



Plant Archives

Journal homepage: <http://www.plantarchives.org>

DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.2.210>

EVALUATION OF MICRONUTRIENT DOSES FOR ENHANCING GROWTH, FLOWERING, YIELD AND QUALITY OF ROSE (*Rosa × hybrida* L.) cv. ARKA SAVI UNDER OPEN-FIELD CONDITIONS OF EASTERN INDIA

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(Date of Receiving-14-07-2026; Date of Revision-06-09-2026; Date of Acceptance-18-09-2026)

ABSTRACT

The present investigation entitled “Evaluation of micronutrient doses for enhancing growth, yield and quality of rose (*Rosa × hybrida* L.) cv. Arka Savi under open-field conditions of Eastern India” was conducted during *rabi* season of 2024–2025 with ten treatments replicated thrice under Randomized Block Design at the AICRP on Floriculture unit, Department of Horticulture, Birsa Agricultural University, Ranchi, Jharkhand, India. The results revealed that treatment T₆ (soil application of Zn @ 5 kg ha⁻¹ + B @ 2 kg ha⁻¹ + Fe @ 2.5 kg ha⁻¹ along with foliar spray of Zn+B+Fe micronutrient mix @ 0.5%) recorded maximum plant height (89.00 cm), plant spread (75.00 cm in E–W direction and 66.33 cm in N–S direction) and early flower bud initiation (27.33 days). The same treatment also produced superior floral quality with maximum flower diameter (7.16 cm), longer flowering duration (124 days) and enhanced shelf life (7.36 days). Yield parameters were significantly improved under T₆, recording the highest number of flowers per plant (59.66), flower yield per plant (609.68 g) and hundred flower weight (1087.82 g). Leaf nutrient analysis indicated higher concentrations of macro- and micronutrients, while post-harvest soil analysis showed significant changes in N, P, K and Zn availability. Economic analysis showed that T₆ recorded the highest benefit-cost ratio (3.92:1), indicating its economic feasibility. Thus, treatment T₆ proved to be the most effective for improving growth, yield and quality of rose cv. Arka Savi under eastern Indian conditions.

Key words : *Rosa × hybrida* L. cv. Arka Savi, Micronutrients, Soil and foliar application, Yield.

Introduction

Roses (*Rosa* spp.), belonging to the family Rosaceae, are among the most admired and economically valuable ornamental plants globally, cultivated since ancient times for their aesthetic appeal, captivating fragrance and versatile uses in the floriculture, perfume and medicinal industries. In the global floriculture trade, roses play a dominant role in event decoration and international commerce. In India, rose cultivation is a significant sector, with the National Horticulture Board (2021) reporting an estimated area of 30.87 thousand hectares and a total production of approximately 334.46 thousand tonnes. Despite its commercial importance, rose cultivation faces significant physiological challenges that limit yield and

quality. Among these, micronutrient deficiencies are the primary constraint. Micronutrients, though required in minute quantities, are indispensable for fundamental plant processes including enzyme activation, hormone regulation and photosynthetic efficiency. Iron (Fe) acts as a critical cofactor for enzymes involved in the electron transport chain and chlorophyll biosynthesis; its deficiency results in interveinal chlorosis and impaired photosynthetic capacity. Zinc (Zn) is essential for the biosynthesis of tryptophan, a precursor to the growth hormone indole-3-acetic acid (IAA), which governs cell division and apical dominance (Alloway, 2008). Boron (B) is fundamental to cell wall structural integrity, meristematic activity and the translocation of sugars, directly influencing floral

induction and bud development (Brown *et al.*, 2002).

The prevalence of micronutrient deficiencies in Indian soils is alarming, with approximately 44% of soils deficient in Zn and 11.2% in Fe and 33% in B (Singh, 2009). In regions like Jharkhand, acidic soil conditions further exacerbate Boron deficiency, affecting nearly 60% of the cultivable area (Sarkar *et al.*, 2013). Unfavourable soil pH and high calcium carbonate levels often fix these nutrients, making them unavailable for plant uptake even when present in the soil. While foliar application has been recognized as an effective method to bypass soil fixation and provide rapid nutrient maintenance (Fageria *et al.*, 2009), soil application provides a sustainable way for providing nutrients. The rose cultivar 'Arka Savi' is a promising Floribunda hybrid known for its high yield potential and long shelf life. However, there is a distinct lack of standardized micronutrient recommendations for this specific cultivar under open field conditions, leaving a knowledge gap for growers in the Ranchi region of Jharkhand. Therefore, keeping these aspects in view, the present study was designed with objectives to optimize the micronutrient requirements to obtain better flower yield and quality and also to investigate the role of micronutrients on the floral attributes of floribunda rose cv. Arka Savi under open field conditions, thereby providing a scientific basis for sustainable rose production in Eastern India.

Materials and Methods

The experiment was conducted during the rabi season of 2024–2025 at the AICRP on Floriculture unit, Department of Horticulture, Birsa Agricultural University, Ranchi, Jharkhand. The experimental site is located in the Jharkhand plateau region at 23°09' N latitude and 85°20' E longitude with an altitude of 625.32 m above mean sea level. The region experiences a humid subtropical climate, where environmental variables such as temperature and relative humidity remained approximately $25 \pm 5^\circ\text{C}$ and 70–80%, respectively, which favoured optimal physiological development of floral crops. Plants of rose (*Rosa* × *hybrida*) cv. Arka Savi were used as the experimental material. The crop was grown under open-field conditions in red loam soil having slightly acidic pH (6.0), typical of the region and often requiring micronutrient supplementation to avoid deficiency-induced physiological disorders. The experiment was laid out in a Randomized Block Design (RBD) consisting of ten treatments replicated three times. **The treatments consisted of:** T_1 = foliar application of Zn-EDTA + B + Fe-EDTA (0.5% each); T_2 = foliar application of a micronutrient mix containing Zn + B +

Fe at 0.5%; T_3 = soil application of Zn (5 kg ha⁻¹) + B (2 kg ha⁻¹) + Fe (2.5 kg ha⁻¹) combined with foliar application of Zn-EDTA + B + Fe-EDTA (0.5% each); T_4 = soil application of Zn (2.5 kg ha⁻¹) + B (1 kg ha⁻¹) + Fe (1.25 kg ha⁻¹) combined with foliar application of Zn-EDTA + B + Fe-EDTA (0.5% each); T_5 = soil application of Zn (1 kg ha⁻¹) + B (0.4 kg ha⁻¹) + Fe (0.5 kg ha⁻¹) combined with foliar application of Zn-EDTA + B + Fe-EDTA (0.5% each); T_6 = soil application of Zn (5 kg ha⁻¹) + B (2 kg ha⁻¹) + Fe (2.5 kg ha⁻¹) combined with foliar application of the Zn+B+Fe micronutrient mix at 0.5%; T_7 = soil application of Zn (2.5 kg ha⁻¹) + B (1 kg ha⁻¹) + Fe (1.25 kg ha⁻¹) combined with foliar application of the Zn+B+Fe micronutrient mix at 0.5%; T_8 = soil application of Zn (1 kg ha⁻¹) + B (0.4 kg ha⁻¹) + Fe (0.5 kg ha⁻¹) combined with foliar application of the Zn+B+Fe micronutrient mix at 0.5%; T_9 = soil application of Zn (5 kg ha⁻¹) + B (2 kg ha⁻¹) + Fe (2.5 kg ha⁻¹); and T_{10} = recommended NPK treatment. All experimental units received a uniform basal dose of macronutrients (NPK) at 200:200:100 kg ha⁻¹ to maintain a standardized nutritional background. Observations were recorded at 30-days interval (30, 60, 90 and 120 days after pruning). Vegetative growth parameters such as plant height (cm) and plant spread (cm) in East–West and North–South directions were measured using a meter scale. Reproductive and phenological traits including days to flower bud appearance, duration of flowering (days) and flower diameter (cm) at full bloom were recorded. Yield parameters comprised number of flowers per plant, flower yield per plant (g) and weight of 100 randomly selected flowers. Post-harvest longevity was evaluated by recording shelf life (days) until the onset of petal senescence under ambient conditions. Economic feasibility of treatments was assessed through benefit-cost (B:C) ratio calculated as the ratio of gross return to total cost of cultivation.

Soil samples were collected before and after treatment imposition, air-dried, ground and passed through a 2-mm sieve for analysis. Available nitrogen was estimated using the alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Bray P_1 extraction (Bray and Kurtz, 1945) and available potassium through neutral normal ammonium acetate extraction followed by flame photometry (Hanway and Heidel, 1952). Soil micronutrients (Fe, Zn and B) were extracted using the DTPA method and quantified with an Atomic Absorption Spectrophotometer (AAS) following Lindsay and Norvell (1978). For leaf analysis, rose leaves were also collected before and after treatment imposition, oven-dried, ground and subjected to chemical

analysis. Leaf nitrogen was determined by the Kjeldahl digestion and distillation method (Piper, 1966). Phosphorus content was analyzed using the vanadomolybdate yellow colour method at 420 nm (Baruah and Barthakur, 1997), while potassium concentration was measured using a flame photometer after diacid digestion (Jackson, 1973). Leaf micronutrients (Fe, Zn and B) were estimated using Atomic Absorption Spectrophotometer (AAS). The experimental data were subjected to analysis of variance (ANOVA) as described by Fisher (1925) to evaluate treatment effects. Treatment means were compared using the Critical Difference (CD) at the 5% level of significance. Changes in soil and leaf nutrient status before and after micronutrient application were further analyzed using paired t-test to assess treatment-induced nutrient dynamics.

Results and Discussion

The vegetative growth, floral quality and yield attributes of *Rosa × hybrida* L. cv. Arka Savi were significantly influenced by different micronutrient treatments as presented in Table 1. Among all treatments, T₆ recorded the maximum plant height (89.00 cm) and plant spread (75.00 cm in E–W direction and 66.33 cm in N–S direction), which was statistically at par with T₇, while the lowest values were observed in the NPK control (T₁₀). The improvement in vegetative growth under T₆ may be associated with the combined effect of zinc, boron and iron (Ahmad *et al.*, 2010 and Poornima *et al.*, 2018), which may contribute to enzymatic activity, chlorophyll synthesis and auxin production. Zinc is involved in the synthesis of tryptophan, a precursor of indole-3-acetic acid (IAA), which promotes cell division and elongation. Iron contributes to chlorophyll formation and enhances photosynthetic efficiency, resulting in increased biomass production. Enhanced canopy development may also be linked to improved root growth and efficient nutrient uptake (Salem *et al.*, 2019).

Flowering phenology and floral quality were significantly influenced by micronutrient application. T₆ recorded the earliest flower bud initiation (27.33 days) and the highest flower diameter (7.16 cm), flowering duration (124 days) and shelf life (7.36 days), with values statistically at par with T₇. The improvement in flowering may be attributed to better micronutrient availability, which favours reproductive growth and flower development (Haider *et al.*, 2014). Dhyani *et al.* (2024) also observed improved flowering and flower production in chrysanthemum with combined soil and foliar application of micronutrients.

Yield attributes were significantly influenced by

Table 1 : Effect of different micronutrient treatments on vegetative growth, flowering, yield and quality parameters of rose (*Rosa × hybrida* L.) cv. Arka Savi.

Treatments	Plant height (cm)	Plant spread (EW) (cm)	Plant spread (NS) (cm)	Time taken for 1 st flower bud appearance (days)	Duration of flowering (days)	Flower diameter (cm)	Shelf life (days)	Number of flowers per plant	Flower yield per plant (g)	Hundred flower weight(g)	B:C ratio
T ₁	65.00	51.33	59.66	34.66	94.00	5.73	4.78	46.96	422.16	833.74	2.15:1
T ₂	65.00	54.00	56.00	31.33	110.00	6.63	6.09	53.76	511.38	964.83	3.40:1
T ₃	74.33	71.00	58.00	32.33	105.60	6.50	5.83	50.80	477.76	923.88	2.56:1
T ₄	74.00	65.66	44.66	32.66	97.46	6.26	5.58	49.54	445.16	886.19	2.42:1
T ₅	65.00	56.66	48.66	33.66	99.20	5.76	5.28	48.04	420.90	853.41	2.31:1
T ₆	89.00	75.00	66.33	27.33	124.00	7.16	7.36	59.66	609.68	1087.82	3.92:1
T ₇	83.00	74.00	58.00	27.66	118.40	7.00	6.89	57.74	577.18	1076.31	3.78:1
T ₈	82.00	68.66	64.66	28.33	114.00	6.80	6.48	55.02	540.10	939.21	3.58:1
T ₉	60.00	50.66	55.33	35.33	90.00	5.63	4.24	43.34	367.82	800.97	2.38:1
T ₁₀	56.00	41.33	36.00	38.00	86.40	5.50	4.10	41.54	332.54	719.05	2.24:1
C.D.	14.30	13.20	17.38	6.75	16.37	1.22	0.41	9.79	99.32	219.68	
SE(m)	4.81	4.44	5.85	2.27	5.50	0.41	0.13	3.29	33.42	73.94	
C.V.	11.68	12.65	18.51	12.25	9.18	11.32	4.25	11.32	12.39	14.09	

Table 2 : Effect of different micronutrient treatments on leaf nutrient status (initial and final) of rose (*Rosa × hybrida* L.) cv. Arka Savi.

Treatments	N %		P (%)		K (%)		Zn(ppm)		B (ppm)		Fe(ppm)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T ₁	2.66	3.50	0.37	0.47	1.21	1.52	30.08	67.66	20.12	22.56	26.62	34.36
T ₂	3.21	3.92	0.46	0.60	1.80	2.13	29.96	80.90	26.55	29.46	41.81	39.73
T ₃	3.08	3.91	0.43	0.58	1.51	1.93	29.31	77.22	25.78	28.43	34.71	38.46
T ₄	2.87	3.85	0.38	0.56	1.42	1.86	30.18	73.63	24.54	24.60	36.87	36.86
T ₅	2.80	3.60	0.37	0.56	1.23	1.69	30.05	69.22	22.64	24.40	33.09	36.20
T ₆	3.64	4.73	0.56	0.95	1.58	2.82	57.75	81.76	34.85	36.63	39.13	98.80
T ₇	3.50	4.63	0.61	0.71	1.76	2.50	46.80	80.74	29.57	36.60	57.11	72.66
T ₈	3.43	3.99	0.53	0.65	1.62	2.36	30.32	80.93	28.46	29.76	44.57	40.70
T ₉	2.66	3.01	0.32	0.46	0.88	1.40	24.94	68.85	20.08	21.42	24.86	30.06
T ₁₀	2.59	2.73	0.35	0.44	1.17	1.25	26.43	54.39	20.07	17.84	26.23	28.53
t-value	7.43		5.79		5.26		13.69		2.57		1.56	
P value	0.00		0.00		0.00		0.00		0.03		0.15	
Significance	Significant		Significant		Significant		Significant		Significant		Non-significant	

Table 3 : Effect of different micronutrient treatments on soil nutrient status (initial and final).

Treatments	N(kg/ ha)		P(kg/ ha)		K(kg/ ha)		Zn(ppm)		B (ppm)		Fe(ppm)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T ₁	232	254	67.20	69.81	478	524	0.80	0.81	0.35	0.36	3.07	3.02
T ₂	248	252	47.04	49.65	257	301	1.08	1.07	0.37	0.36	4.23	3.60
T ₃	221	239	56.89	58.61	397	379	0.85	1.60	0.50	0.52	4.34	5.67
T ₄	192	204	50.17	55.25	370	364	0.80	2.11	0.44	0.44	3.09	5.48
T ₅	201	204	51.07	55.25	424	479	0.89	1.10	0.40	0.40	2.93	3.12
T ₆	165	176	33.60	40.32	246	278	0.76	1.72	0.54	0.56	2.98	2.98
T ₇	173	202	88.36	89.60	371	366	0.82	1.75	0.44	0.44	2.41	3.35
T ₈	172	187	65.40	73.54	339	348	0.79	1.82	0.42	0.43	2.32	3.09
T ₉	165	205	32.14	33.93	265	308	0.88	0.92	0.52	0.53	2.70	2.84
T ₁₀	136	139	88.25	90.49	248	330	1.00	0.98	0.33	0.31	3.00	2.90
t-value	4.09		4.95		2.78		3.15		1.00		1.79	
P value	0.0027		0.0008		0.0213		0.0117		0.3434		0.1066	
Significance	Significant		Significant		Significant		Significant		Non-significant		Non-significant	

micronutrient treatments. The highest number of flowers per plant (59.66), flower yield per plant (609.68 g) and weight of 100 flowers (1087.82 g) were recorded under T₆, which was statistically at par with T₇, whereas the lowest values were observed in the NPK control. The increased flower production may be attributed to improved vegetative growth and the development of more flowering shoots (Karthik *et al.*, 2022 and Vanlalruati *et al.*, 2019). Higher yield and flower weight are likely due to enhanced photosynthetic activity and efficient translocation of assimilates to developing floral buds. Additionally, increased flower size contributed to higher individual flower weight, thereby increasing the cumulative weight of flowers. These results were consistent with the findings

of Thirumalmurugan *et al.* (2021) in marigold.

Leaf nutrient analysis as presented in Table 2 revealed that combined soil and foliar application significantly improved plant nutrient status. Treatment T₆ recorded the highest concentrations of Zn (81.76 ppm), Fe (98.80 ppm) and B (36.63 ppm), indicating efficient uptake and translocation. Macronutrient levels also increased, with T₆ showing higher leaf N (4.73%), P (0.95%) and K (2.82%) (Anjaneyulu *et al.*, 2006). The paired t-test indicated significant changes in leaf N, P, K, Zn and B, while soil N, P, K and Zn also increased significantly ($p < 0.05$). The significant increase in leaf nutrient concentration reflected efficient uptake and translocation of these nutrients following micronutrient application.

Although soil boron remained non-significant, leaf boron increased significantly, suggesting rapid plant uptake with little residual accumulation in the soil. Iron remained non-significant in both leaf and soil, which may be attributed to the naturally high iron content of the red lateritic soils of Jharkhand and the limited residual effect of applied iron. Post-harvest soil analysis (Table 3) showed that T₆ increased available soil Zn from 0.76 to 1.72 ppm, whereas B showed only a marginal increase from 0.54 to 0.56 ppm and Fe remained unchanged at 2.98 ppm. In acidic red loam soils of the Ranchi plateau, micronutrients are prone to fixation and leaching; therefore, the combined soil and foliar approach ensures both immediate nutrient uptake and sustained soil fertility (Fageria *et al.*, 2009). Foliar application bypasses soil-related losses, while soil supplementation maintains a long-term nutrient reservoir, reducing nutrient mining in perennial crops like rose. Economic analysis clearly indicated the superiority of integrated micronutrient management. Treatment T₆ generated the highest net return (Rs. 4,65,913.20 ha⁻¹) with a benefit–cost ratio of 3.92:1, whereas the NPK control recorded only 2.24:1. Although, micronutrient supplementation slightly increased input costs, the substantial improvement in yield, flower size and shelf life resulted in higher market value and profitability as also reported by Pal *et al.* (2016) in gerbera and Subramanyam (1989) in rose. The results suggest that integrating soil and foliar micronutrient application offers a sustainable and economically viable strategy for rose cultivation under the eastern Indian plateau conditions. Adoption of such balanced nutrient management practices can enhance productivity while maintaining soil health, thereby supporting long-term commercial floriculture.

Conclusion

The present study clearly demonstrated that micronutrient management plays a crucial role in improving growth, flowering, yield, and quality of rose (*Rosa × hybrida* L.) cv. Arka Savi under open-field conditions. Treatment T₆, comprising soil application of Zn (5 kg ha⁻¹), B (2 kg ha⁻¹) and Fe (2.5 kg ha⁻¹) along with foliar application of Zn+B+Fe micronutrient mix at 0.5%, recorded superior performance in terms of vegetative growth, enhanced floral quality and higher yield. It also improved leaf nutrient status and influenced the post-harvest availability of specific nutrients in the soil. Furthermore, the highest benefit–cost ratio also observed under T₆ indicates its economic viability.

Acknowledgement

The authors sincerely express gratitude to the Department of Horticulture, Department of Agronomy,

Department of Soil Science and Department of Agrometeorology, along with the Directorate of Post Graduate Studies, Birsa Agricultural University, Ranchi, for their valuable support, guidance and facilities provided during the course of this study.

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