International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(9): 490-494
www.biochemjournal.com
Received: 15-06-2025
Accepted: 18-07-2025

Bagda SP
M.Sc. (Horticulture) Fruit Science, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Patel VK
Assistant Professor, Sheth D.M. Polytechnic in Horticulture, Model Farm, Vadodara, Anand Agricultural University, Vadodara, Gujarat, India

Viththalapara MK
M.Sc. (Horticulture) Fruit Science, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Verma Anuj
M.Sc. (Horticulture) Fruit Science, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Corresponding Author:
Bagda SP
M.Sc. (Horticulture) Fruit Science, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Effect of different nano micronutrient on yield of mango (*Mangifera indica* L.) CV. Amrapali

Bagda SP, Patel VK, Viththalapara MK and Verma Anuj

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i9Sg.5539

Abstract
A field experiment was carried out in 2024, at the Horticultural Research Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, for evaluating the effect of different nano micronutrient on yield of mango (*Mangifera indica* L.) cv. Amrapali. The experiment was conducted using a completely randomized design with nine treatments (T_1: Nano Zn 1.0 ml/L, T_2: Nano B 1.0 ml/L, T_3: Nano Fe 1.0 ml/L, T_4: Nano Zn 1.0 ml/L + B 1.0 ml/L, T_5: Nano Zn 1.0 ml/L + Fe 1.0 ml/L, T_6: Nano B 1.0 ml/L + Fe 1.0 ml/L, T_7: Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L, T_8: Micronutrient 1% $ZnSO_4$ + 0.5% Borax, T_9: water spray) All treatments were applied through foliar application and repeated twice, at 50 percent flowering and at one month after 1st spray during the year 2024. Among the treatments, the foliar application of nano Zn 1.0 ml/L + nano B 1.0 ml/L + nano Fe 1.0 ml/L significantly enhanced yield parameters, including no. of fruit set per panicle (at pea stage) (35.35), no. of fruit set per panicle (at harvest stage) (1.52), no. of fruit per tree (at harvest stage) (363.33), fruit length (10.54 cm), fruit weight (180.26 g), fruit girth (17.31 cm), pulp weight (115.68 g), peel weight (35.19 g), fruit yield (63.03 kg/tree and 17.46 t/ha) and lowest stone: pulp ration (0.25).

Keywords: Mango, nano micronutrient, *Mangifera indica*, Amrapali, yield

Introduction
The mango (*Mangifera indica* L.), a member of the Anacardiaceae family, is a major fruit crop in tropical and subtropical regions. It is believed to have originated in the Indo-Burma region and is recognized as the national fruit of India. Globally, there are more than 11,000 cultivars of *Mangifera*, with up to 69 genuine species identified (Bose *et al*., 2001) [4]. The mango has gained worldwide popularity and is one of the principal fruit crops in Asia. In India, thousands of mango varieties are cultivated across a wide range of agroclimatic conditions, including tropical and subtropical zones, humid and semi-humid tropics. Mango trees grow from sea level up to 1200 meters in diverse environments such as wet valleys, riversides, coastal forests, natural grasslands and also in open and disturbed areas like roadsides, pastures and both wet and dry secondary forests (Orwa *et al*., 2009) [11]. The major mango-growing states in India include Maharashtra, Karnataka, Kerala, Tamil Nadu, Odisha, West Bengal, Gujarat, Uttar Pradeshandhra Pradesh and Bihar. Currently, mangoes are grown in every district of Gujarat; however, due to their ideal agroclimatic conditions, Valsad, Navsari, Surat, Bharuch, Rajkot, Jamnagar, Kutch and Junagadh are the main growing districts. Commercial cultivation of Kesar, Alphanso, Rajapuri, Totapuri, Jamadar, Dashehari, Langra, Amrapali, Mallika, Sonpari and Neelum are the key cultivars across Gujarat. Micronutrients can significantly boost crop yields and improve the quality and shelf life of produce. Their position as enzyme activators and their involvement in lignin production make them important for disease resistance (Parmar *et al*., 2017) [12]. Nanoparticles (NPs) are nutrient carriers about nano-dimensions (10-9 m) and sizes ranging from 1 to 100 nm. Their high surface area, small size, high reactivity, high dispersibility and superior catalytic activity make them capable to hold large amounts of nutrient ions and aid in ultra-high absorption to enhance crop performance (Subramanian *et al*., 2015) [14]. Zinc, boron and iron are essential micronutrients that support key plant functions such as growth regulation, reproduction and photosynthesis. Their nano formulations improve foliar absorption and nutrient use efficiency, ultimately enhancing crop productivity under challenging soil conditions.

Foliar application of nano micronutrients has emerged as an effective and practical approach in mango cultivation. Challenges such as nutrient fixation in the soil, which limits the availability of essential elements to the crop, have highlighted the need for foliar delivery of these nutrients in nano form. Unlike traditional soil application, which often results in slower plant response, foliar spraying of nano micronutrients ensures faster absorption and mobility within the plant. This method helps prevent deficiencies and potential yield losses in mango before visual symptoms appear, enhancing nutrient use efficiency and supporting healthy crop growth.

Materials and Methods

The experiment was conducted on twenty-year-old trees of mango planted at Horticultural Research Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during 2024. It was carried out using a Completely Randomised Design with nine treatments *viz*., T_1: Nano Zn 1.0 ml/L, T_2: Nano B 1.0 ml/L, T_3: Nano Fe 1.0 ml/L, T_4: Nano Zn 1.0 ml/L + B 1.0 ml/L, T_5: Nano Zn 1.0 ml/L + Fe 1.0 ml/L, T_6: Nano B 1.0 ml/L + Fe 1.0 ml/L, T_7: Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L, T_8: Micronutrient 1% $ZnSO_4$ + 0.5% Borax, T_9: water spray repeated twice at 50% flowering and one month after 1st spray in the year 2024. Each selected tree given 100 kg of well-decomposed FYM and chemical fertilizers comprising 750 g nitrogen (as 1.5 kg urea per plant), 160 g phosphorus (0.35 kg DAP per plant)and 750 g potash (1.25 kg MOP per plant). Half of the nitrogen and all of the phosphorus and potassium were applied in June 2023, with the remaining nitrogen applied in February 2024.

Results and Discussion

Effect of different nano micronutrient on yield parameter No. of fruit set per panicle (at pea stage and at harvest stage)

According to the observations from Table 1, among the various treatments, the treatment T_7 (nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L) had the highest no. of fruit set per panicle (at pea stage) (35.35) and no. of fruit set per panicle (at harvest stage) (1.52). However, T_9 (control) had the lowest number of fruit set per panicle (at pea stage) (19.16). The increase in no. of fruit set per panicle (at pea stage) in mango is attributed to the combined effects of nano zinc, boron and iron on key physiological processes. Zinc promotes auxin production, boron supports pollen germination and iron enhances chlorophyll synthesis and energy generation. Their nano form ensures better absorption and mobility within the plant, improving nutrient efficiency, hormonal balance and photosynthesis, which collectively reduce fruit drop and enhance fruit maturity (Yadav *et al*., 2011; Deb and Reza, 2024) [15, 5].

No. of fruit per tree (at harvest stage)

Data pertaining to quality parameters presented in Table 1 revealed that the treatment T_7 had the highest no of fruit per tree (363.33), which was at par with treatments T_4 (343.26), T_5 (330.41), T_6 (341.01) and T_8 (349.09). On the other hand, T_9 (control) had the lowest no. of fruits per tree (at harvest stage) (262.00). The application of zinc, boron and iron enhances fruit number per tree by positively influencing physiological processes and enzymatic activity. Zinc supports auxin synthesis and photosynthesis, while boron aids in starch translocation and fruit setting, contributing to better fruit retention and yield. These effects are consistent with findings in strawberry (Kumar, 2021; Kumar *et al*., 2017) [8] and Washington navel orange (El-Gioushy *et al*., 2021; Al-Sabbagh *et al*., 2024) [6, 7].

Fruit drop (%)

Table 1 displays the data relating to the mango fruit drop (%) that was impacted by various treatments. The results of the different nano Zn, nano B and nano Fe treatments on the mango fruit drop (%) showed no significant variations.

Table 1: Effect of different nano micronutrient on no. of fruit set and fruit drop of mango cv. Amrapali

Sr. No.	Treatment	No. of fruit set/panicle (at pea stage)	No. of fruit set/panicle (at harvest stage)	No. of fruit (at harvest stage)	Fruit drop (%)
T_1	Nano Zn 1.0 ml/L	20.37	0.98	311.84	95.67
T_2	Nano B 1.0 ml/L	22.29	0.94	318.18	95.59
T_3	Nano Fe 1.0 ml/L	20.70	0.91	303.29	95.60
T_4	Nano Zn 1.0 ml/L + B 1.0 ml/L	28.30	1.25	343.36	95.41
T_5	Nano Zn 1.0 ml/L + Fe 1.0 ml/L	25.48	1.20	330.41	95.52
T_6	Nano B 1.0 ml/L + Fe 1.0 ml/L	25.84	1.15	341.01	95.58
T_7	Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L	35.35	1.52	363.33	95.10
T_8	Micronutrient 1% $ZnSO_4$ + 0.5% Borax	27.10	1.21	349.09	95.53
T_9	Water spray	19.16	0.65	262.00	96.61
S.Em±		1.23	0.06	12.46	3.45
CD at 5%		3.67	0.1	37.03	NS
CV%		8.58	9.60	6.65	6.25

Effect of different nano micronutrient on yield parameter Fruit weight (g)

Table 2 displays the results of the various treatments that had an impact on the fruit weight. Treatment T_7 (Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L) gave highest fruit weight (180.26 g), which was at par with treatments T_4 (172.84 g) and T_8 (170.48 g). Whereas, the control treatment showed minimum fruit weight (145.52 g). The increase in fruit weight may be attributed to the combined effects of zinc, boron and iron—zinc enhances starch production, iron supports cell division and enlargement and boron aids in carbohydrate transport. These nutrients likely improved the mobilization of photo assimilates and boosted cell activity, resulting in heavier fruits. Similar findings have been reported in date palm, olive, pomegranate and mango by various researchers including Mahida *et al.* (2018) [9] and Kumar (2021) [7].

Fruit length (cm)
The data shows on table 2 represent the effect of different treatments on fruit length (cm). Significantly highest fruit length (10.54 cm) was recorded in treatment T_7, which was at par with treatments T_4 (9.81 cm) and T_8 (9.86 cm). However, the minimum fruit length (8.53 cm) was found in T_9 (control). This may be due to the combined application of nano zinc, boron and iron likely led to the longest fruit length due to their synergistic effects on hormone regulation, cell elongation and fruit development. Zinc promotes auxin synthesis, boron aids in nutrient transport and structural integrity and iron supports metabolic activity and energy production. In nano form, these nutrients are more efficiently absorbed and utilized by plants, enhancing fruit expansion. Similar results have been reported by Beniwal *et al*. (2024) [3] and Mosa *et al*. (2024) [10].

Fruit girth (cm)
The data of fruit girth affected by various treatments shown in Table 2. The highest fruit girth (17.31 cm) was achieved by treatment T_7 (Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L), which was at par with treatments T_4 (16.19 cm) and T_8 (16.93 cm). Treatment T_9 (control) showed the minimum fruit girth (14.17 cm). The combined application of nano zinc, boron and iron significantly enhanced fruit girth by promoting cell expansion and overall fruit development. Zinc supported auxin production, boron facilitated cell wall formation and nutrient transport, while iron maintained active metabolism and chlorophyll synthesis during fruit growth. The nano formulation ensured better absorption and nutrient availability, leading to improved internal tissue development. Similar results have been reported by Auda *et al*. (2022) [2] and Sayed and Gomma (2024) [13].

Pulp weight (g)
The effects of all of the treatments that affected the pulp weight are given in Table 2. Treatment T_7 (Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L) generated the highest pulp weight (115.68 g) which was at par with treatments T_4 (110.10 g) and T_8 (107.90 g). Treatment T_9 (control) gave the lowest pulp weight (88.64 g). The combined application of nano iron, boron and zinc enhanced fruit development and resulted in the highest pulp weight. Boron improved sugar transport and cell wall integrity, zinc supported fruit growth and cell division and iron boosted photosynthesis and energy production—key processes for pulp formation. The nano form of these nutrients allowed for faster absorption and efficient transport, leading to better nutrient utilization. This balanced nutrient supply throughout fruit development promoted greater pulp accumulation. Similar findings were reported by Sayed and Gomma (2024) [13].

Stone weight (g)
The data of mango stone weight affected by various treatments shown in Table 2. The results show that there were non-significant differences in stone weight between treatments as a result of applying nano Zn, nano B and nano Fe.

Stone: pulp ratio
Table 2 shows the result of the different treatments that influenced the stone: pulp ratio. The lowest stone: pulp ratio (0.25) was achieved by treatment T_7 (Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L), which was at par with treatments T_4 (0.26) and T_8 (0.26). As a result, the T_9 (control) treatment showed the maximum stone: pulp (0.32). The combined application of nano zinc, boron and iron enhanced pulp development and reduced the stone: pulp ratio without affecting stone weight, due to improved cell division, nutrient transport and metabolic activity. This coordinated nutrient effect, supported by efficient nano nutrient absorption, led to better internal fruit growth. Similar findings were supported by Sayed and Gomma (2024) [13] and Yadav *et al*. (2011) [15]

Peel weigh (g) and (%)
Table 2 shows the result of the different treatments that influenced the peel weight. The highest peel weight (35.19 g) was achieved by treatment T_7 (Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L), which was at par with treatments T_4 (34.30 g) and T_8 (34.27 g). As a result, the T_9 (control) treatment showed the lowest peel weight (27.98 g). Peel (%) was non-significant by the application of nano Zn, nano B and nano Fe throughout all of the treatments.

Table 2: Effect of different nano micronutrient on physical parameter of mango cv. Amrapali

Sr. No.	Treatment	Fruit weight	Fruit length	Fruit girth	Pulp weight	Stone weight	Stone: pulp	Peel weight	Peel%
T_1	Nano Zn 1.0 ml/L	157.90	8.95	14.20	96.96	27.96	0.28	30.82	19.51
T_2	Nano B 1.0 ml/L	157.17	8.88	15.17	96.36	27.70	0.28	30.86	19.62
T_3	Nano Fe 1.0 ml/L	155.42	9.14	14.32	95.28	28.00	0.29	29.98	19.28
T_4	Nano Zn 1.0 ml/L + B 1.0 ml/L	172.84	9.81	16.19	110.10	27.60	0.26	34.30	19.84
T_5	Nano Zn 1.0 ml/L + Fe 1.0 ml/L	160.56	9.08	16.05	101.00	28.09	0.28	30.64	19.07
T_6	Nano B 1.0 ml/L + Fe 1.0 ml/L	166.84	9.31	16.03	104.30	28.61	0.27	31.45	18.84
T_7	Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L	180.28	10.54	17.31	115.68	29.21	0.25	35.19	19.52
T_8	Micronutrient 1% $ZnSO_4$ + 0.5% Borax	170.48	9.86	16.93	107.90	27.68	0.26	34.27	20.09
T_9	Water spray	145.52	8.83	14.17	88.64	28.50	0.32	27.98	19.22
	S. Em±	3.80	0.26	0.38	1.83	0.80	.004	0.86	0.48
	CD at 5%	11.28	0.78	1.12	8.42	NS	0.01	2.55	NS
	CV%	4.04	4.84	4.19	4.82	4.91	2.79	4.69	4.31

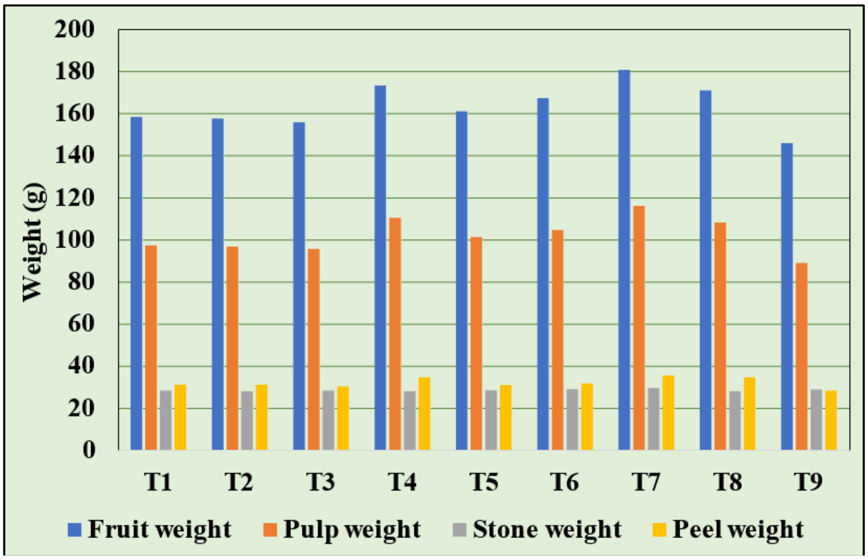

Fig 1: Effect of different nano micronutrient on fruit weight, pulp weight, stone weight and peel weight of mango cv. Amrapali

Fruit yield (kg/plant and t/ha)

Table 3 shows the results of the several treatments that had an impact on the fruit yield (kg/tree and t/ha). Fruit yield (kg/tree and t/ha) was significantly impacted by the direct application of nano Zn, nano B and nano Fe. The highest fruit yield (63.03 kg/tree and 17.46 t/ha) was obtained from treatment T_7 (Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L). Treatment T_9 (control) produced the lowest fruits yield (40.43 kg/tree and 11.20 t/ha). The combined use of nano zinc, boron and iron enhances nutrient absorption and key physiological functions, leading to better fruit set, reduced fruit drop, improved fruit growth and significantly higher yields. This is supported by the findings of El-Gioushy *et al*. (2021) [7], Al-Sabbagh *et al*. (2024) [1].

Table 3: Effect of different nano micronutrient of fruit yield on mango cv. Amrapali

Sr. no.	Treatment	Fruit yield (kg/tree)	Fruit yield (t/ha)
T_1	Nano Zn 1.0 ml/L	46.49	12.88
T_2	Nano B 1.0 ml/L	48.90	13.54
T_3	Nano Fe 1.0 ml/L	44.10	12.21
T_4	Nano Zn 1.0 ml/L + B 1.0 ml/L	55.86	15.47
T_5	Nano Zn 1.0 ml/L + Fe 1.0 ml/L	51.89	14.37
T_6	Nano B 1.0 ml/L + Fe 1.0 ml/L	50.70	14.04
T_7	Nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L	63.03	17.46
T_8	Micronutrient 1% $ZnSO_4$ + 0.5% Borax	57.32	15.88
T_9	Water spray	40.43	11.20
S.Em±		2.46	0.68
CD at 5%		7.31	2.02
CV%		8.36	8.68

Conclusion

The result obtained from the research experiment, it can be concluded that the foliar application of nano Zn 1.0 ml/L + B 1.0 ml/L + Fe 1.0 ml/L (two sprayed one at 50% flowering and 2nd at one month after 1st spray) treatment was recorded significant effect on yield parameters *viz*., highest no. of fruit set (at pea and harvest stage), no. of fruit per tree (at harvest stage), fruit length, fruit weight, fruit girth, peel weight and fruit yield (kg/tree and t/ha) and lowest stone:pulp ratio in mango cv. Amrapali.

Reference

1. Al-Sabbagh MN, El-Gioushy SF. Impact of various iron forms on the nutritional status, productivity and fruit quality of Washington navel orange trees. Annals of Agricultural Science, Moshtohor. 2024;62(1):129-142.
2. Auda MS, Obeid NA, Jasem HH. The effect of foliar spraying with nano iron oxide and tryptophan acid on some indicators of fruit growth of Barhee tissue culture date palm. International Journal of Agricultural and Statistical Sciences. 2022;18:2175-2182.
3. Beniwal M, Mishra S, Bahadur V. Effect of foliar application of nano urea, boron and zinc sulphate on growth fruit yield and quality of strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter Dawn. Journal of Advances in Biology & Biotechnology. 2024;27(6):725-735.
4. Bose TK, Mitra SK, Sanyal D. Fruits: tropical and subtropical. Vol. 1. 2001.
5. Deb P, Reza S. Effect of pre-flowering sprays of micronutrients on flowering, fruit set, fruit drop and yield of mango cv. Amrapali. Crop Research. 2024;59.
6. El-Gioushy SF, Ding Z, Bahloul AM, Gawish MS, Abou El Ghit HM, Abdelaziz AM, *et al*. Foliar application of nano, chelated and conventional iron forms enhanced growth, nutritional status, fruiting aspects and fruit quality of Washington navel orange trees (*Citrus sinensis* L. Osbeck). Plants. 2021;10(12):2577.
7. Kumar D. Response of micro-nutrients on yield, fruit quality and nutrient status of mango cv. Dashehari. Indian Journal of Horticulture. 2021;(4):404-408.

8. Kumar UJ, Bahadur V, Prasad VM, Mishra S, Shukla PK. Effect of different concentrations of iron oxide and zinc oxide nanoparticles on growth and yield of strawberry (*Fragaria* × *ananassa* Duch.) cv. Chandler. International Journal of Current Microbiology and Applied Sciences. 2017;6(8):2440-2445.
9. Mahida A, Tandel YN, Mantri A, Nikshita P, Parmar VK. Effect of Fe and Zn fertilization on fruit setting and yield attributes of mango cv. Kesar. International Journal of Chemical Studies. 2018;6(5):532-534.
10. Mosa WF, Al-Saif AM, Sas-Paszt L, Górnik K, Eladly RM. Effect of the combined application of compost with the spraying of some nano fertilizers on the performance of mango. Sustainability. 2024;16(23).
11. Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A. Agroforestree database: a tree species reference and selection guide version 4.0. Nairobi: World Agroforestry Centre ICRAF; 2009.
12. Parmar P, Patil SJ, Kumar S, Chaudhari AM, Tandel BM. Response of fertilizer application on growth of papaya var. Red Lady. International Journal of Current Microbiology and Applied Sciences. 2017;6(12):2375-2379.
13. Sayed HF, Gomaa AM. Evaluating the impact of spraying nano potassium and nano boron on productivity and fruit quality of Medjool date palm. Journal of Plant Production. 2024;15(7):373-378.
14. Subramanian KS, Manikandan A, Thirunavukkarasu M, Rahale CS. Nano-fertilizers for balanced crop nutrition. In: Nanotechnologies in Food and Agriculture. 2015. p. 69-80.
15. Yadav AK, Singh JK, Singh HK. Studies on integrated nutrient management in flowering, fruiting, yield and quality of mango cv. Amrapali under high density orcharding. Indian Journal of Horticulture. 2011;68(4):453-460.