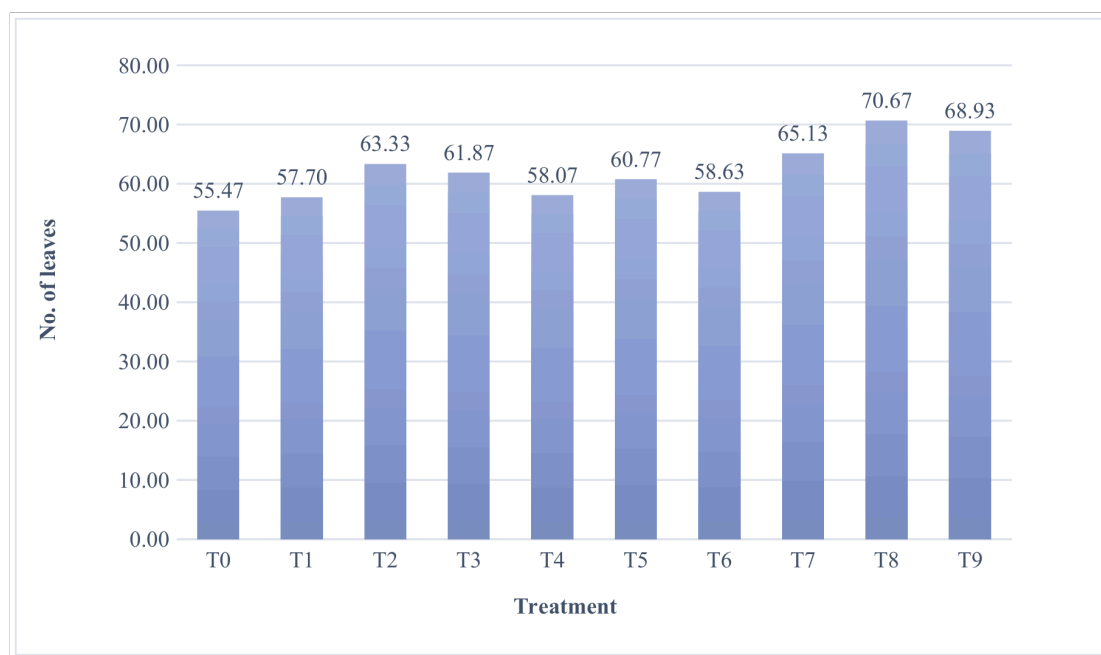
3.1.4 Number of leaves

The effect of Nano DAP and Nano Zinc foliar application on number of leaves in rose plants is presented in Table 3.1. Significant differences were observed among treatments. The highest number of leaves (70.67 plant⁻¹) was recorded in T₈, followed by T₉ (68.93 plant⁻¹),

whereas the lowest number of leaves (55.47 plant⁻¹) was observed in control (T₀). The increased leaf production may be associated with improved nutrient availability, enhanced photosynthetic efficiency and better vegetative development. Saikia *et al.* (2018) [15] also reported improved leaf growth and vegetative parameters with zinc application in *Rhynchosyilis* (*Rhynchosyilis retusa* L.).

Table 1. Details of various treatments including Nano DAP and Nano Zinc

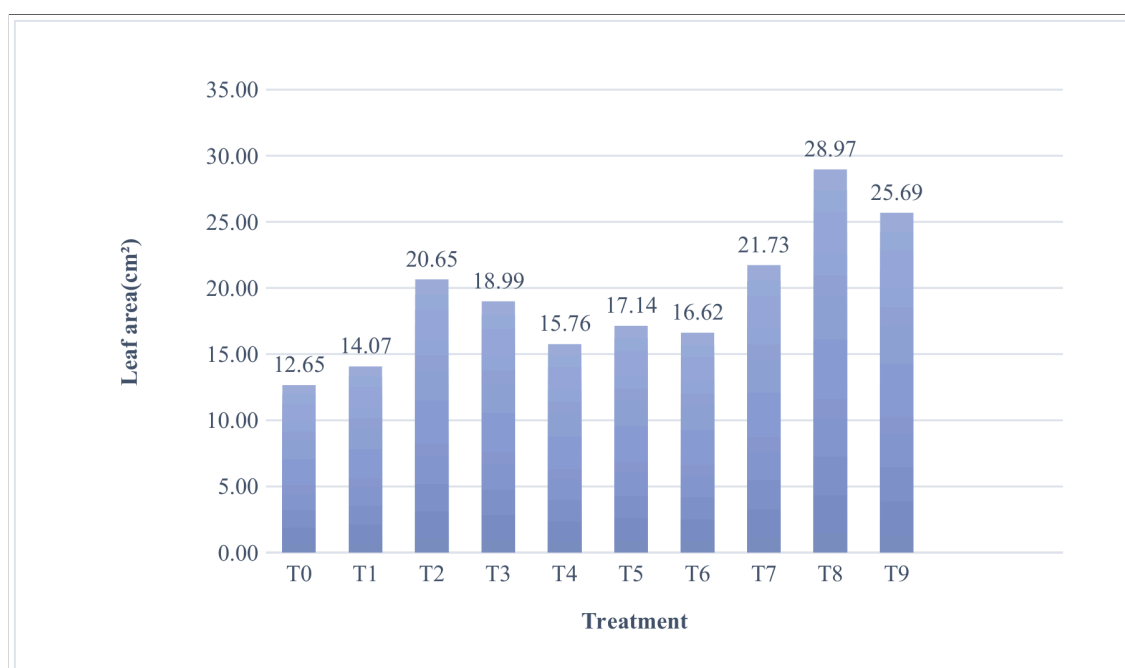
S.N.	Treatment Notations	Treatment details
1.	T ₀	Control
2.	T ₁	Nano DAP 4 ml/L ⁻¹
3.	T ₂	Nano DAP 6 ml/L ⁻¹
4.	T ₃	Nano DAP 8 ml/L ⁻¹
5.	T ₄	Nano zinc 0.05 ml/L ⁻¹
6.	T ₅	Nano zinc 0.075 ml/L ⁻¹
7.	T ₆	Nano zinc 0.1 ml/L ⁻¹
8.	T ₇	Nano DAP 4 ml/L ⁻¹ + Nano zinc 0.05 ml/L ⁻¹
9.	T ₈	Nano DAP 6 ml/L ⁻¹ + Nano zinc 0.075 ml/L ⁻¹
10.	T ₉	Nano DAP 8 ml/L ⁻¹ + Nano zinc 0.1 ml/L ⁻¹



3.1.5 Leaf area (cm²)

The influence of Nano DAP and Nano Zinc application on leaf area of rose plants is presented in Table 3.1. Significant differences were observed among treatments. The maximum leaf area (28.97 cm²) was recorded in T₈, followed by T₉ (25.69 cm²), whereas the minimum

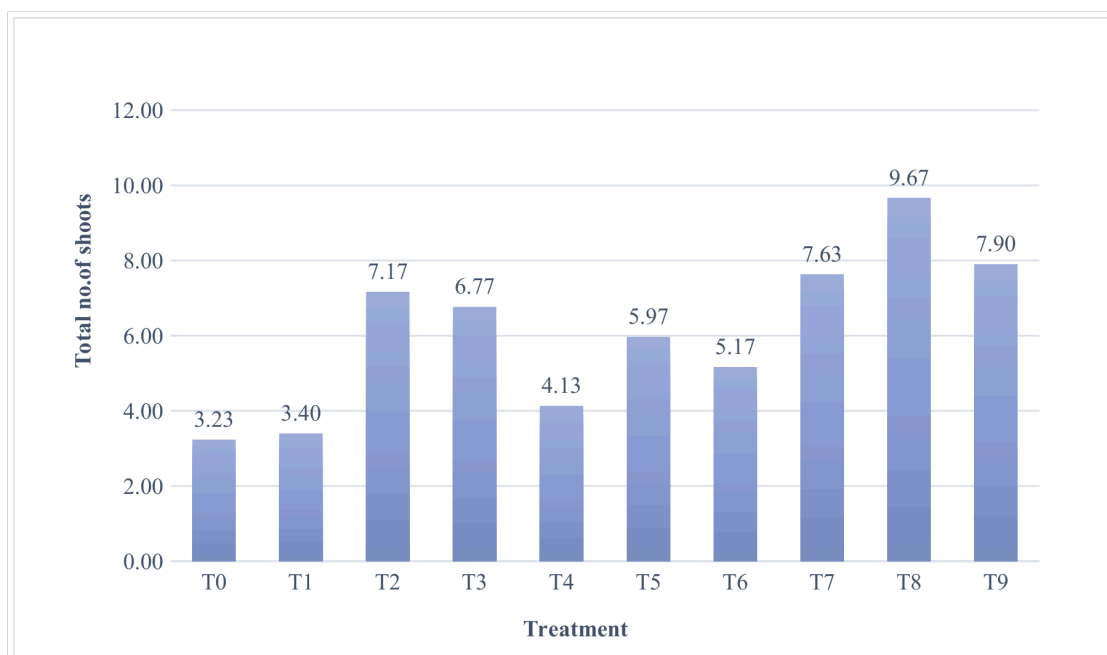
leaf area (12.65 cm²) was recorded in the control (T₀). The increased leaf expansion under nano fertilizer application may be due to improved nutrient uptake, enhanced cell expansion and better physiological activity of plants. These findings are in accordance with Singh *et al.* (1997) [16] in rose (*Rosa hybrida* L. cv. 'Rakta Gandha'), where foliar micronutrient application improved leaf growth parameters.



3.1.6 Total number of shoots

The effect of Nano DAP and Nano Zinc application on shoot production in Rose is presented in Table 3.1. Significant variation was observed among the treatments. The maximum number of shoots (9.67 plant⁻¹) was recorded in T₈, followed by T₉ (7.90 plant⁻¹) and T₇ (7.63 plant⁻¹), whereas the minimum number of shoots (3.23 plant⁻¹)

was observed in control (T₀). The enhanced shoot production may be attributed to improved nutrient availability, greater vegetative vigour and efficient translocation of assimilates towards actively growing regions. Comparable results were reported by Meena *et al.* (2019) in rose (*Rosa hybrida* L. cv. 'Ganganagri'), where nano nutrient application improved growth and yield-related traits.



3.2 Flowering parameters

3.2.1 Days to flower bud appearance and days to flower bud opening

The application of Nano DAP and Nano Zinc significantly influenced the duration required for flower bud appearance and opening in rose (Table 3.2). The earliest flower bud appearance (35.33 days) was recorded in T₈ (Nano DAP 6 ml L⁻¹ + Nano Zinc 0.075 ml L⁻¹), followed by T₉ (38.33 days) and T₇ (41.33 days), whereas the control (T₀) required the maximum duration (52.67 days). A similar trend was

observed for flower bud opening, where T₈ recorded the minimum duration (5.30 days), followed by T₉ (6.97 days) and T₇ (7.07 days), while the maximum duration (11.93 days) was recorded in T₀. The earlier bud initiation and opening under nano fertilizer application may be attributed to improved nutrient availability and utilization, leading to enhanced metabolic activity and assimilate translocation towards reproductive development. These findings are in agreement with Naik (2007) [17] in rose (*Rosa hybrida* L.), who reported that foliar zinc application promoted early bud emergence and improved flowering behaviour.

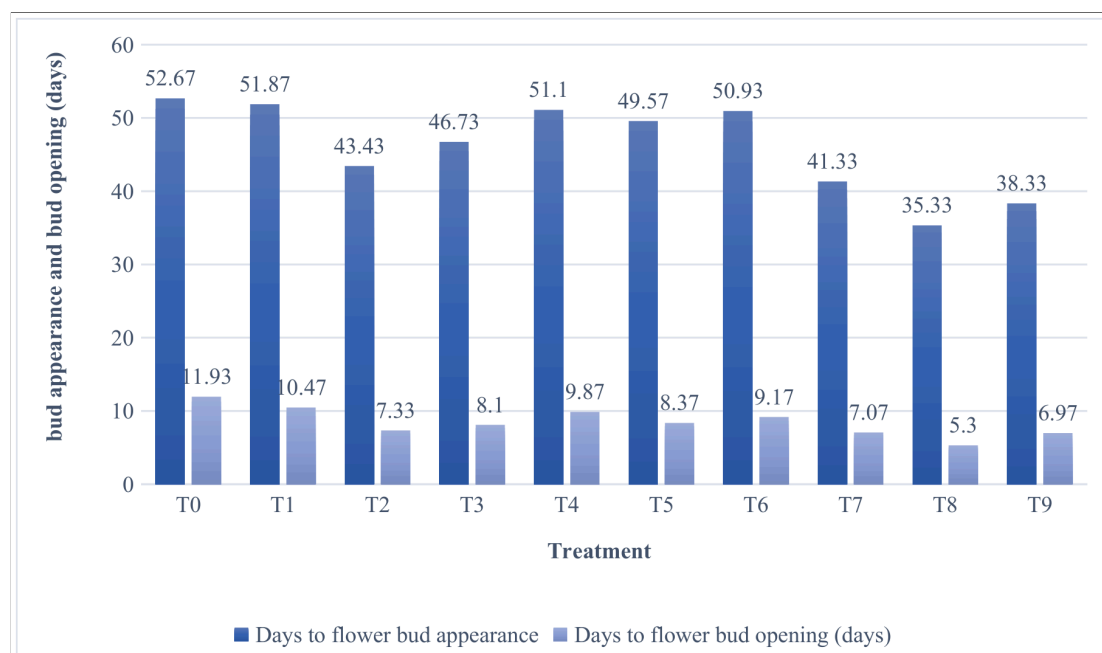
Table 3.1. Effect of foliar application of Nano DAP and Nano Zinc on vegetative growth and flowering parameters of rose (*Rosa hybrida* L.) cv. 'Taj'

Treatment	Plant height (cm)		Number of branches	Stem diameter (mm)	Number of leaves	Leaf area (cm ²)	Total number of shoots	Flower bud appearance (days)	Days to flower bud opening (days)
	30 DAT	60 DAT							
T ₀	89.83	101.83	3.67	3.13	55.47	12.65	3.23	52.67	11.93
T ₁	93.83	104.03	3.87	3.37	57.70	14.07	3.40	51.87	10.47
T ₂	119.53	125.47	5.03	5.10	63.33	20.65	7.17	43.43	7.33
T ₃	115.67	120.93	4.70	4.87	61.87	18.99	6.77	46.73	8.10
T ₄	101.00	109.50	3.93	3.43	58.07	15.76	4.13	51.10	9.87
T ₅	109.33	114.47	4.03	3.93	60.77	17.14	5.97	49.57	8.37
T ₆	103.67	111.97	3.87	3.67	58.63	16.62	5.17	50.93	9.17
T ₇	121.70	126.97	5.80	5.23	65.13	21.73	7.63	41.33	7.07
T ₈	127.67	136.10	7.97	6.02	70.67	28.97	9.67	35.33	5.30
T ₉	125.03	130.13	6.20	5.73	68.93	25.69	7.90	38.33	6.97
SEm±	2.37	0.85	0.32	0.38	1.05	0.96	0.56	1.25	0.31
CD at 5%	6.99	2.50	0.94	1.12	3.11	2.84	1.67	3.70	0.92

4. Conclusion

The present study revealed that foliar application of Nano DAP and Nano Zinc significantly enhanced the growth and flowering performance of Rose (*Rosa hybrida* L.) cv. 'Taj' under protected cultivation conditions. Among the evaluated treatments, the combined application of Nano DAP @ 6 ml L⁻¹ + Nano zinc @ 0.075 ml L⁻¹ (T₈) exhibited the best response as evidenced by the maximum plant height,

number of branches, stem diameter, number of leaves, leaf area and total number of shoots, along with early flower bud appearance and reduced duration for flower bud opening. The control treatment (T₀) showed comparatively inferior performance for all the recorded parameters. Hence, foliar application of Nano DAP @ 6 ml L⁻¹ combined with Nano zinc @ 0.075 ml L⁻¹ can be recommended for improving vegetative growth and flowering attributes of Rose cv. 'Taj' under protected cultivation.



Disclaimer (artificial intelligence)

The authors declare that no generative artificial intelligence (AI) tools, including Large Language Models (such as ChatGPT, Copilot, etc.) or AI-based image generation technologies, were utilized in the preparation, writing, or revision of this manuscript.

Competing interests

The authors confirm that there are no competing interests associated with this manuscript.

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