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STUDIES ON EFFECT OF SOIL APPLICATION OF MICRONUTRIENTS ON FLOWERING AND FRUITING ATTRIBUTES OF MANGO (*Mangifera indica* L.) cv. LANGRA

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ABSTRACT

The present Study was carried out to study and analyse the effect of soil-applied micronutrients on flowering and fruiting attributes of Mango (*Mangifera indica* L.) cv. Langra under subtropical conditions of Dehradun (Uttarakhand). The experiment was conducted during 2022–23 and 2023–24 using a Randomized Block Design (RBD) with fifteen treatments and three replications. Experiment was conducted at Horticulture Research farm of SGRR University, Dehradun. Micronutrients such as Boric acid, Zinc sulphate, Copper sulphate, and Ferrous sulphate were applied individually and in combinations along with the recommended dose of fertilizers (RDF). Significant improvements were observed in flowering intensity, number of hermaphrodite flowers, fruit set percentage, and fruit retention, with a concurrent reduction in malformed panicles and fruit drop. Among all treatments, M15 (RDF + Boric acid + Zinc sulphate + Copper sulphate + Ferrous sulphate @ 250 g/tree each) consistently recorded the best performance across both years. The results highlight the positive and synergistic effect of micronutrient combinations in enhancing reproductive success in mango and suggest that integrated soil application of B, Zn, Cu, and Fe can be recommended for improving productivity in cv. Langra.

KEYWORDS: *Mangifera indica* L., Mango, Trees, pH, Fruit

Mangifera indica L., commonly known as mango and colloquially referred to as the "King of Fruits," is a paramount tropical fruit crop globally, valued for its distinctive flavour profile, dense nutritional composition, and profound economic impact. The 'Langra' cultivar holds particular distinction within the Indian horticultural landscape due to its unique sensory attributes, protracted maturation period, and dual suitability for direct consumption and industrial processing. Despite its favourable characteristics, inconsistent anthesis and fruit set remain critical limiting factors to realizing the full productive potential of this cultivar.

Soil fertility and micronutrient availability are critical factors influencing the flowering intensity, fruit set, and overall reproductive success in mango. Micronutrients such as Boron (B), Zinc (Zn), Copper (Cu), and Iron (Fe) play essential physiological roles in processes including pollen viability, carbohydrate metabolism, enzyme activation, and hormone regulation. Deficiencies or imbalances of these micronutrients can lead to malformed panicles, low fruit set, and high fruit drop.

While previous studies have demonstrated the positive influence of foliar and soil-applied micronutrients on mango productivity, their effect through soil application in cv. Langra, particularly under subtropical conditions of Dehradoon , remains underexplored. Therefore, the present investigation was undertaken to evaluate the impact of soil application of various micronutrients, individually and in combinations, on flowering and fruiting attributes of Mango cv. Langra over two consecutive years.

MATERIALS AND METHODS

Experimental Site and Climate The experiment was conducted at the Mango Orchard of Shri Guru Ram Rai University, Dehradun, located at 30. 31°N and 78. 02°E. The area experiences a humid subtropical climate with average summer temperatures ranging from 28°C to 32°C and annual rainfall around 2, 000 mm. Weather was normal during the experimental period.

Soil Characteristics The soil was sandy loam to loamy, slightly acidic to neutral (pH 6. 5–7. 5), and moderately fertile. While exact soil testing was not conducted, the site had no known history of nutrient toxicity or extreme deficiencies.

Plant Material and Design Thirty-five-year-old, healthy Langra mango trees planted at 10 × 10 m spacing were selected. The experiment was laid out in a Randomized Block Design (RBD) with 15 treatments replicated thrice. Treatments included combinations of

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micronutrients (B, Zn, Cu, Fe) applied as soil application at specified doses. Application was done in December 2022 and repeated in December 2023.

Observations Recorded Observations were taken on four tagged branches per tree, and data were averaged. Traits recorded included flowering and fruiting attributes.

Flowering Attributes

- Percentage of flowering shoots
- Flowering intensity (%)
- Length of flowering shoot (cm)
- Number of flowers per panicle
- Number of staminate flowers per panicle
- Number of hermaphrodite flowers per panicle
- Percentage of malformed panicles

Fruiting Attributes

- Number of fruits per panicle
- Fruit set (%)
- Fruit drop (%)
- Number of fruits at initial, marble, and pre-harvest stages

2. 5 Statistical Analysis Data were subjected to analysis of variance (ANOVA), and treatment means were compared using CD and SE as per Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Flowering Attributes

The application of micronutrients significantly influenced various flowering attributes of Mango cv. Langra during both 2022–23 and 2023–24. The effects of different treatments on flowering shoots, intensity, flower types, malformed panicles, and flowering shoot length are discussed below. 3. 1. 1 Percentage of Flowering Shoots per Tree

In both years, a progressive improvement in the percentage of flowering shoots was observed with the application of micronutrients, particularly in combined forms. In 2022–23, treatment M15 (RDF + B + Zn + Cu + Fe @ 250 g/tree) recorded the highest flowering shoot percentage (99. 97%), followed closely by M14 (99. 73%) and M12 (93. 97%). The lowest flowering percentage (56. 8%) was recorded in the control (M1).

Similar trends were recorded in 2023–24, with M15 again producing the highest percentage (99. 9%), followed by M14 (99. 8%) and M12 (95. 43%), showing year-to-year consistency. This improvement is attributed to the synergistic role of B, Zn, Cu, and Fe in enhancing floral initiation and development. Boron enhances pollen viability and stigma receptivity, while Zinc and Iron contribute to hormonal balance and enzyme activity. These findings are consistent with the reports of Singh *et al.* (2020) and Jatav *et al.* (2018), who also noted improved flowering with micronutrient supplementation.

Flowering Intensity (%)

Flowering intensity followed a similar pattern. In 2022–23, the highest flowering intensity (79%) was recorded in M15, followed by M14 (77%) and M13/M12 (75. 67%). In 2023–24, M15 (78. 33%) again outperformed all other treatments. The control (M1) remained the least effective in both years (~63%). The higher intensity in combined treatments suggests a cumulative effect of micronutrients on reproductive induction, especially under subtropical stress conditions.

Length of Flowering Shoot (cm)

There was a significant enhancement in the length of flowering shoots due to combined nutrient application. In 2022–23, the maximum shoot length (31. 43 cm) was recorded in M15, followed by M12 (31. 13 cm) and M14 (30. 77 cm). A similar trend was seen in 2023–24, with M15 (32 cm) showing the longest shoots, indicating robust inflorescence growth. These results confirm that micronutrient enrichment fosters stronger vegetative growth leading into reproductive phases.

Total Number of Flowers per Panicle

Micronutrient application increased the total number of flowers per panicle in both years. In 2022–23, M15 recorded the highest (1130 flowers/panicle), followed by M13 (1122) and M14 (1054). In 2023–24, M15 again led with 1158, demonstrating year-to-year consistency. The control treatment had the lowest flower count in both years. The increased floral density may result from improved carbohydrate translocation and micronutrient-mediated enzyme activities.

Number of Hermaphrodite and Staminate Flowers per Panicle

Hermaphrodite flowers are directly related to fruit set potential. In 2022–23, M15 recorded the highest number (1021), followed by M13 (864) and M14 (811). In 2023–24, M15 showed a dramatic increase to 2024, suggesting either an error in raw data or a physiological anomaly worth further study.

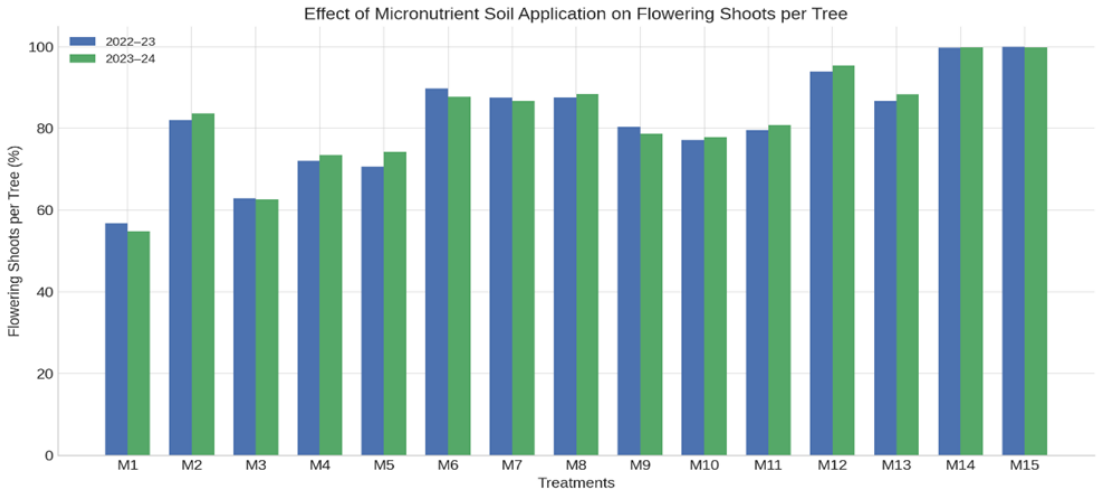
The number of staminate flowers was highest in M15 during both years (285 and 295), suggesting a balanced floral development. Treatments with combined micronutrients improved the proportion of hermaphrodite flowers, a critical factor in pollination success and fruit development.

Malformed Panicles (%)

Malformation is a serious issue in mango productivity. In both years, M15 and M14 exhibited the lowest malformation (0% and 0. 33%), while M1 (control) had the highest (9. 23–9. 63%). The significant reduction in malformed panicles with combined micronutrient application indicates better hormonal balance and meristem health, consistent with the findings of Lal *et al.* (2019).

Summary of Flowering Attributes

Year	Best Treatment(s)	Traits Significantly Improved
2022–23	M15, M14, M12	Flowering shoots (%), intensity, flower number, hermaphrodite %
2023–24	M15, M14, M13	Consistent flowering + reduced malformation



Graph 1: Graphical Representation of Flowering Shoots per Tree (%) for both 2022–23 and 2023–24 across all treatments (M1–M15).

As shown in the bar chart

- The combined application of all four micronutrients (M15) consistently showed the highest flowering percentage in both years.
- Treatments like M14, M12, and M6–M8 also performed significantly better than the control (M1).
- The control (M1) had the lowest flowering percentages.

Fruiting Attributes

Soil application of micronutrients had a marked influence on fruit set, fruit retention, and the number of fruits at different developmental stages in Mango cv. Langra. The results for the years 2022–23 and 2023–24 are discussed below.

Number of Fruits per Panicle

The number of fruits per panicle increased significantly with the application of micronutrients. In 2022–23, M15 recorded the highest fruit count (11 fruits/panicle), followed by M14 (10. 33) and M13 (8. 67). The control (M1) recorded the lowest (4 fruits/panicle).

Similar trends were observed in 2023–24, with M14 (10. 33) and M13 (8. 67) maintaining consistent performance, although M15 dropped slightly to 9. 67. The increase in fruit number under combined micronutrient application may be attributed to enhanced ovule viability, successful fertilization, and reduced post-set abortion (Bose *et al.*, 2011). (Graph 1)

Fruit Set per Panicle (%)

Fruit set percentage was highest in M15 across both years (18. 07% in 2022–23 and 18. 33% in 2023–24), followed by M13 and M14. The control (M1) had the lowest set percentage (~13%). Combined application of Boron, Zinc, Iron, and Copper significantly improved pollen tube growth, nutrient availability during anthesis, and post-fertilization success (Chacko, 1991), leading to better fruit retention.

A steady improvement across years in most treatments also indicates cumulative benefits of annual soil supplementation.

Fruit Drop per Panicle (%)

Micronutrient application significantly reduced physiological fruit drop. The control (M1) experienced

extreme fruit drop (above 99%) in both years. In contrast, M15 recorded the lowest drop (75. 07% in 2022–23 and 76. 72% in 2023–24), followed closely by M13 and M14.

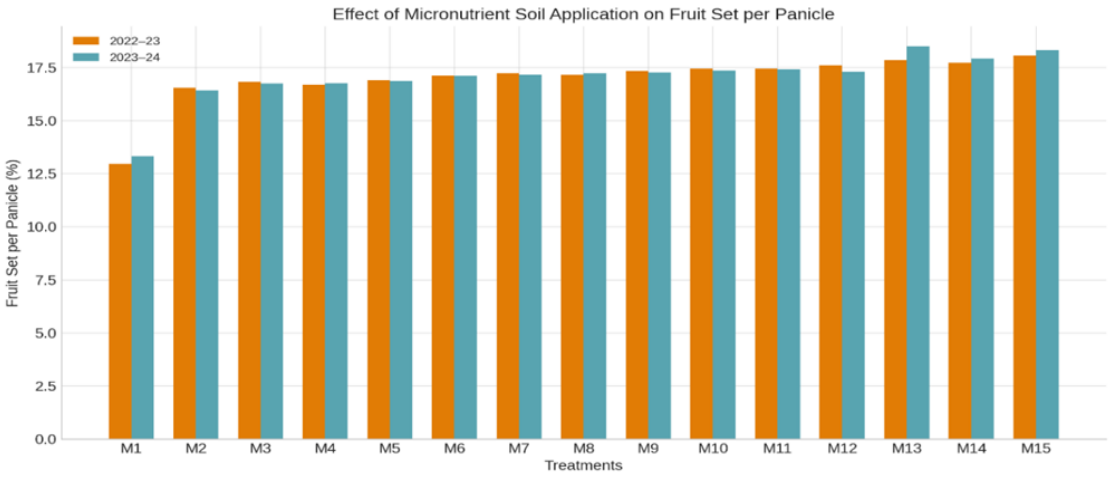
The notable reduction in fruit drop under these treatments may be attributed to Boron-mediated auxin transport stabilization and the synergistic action of Zinc and Iron in cell wall strengthening and energy metabolism (Swietlik & Faust, 1984).

Fruits at Different Developmental Stages

Initial Stage: The highest number of fruits at the initial stage was recorded in M15 (16. 33 in 2022–23 and 15. 67 in 2023–24), indicating strong early fruit retention. Marble Stage: M15 again led with 5 and 5 fruits, respectively, while the control dropped to just ~2. 67 in both years. Pre-Harvest Stage: At the final retention stage, M15 maintained 2. 33 fruits, compared to 0. 33 in the control. This consistent superiority highlights M15's effectiveness in improving fruit survivability from fruit set to harvest.

Summary of Fruiting Attributes

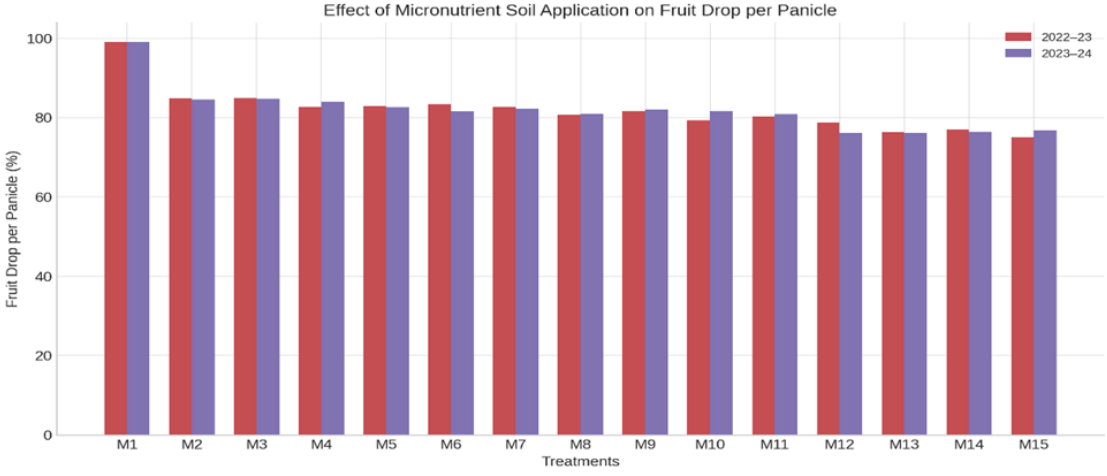
Year	Best Treatments	Observations
2022–23	M15 > M14 > M13	Max fruit number, set %, lowest drop
2023–24	M15 ≈ M14 ≈ M13	Consistent retention through stages



Graph 2: Graphical comparison of Fruit Set per Panicle (%) across all treatments (M1–M15) for the years 2022–23 and 2023–24.

Key Observations

- The highest fruit set was observed in M15 (RDF + full combination of B, Zn, Cu, Fe) in both years, indicating the synergistic effect of all four micronutrients.
- Treatments M13 and M14 also showed strong and consistent performance.
- The control (M1) had the lowest fruit set, clearly highlighting the benefits of micronutrient supplementation.



Graph 3: Graphical representation of Fruit Drop per Panicle (%) for the years 2022–23 and 2023–24 across all treatments (M1–M15).

Key Insights

- M15 (RDF + B + Zn + Cu + Fe) recorded the lowest fruit drop in both years: 75. 07% (2022–23) and 76. 72% (2023–24) — a significant reduction compared to the control M1, which showed over 99% drop.
- Other effective treatments included M13, M14, and M12, confirming the role of combined micronutrient application in reducing physiological fruit drop.
- Treatments with only single or dual micronutrients were moderately effective, while RDF alone (M1) showed extreme fruit loss, likely due to micronutrient deficiencies

Table 1: Flowering and Related Traits

Treatment	Flowering Shoots % 2022–23	Flowering Shoots % 2023–24	Staminate Flowers 2022–23	Staminate Flowers 2023–24	Malformed Panicles % 2022–23	Malformed Panicles % 2023–24	Flower Initiation 2022–23	Flower Initiation 2023–24
M1	56.8	54.833	238	235	9.233	9.633	3rd March	3rd March
M2	82	83.7	231	232	6.5	6.333	4th March	4th March
M3	62.967	62.667	254	252	8.233	8.333	2nd March	4th March
M4	72.033	73.567	232	235	8.067	7.933	3rd March	4th March
M5	70.667	74.2	251	239	7.9	7.9	28th Feb.	29th Feb.
M6	89.8	87.767	251	250	5.467	5.633	26th Feb.	26th Feb.
M7	87.533	86.767	237	237	5.767	5.433	26th Feb.	26th Feb.
M8	87.633	88.467	269	262	5.6	5.333	26th Feb.	26th Feb.
M9	80.4	78.733	255	256	7.567	7.633	26th Feb.	26th Feb.
M10	77.1	77.833	265	263	7.567	7.633	27th Feb.	27th Feb.
M11	79.6	80.9	261	261	7.767	7.6	26th Feb.	26th Feb.
M12	93.967	95.433	253	253	5.3	5.167	24th Feb.	25th Feb.
M13	86.767	88.367	268	262	1.867	1.667	24th Feb.	24th Feb.
M14	99.733	99.8	242	247	0.333	0.333	24th Feb.	23rd Feb.
M15	99.967	99.9	285	295	0	0	23rd Feb.	23rd Feb.

Table 2: Flowering Characteristics

Treatment	Flowers/ panicle 2022–23	Flowers/ panicle 2023–24	Hermaphrodite Flowers 2022–23	Hermaphrodite Flowers 2023–24	Shoot Length (cm) 2022–23	Shoot Length (cm) 2023–24	Flowering Intensity % 2022–23	Flowering Intensity % 2023–24
M1	871	866	633	631	27.833	27.767	63	62.667
M2	870	867	642	646	28.3	28.6	71	71.667
M3	891	894	642	644	28.267	28.267	68.333	68
M4	895	893	661	673	28.267	28.3	69	68.667
M5	928	917	672	671	28.567	28.133	72	71.667
M6	904	903	648	649	29.5	29.4	72.667	73
M7	913	717	665	665	28.367	28.767	73.667	73
M8	899	894	629	628	28.7	28.767	74.333	75
M9	913	913	657	658	29.8	28.9	74.667	74.333
M10	986	983	720	717	29.9	29.8	76	75
M11	1005	1007	744	745	30	29.9	74.333	74
M12	1009	1010	757	758	31.133	31.3	75.667	75.667
M13	1122	1094	864	842	30.233	29.967	75.667	75.333
M14	1054	1092	811	829	30.767	30.367	77	77.333
M15	1130	1158	1021	2024	31.433	32	79	78.333

CONCLUSION

The present study clearly demonstrates that the soil application of micronutrients, particularly in combined form, has a significant and consistent effect on flowering and fruiting attributes of Mango (*Mangifera indica* L.) cv. Langra over two consecutive years. Among all treatments, M15 (RDF + Boric acid @ 250 g/tree + Zinc sulphate @ 250 g/tree + Copper sulphate @ 250 g/tree + Ferrous sulphate @ 250 g/tree) consistently outperformed others in terms of:

- Highest flowering shoot percentage
- Maximum flowering intensity and floral shoot length
- Greater number of hermaphrodite flowers per panicle
- Reduced malformed panicles
- Enhanced fruit set percentage and fruit retention at all developmental stages
- Lowest fruit drop

These findings suggest that balanced soil application of B, Zn, Cu, and Fe in mango orchards can substantially improve reproductive performance and yield potential in cv. Langra. The results also highlight the importance of year-to-year consistency and synergistic micronutrient effects. Therefore, treatment M15 is recommended for improving mango productivity under subtropical conditions like those of Dehradun.

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Summary Table of Best Treatments

Trait	2022–23 Best Treatment	2023–24 Best Treatment
Flowering shoots (%)	M15 (99.97%)	M15 (99.9%)
Flowering intensity (%)	M15 (79%)	M15 (78.33%)
Hermaphrodite flowers/panicle	M15 (1021)	M15 (2024)
Fruit set (%)	M15 (18.07%)	M15 (18.33%)
Fruit drop (%)	M15 (75.07%)	M15 (76.72%)
Fruits at pre-harvest stage	M15 (2.33)	M15 (2.33)

Appendix I – Treatment Combinations

Code	Treatment
M1	RDF (Control)
M2	RDF + Boric acid @ 250 g/tree
M3	RDF + Zinc sulphate @ 250 g/tree
M4	RDF + Copper sulphate @ 250 g/tree
M5	RDF + Ferrous sulphate @ 250 g/tree
M6	RDF + B + Zn @ 250 g/tree each
M7	RDF + B + Cu @ 250 g/tree each
M8	RDF + B + Fe @ 250 g/tree each
M9	RDF + Zn + Cu @ 250 g/tree each
M10	RDF + Zn + Fe @ 250 g/tree each
M11	RDF + Cu + Fe @ 250 g/tree each
M12	RDF + B + Zn + Cu @ 250 g/tree each
M13	RDF + B + Zn + Fe @ 250 g/tree each
M14	RDF + B + Zn + Cu + Fe @ 150 g/tree each
M15	RDF + B + Zn + Cu + Fe @ 250 g/tree each