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# Maximizing Fruit Quality and Production of Mango cv Dashehari: The Impact of Micronutrient Treatments

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## ABSTRACT

**Background:** The research aims to enhance fruit quality and production of the Dashehari mango variety through micronutrient treatments in Rajasthan, India. Micronutrients play a crucial role in plant growth and development and their deficiency can lead to suboptimal yields and reduced fruit quality. This study seeks to investigate the effects of micronutrient application on mango trees, particularly focusing on the Dashehari variety, to improve both the quantity and quality of mango production. By understanding the impact of micronutrient treatments, the research aims to provide valuable insights into sustainable agricultural practices that can optimize mango cultivation and contribute to increased agricultural productivity.

**Methods:** The research administered borax, ferrous sulphate and zinc sulphate to soil and trees in 10 treatments. The soil of an 18-year-old mango variety named Dashehari was treated in the first week of October with foliar sprays throughout the flower bud initiation, full bloom and pea stage initiation stages. A three-replication randomized block design was employed for the investigation.

**Result:** The results show that the treatment known as "T9"-Application of borax to the soil in the amount of 125 grams, followed by the application of borax to the foliar in the amount of 0.2 per cent-produced the highest quality and quantity of mango fruit. Additionally, treatments of soil application of $ZnSO_4$ per tree 125 g, followed by foliar application of $ZnSO_4$ 0.4% and soil application of $FeSO_4$ per tree 125 g, followed by foliar application of $FeSO_4$ 0.4%, also showed promising results.

**Key words:** Boron, Economic productivity, Ferrous sulfate, Iron, Mangifera, Socio-economic, Zinc sulfate.

## INTRODUCTION

The mango (*Mangifera indica* L.) is one of India's most important crops. It is extensively farmed, produces a large crop and is in high consumer demand. The event is called "National Fruit of India". India has grown mangoes for over 4,000 years. plays a major part in the country's culture and cuisine. The mango is the best-known member of the genus Mangifera, which comprises several tropical fruit trees grown for their wonderful fruit. The Anacardiaceae family comprises the mango tree, cashew and pistachio trees, two profitable fruit crops. This family includes mangoes. The fleshy stone fruit mango varies in shape, size and color according to the variety. Mangoes vary in form by cultivar. Different mangoes have different shapes and sizes. In addition to eating, fresh, mango is processed into pulp, juice and dried fruit. Mango is rich in vitamins, minerals and antioxidants. Southeast Asia seems to be the origin. The mango is a fruit that originated in Asia and has spread worldwide. Mangoes are South Asian. India produces 56% of global mangoes. Its yearly output is 21.82 million tonnes in India, where it is grown on 2.26 million hectares at 9.65 MT per hectare (Anonymous, 2018). Nutrient imbalances affect mango fruit set, production and quality. This imbalance worsens plant health, fruit quality and fruit drop which increases fruit drop. In addition, insects and other illnesses are more prone to target sick plants. Mango production in India is plagued by fruit loss (*Mangifera indica* L.), one of the world's most important crops. The state's mangoes come mostly from Rajasthan, including Banswara, Dungarpur, Chittorgarh, Udaipur, Jaipur, Baran and Rajsamand. Mango trees are grown over 6,400 hectares in Rajasthan, India. The region has high production potential and might become a mango bowl. Mango producers' economic production and social status may benefit from micronutrients. Low yield, fruit drops and small fruit may be caused by genetic, environmental and cultural factors such as chemical fertilizers (Joshi *et al.*, 2015). Micronutrients are needed for several enzymatic activities, assimilates and hormones. Micronutrients help plants absorb macronutrients and regulate metabolism. This includes cell wall development, enzymatic activity, hormone production, nitrogen fixation, chlorophyll creation, respiration, reduction and photosynthesis. Plant cell walls grow with micronutrients (Das, 2003 and Sharma and Kumawat, 2019). Zinc is needed to make chlorophyll, activate it and run enzymes. It is crucial for glucose conversion and sugar management, as well as tryptophane, a precursor of auxin.

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Iron is needed for several enzymatic reactions, protein and chlorophyll production and respiration control. It is crucial to the growth of the young, growing plant parts. It is essential to ferredoxin. Iron scarcity induces yellowing of the leaves due to chlorosis in the interveinal tissues of the younger upper leaves. Also known as chlorosis. Iron deficiency may cause leaves to become yellow or white before becoming brown and dropping off (Pandey and Sinha, 2006). Boron is necessary for cell division and plant development, especially in shoots and roots at their tips. This is done by increasing sugar and carb production. It also affects sugar transport and several calcium-related processes. Boron affects proper fruit development, seed germination and pollination (Zia *et al*., 2006). It also enhances pollen tube development, which increases pollen germination, sugar synthesis and accumulation (Shaban, 2010). A shortage of boron in the soil may distort plants and destroy fruit. The purpose of this study was to establish the best timing and amount of micronutrient application given the local meteorology.

## MATERIALS AND METHODS

In 2019-20 *Rabi Summer*, Bhagwant University's Department of Horticulture's Horticultural Study Farm in Ajmer conducted the study. Ajmer is characterized by a semi-arid climate, featuring hot and dry summers along with moderate and wet winters. The region experiences an average annual rainfall of 473 mm, accompanied by an average annual temperature of 25.0°C. The majority of precipitation, around eighty percent, occurs during the monsoon season spanning from July to September. Relative humidity fluctuates between 19% and 76% and wind speeds range from 5 to 8 mph. The soil composition in the Ajmer district encompasses primarily clay loam, sandy loam and sandy clay loam, each exhibiting varying degrees of salinity and fertility. The soil pH registers as alkaline, ranging from 7.5 to 8.5. The investigation comprised a total of ten applications (Table 1) of various micronutrients. These applications were as follows: (T1) Soil application of ferrous sulphate 125 grams; (T2) Soil application of zinc sulphate 125 grams (T3) Soil application of borax 125 grams (T4) Foliar application of ferrous sulphate 0.4%; (T5 Foliar application of $ZnSO_4$ 0.4%, (T6) Foliar application of borax 0.2 %, (T7) Application of 125 g of $FeSO_4$ to the soil, followed by an application of 0.4% $FeSO_4$ to the foliar, (T8) Application of $ZnSO_4$ 125 g to the soil, followed by application of $ZnSO_4$ 0.4% to the foliar, (T9) Application of borax to the soil in the amount of 125 grams, followed by application of borax to the foliar in the amount of 0.2 per cent, (T10) Control. An 18-year-old mango cv. Dashehari was given soil treatment in the second week of September and foliar sprays at flower bud initiation, full bloom and pea stage initiation in a randomized block design (RBD) with three replications. The second week of September saw soil treatment. Each treatment applied the right quantities of farmyard manure (100 g per tree), NPK fertilizers (750:160:750 g NPK per tree) and micronutrients (400 g per tree) *via* band placement.

## RESULTS AND DISCUSSION

According to the indicators of quality, it appears that the mango trees had different responses to the foliar and soil applications of micronutrients.

### Number of fruits per panicle

During the research work, it became evident that the quantity of fruits produced by individual trees significantly contributed to the overall number of fruit yield per plant, reaching its peak at 2.10 per plant after treatment T9. This aligns with similar observations in guava by Trivedi *et al*. (2012) and Rajkumar *et al*. (2014). Analysis of Table 1 reveals that the maximum number of fruits per panicle (2.10) was recorded under T9, involving the application of 125 grams of borax to the soil followed by a 0.2 per cent borax foliar application. Additionally, T8, which included the application of 125 grams of $ZnSO_4$ to the soil followed by a 0.4% $ZnSO_4$ foliar application, resulted in 2.05 fruits per panicle. Conversely, the minimum number of fruits per panicle (1.67) was observed under T10 (Control). The application of boron was found to expedite the growth of differentiated inflorescence, leading to an increased number of fruits per panicle. These outcomes are in line with similar findings in guava reported by Badal and Tripathi (2021b).

### Average fruit weight (g)

Table 1 reveals significant variations in average fruit weight across different treatments. The highest mean fruit weight (368 g) was observed with T9 (125 grams of borax applied to the soil and 0.2% borax foliar application), closely followed by T7 (125 g of $FeSO_4$ to the soil and 0.4% $FeSO_4$ foliar application) with a weight of 365 g. Conversely, the lowest average fruit weight (346 g) was observed in the control group (T10). Micronutrient application, particularly at higher concentrations, played a pivotal role in enhancing fruit quality by catalyzing various physiological processes. The foliar spray of micronutrients not only mitigated nutritional deficiencies but also bolstered fruit weight by facilitating the efficient uptake of macronutrients in mango plant tissues and organs. The findings align with previous studies conducted by Asad (2013) on pears and Dhaker *et al*. (2013) on bael. Except treatments T6, T8 and T7, T9 consistently yielded the highest average fruit weight (368 g), establishing statistical significance. In contrast, the control group (T10) consistently exhibited the lowest fruit weight. The beneficial effects of micronutrients such as zinc, promoting starch formation; iron, aiding cell growth and division; and boron, facilitating carbohydrate transport, are implicated in these outcomes. This synergy is supported by earlier research in mango cultivation by Dutta (2004), Nehete *et al*. (2011) and Bhatt *et al*. (2012). The combined application of boron, iron and zinc (B+Fe+Zn) appears to have a cumulative positive impact on fruit weight, as suggested by a previous study (2012).

**Table 1:** Impact of Soil and foliar treatment of micronutrients on number of fruits per panicle, fruit weight on average, total soluble solids, titrable acidity, total soluble solids comparing sugar reduction vs non-reduction, total sugar, ascorbic acid, the shelf life of fruits and yield.

| Treat. no | Treatments details | Number of fruits per panicle | Average fruit weight (g) | Total soluble solid (Brix) | Titrable acidity (%) | Reducing sugar (%) | Non-Reducing sugar (%) | Total sugar (%) | Ascorbic acid (mg/ 100 g pulp) | Shelf life of fruits (days) | Yield (kg/ tree) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Soil application of $FeSO_4$ 125 g | $1.75^{g}$ | $357^{e}$ | $20.4^{e}$ | $0.33^{a}$ | $7.4^{de}$ | $10^{dfg}$ | $17.4^{d}$ | $22.1^{b}$ | $10.3^{fg}$ | $62.5^{e}$ |
| 2 | Soil application of $ZnSO_4$ 125 g | $1.81^{f}$ | $352^{f}$ | $20.7^{de}$ | $0.33^{a}$ | $7.8^{cd}$ | $10.7^{def}$ | $18.6^{c}$ | $22.6^{b}$ | $10.8^{efg}$ | $64.0^{e}$ |
| 3 | Soil application borax 125 g | $1.88^{e}$ | $360^{d}$ | $21.4^{cde}$ | $0.31^{a}$ | $8.0^{bcd}$ | $11^{bcde}$ | $19^{bc}$ | $23.4^{b}$ | $11.1^{def}$ | $68.7^{d}$ |
| 4 | Foliar application of $FeSO_4$ 0.4% | $1.93^{d}$ | $335^{h}$ | $21.8^{bcd}$ | $0.30^{a}$ | $8.1^{abcd}$ | $11^{bcd}$ | $19.1^{bc}$ | $23^{b}$ | $11.5^{cde}$ | $64.6^{e}$ |
| 5 | Foliar application of $ZnSO_4$ 0.4% | $1.97^{c}$ | $347^{g}$ | $22.1^{abc}$ | $0.30^{a}$ | $8.5^{abc}$ | $11.5^{abc}$ | $20^{ab}$ | $23.5^{b}$ | $11.8^{bcde}$ | $68.1^{d}$ |
| 6 | Foliar application of borax 0.2% | $2.08^{ab}$ | $366^{ab}$ | $23^{ab}$ | $0.28^{a}$ | $9.0^{a}$ | $11.9^{ab}$ | $20.9^{a}$ | $25.6^{a}$ | $12.6^{ab}$ | $77.1^{ab}$ |
| 7 | Application of 125 g of $FeSO_4$ to the soil, followed by an application of 0.4% $FeSO_4$ to the foliar | $2.00^{c}$ | $365^{bc}$ | $22.2^{abc}$ | $0.27^{a}$ | $8.4^{abc}$ | $11.4^{abc}$ | $19.8^{abc}$ | $25.2^{a}$ | $12^{abcd}$ | $74^{c}$ |
| 8 | Application of $ZnSO_4$ 125 g to the soil, followed by application of $ZnSO_4$ 0.4% to the foliar | $2.05^{b}$ | $363^{c}$ | $22.9^{ab}$ | 0.28a | $8.6^{abc}$ | $11.7^{abc}$ | $20.3^{ab}$ | $25.4^{a}$ | $12.3^{abc}$ | $75.4^{bc}$ |
| 9 | Application of borax to the soil in the amount of 125 grams, followed by application of borax to the foliar in the amount of 0.2 per cent | $2.10^{a}$ | $368^{a}$ | $23.^{4a}$ | 0.26a | $8.9^{ab}$ | $12.1^{a}$ | $21^{a}$ | $26.3^{a}$ | $13^{a}$ | $78.3^{a}$ |
| 10 | Control | $1.67^{h}$ | $346^{g}$ | $17.6^{f}$ | 0.34a | $6.6^{e}$ | $9^{g}$ | $15.7^{e}$ | $20.4^{c}$ | $9.8^{g}$ | $56.8^{f}$ |
| | C.D. | 0.02 | 2.004 | 0.027 | 0.019 | 0.033 | 0.017 | 0.031 | 0.133 | 0.131 | 0.138 |
| | SE(m) | 0.007 | 0.669 | 0.009 | 0.006 | 0.011 | 0.006 | 0.01 | 0.044 | 0.044 | 0.046 |
| | SE(d) | 0.01 | 0.947 | 0.013 | 0.009 | 0.016 | 0.008 | 0.014 | 0.063 | 0.062 | 0.065 |
| | C.V. | 0.608 | 0.326 | 0.073 | 3.568 | 0.235 | 0.089 | 0.092 | 0.328 | 0.678 | 0.116 |

**Total soluble solids (°Brix)**

Table 1 reveals that the highest total soluble solids (TSS) value of 23.4 °Brix was observed in treatment T9, involving the application of 125 grams of borax to the soil followed by a 0.2% foliar application of borax. Following closely, treatment T7, which included the application of 125 g of FeSO4 to the soil followed by a 0.4% foliar application of FeSO4, exhibited a TSS value of 23 °Brix. Conversely, the lowest TSS value of 17.6 °Brix was recorded in the control group (T10). The improvement in TSS can be linked to the regulatory role of zinc, promoting auxin-induced cell expansion, water and solute accumulation in the vacuole and boron's influence on sugar translocation. Micronutrients, such as zinc and boron, enhance enzyme activity and carbohydrate accumulation during photosynthesis, facilitating sugar transport within plants. These results align with previous findings by Hamouda *et al*. (2016). Notably, treatment T9 significantly increased TSS (23.4 °Brix) in mango fruit, comparable to treatments T6 (23 °Brix), T8 (22.9 °Brix), T7 (22.2 °Brix), T5 (22.1 °Brix) and T4 (21.8 °Brix). In contrast, the control (T10) exhibited the lowest reading (17.6 °Brix). The heightened TSS in T9 may be attributed to zinc's promotion of tryptophan, a precursor to auxin, crucial for protein synthesis, sugar metabolism and structural integrity. Additionally, boron's association with the cell membrane, potentially interacting with sugar molecules, may facilitate their passage, explaining the increased TSS. This aligns with similar findings in mango (Bhowmick and Banik, 2011; Nehete *et al*., 2011; Bhatt *et al*., 2012; Bhowmick *et al*., 2012), ber (Meena *et al*., 2006) and aonla (Singh *et al*., 2001; Vishwakarma *et al*., 2013; Chandra and Singh, 2015), as reported by Shukla *et al*. (2011).

**Titrable acidity (%)**

Remarkably, treatment T9 yielded fruit with the lowest acidity level (0.20%), while the control treatment (T10) resulted in the most acidic fruit, registering at 0.34%. This variation may be attributed to boron's facilitation of nutrient transport, including phosphorus, starch and sugar, within the framework of carbohydrate metabolism. As a borate complex, boron enhances the ease of sugar transfer across the cell membrane. Chandra and Singh's (2015) study on aonla aligns with our findings. In addition to boron's impact on acidity, zinc's influence on glucose-6 and phosphate dehydrogenase enzymes could contribute to acidity reduction. On the other hand, iron and manganese, by diminishing respiration and engaging in enzymatic activities, may also contribute to acidity reduction. Balakrishnan (2001) discovered a similar outcome in guava, demonstrating that a foliar treatment combining 0.1% B, 0.25% Mn, 0.25% Fe and 0.25% Zn resulted in the lowest acidity percentage. Our findings find resonance with previous research, such as that conducted by Bhowmick and Banik (2011); Nehete *et al*. (2011); Singh *et al*. (2013) in mango and Meena *et al*. (2006) in ber. In mango, the present study's conclusions align with those of prior research.

**Reducing sugar (%)**

The greatest decrease in sugar percentage was seen with treatment T9. This treatment was statistically equal to treatment T8, which had a value of 10.2%. Despite this, the control group had a little reduction in sugar (6.6%). Both the soil and the foliar spray of micronutrients contained more reducing sugar. Plants needed zinc and auxin to boost enzyme activity. Also catalyzes plant oxidation-reduction. The climacteric properties of mangoes lead respiration to fluctuate substantially throughout growth. Starch is converted to glucose via dynamic metabolic processes. The metabolism breaks down complex food into smaller ones. Fe seems to have produced taste-enhancing proteins. Zn aids hexokinase, cellulose and carbohydrate-to-sugar conversion. The results of Anees *et al*. (2011); Nehete *et al*. (2011); Bhatt *et al*. (2012) and Jat and Kacha (2014) in mango and guava are similar.

**Non-reducing sugar (%)**

Data (Table 1) scores for notably most non-decreasing sugar percent (12.1%) registered with remedy T9 which changed into at par with remedies *viz*. T6 foliar utility of borax 0.2%, T8 soil utility of $Znso_4$ one hundred twenty-five g observed with the aid of using the foliar utility of $Znso_4$ 0.4% and T7 at the same time as minimal non-decreasing sugar per cent (9.0%) changed into stated below control.

**Total sugar (%)**

Throughout the experiment, treatment T9 was used, which resulted in the production of mango fruit with a maximum total sugar content of 21%. Based on the findings of the experiment, it was determined that treatment T9 was statistically equivalent to treatment T6 (20.9%). The amount of total sugar in the mango fruit was the lowest among those that were monitored (15.7%). The catalytic impact of micronutrients, particularly in large doses, may explain fruit sugar increases. The observed elevation in total soluble solids (TSS) and total sugars could be attributed to an augmented mobilization of carbohydrates from the source to the sink (fruits) induced by auxin. This phenomenon may be associated with an increase in α-amylase activity, stimulated by boron application, leading to the conversion of starch into sugars and an enhancement in TSS content. Similar findings have been reported by various researchers, including Shukla *et al*. (2011) in aonla, Gupta *et al*. (2022) in litchi, Tsomu and Patel (2019) in mango cv. Mallika, Goswami *et al.* (2014) in guava and Tripathi *et al.* (2018).

**Ascorbic acid (mg/100 g pulp)**

Throughout the course of the experiment, treatment T9 was used, which resulted in the production of mango fruit with a maximum Ascorbic content of 26.3 g/100 pulp. Based on the findings of the experiment, it was determined that treatment T9 was statistically equivalent to treatment T6 (25.6 g/100 pulp). The amount of Ascorbic acid in the mango fruit was the lowest among those that were monitored (15.7/100 g pulp). This rise in ascorbic acid levels could be the consequence of favorable metabolic activity involving specific enzymes and metallic ions under the impact of micronutrients like boron, which would have led to increased ascorbic acid synthesis. The constant synthesis of glucose-6-phosphate, which is regarded to be the precursor of vitamin C, during the fruits' growth and development may be the cause of an increase in ascorbic acid content. Numerous researchers, including Dubey *et al*. (2017) for the strawberry cv. chandler and Kumar and Singh (2019) in the mango cv. Amrapali, have found similar results.

**Shelf life (Days)**

The consequences of the exercise showed that the shelf life of mango fruit could be greatly increased (to 13 days) by using the treatment T9 It was numeric equal to treatments T6 and T8 with numerical data of 12.6 days and 12.3 days, respectively; however, the control had a shorter shelf life (9.8 days) (T10). This might be the result of a risen concentration of boron in the central lamella of the cell wall. Boron gives the cell wall its physical strength and boosts the development as well as the look of the colour of the fruit. Several fruits and vegetables contain significant amounts of boron in their natural composition. The research that was done on mango by Bhatt *et al*. (2012); Singh *et al*. (2012) and Kumar *et al.* (2019) have found a similar result.

**Fruit yield per tree (kg)**

Table 1 illustrates the notable fruit yield variations observed throughout the experiment; with treatment T9 exhibiting the highest yield (78.3 kg per tree). This superiority persisted despite the application of treatment T9. Over the trial year, treatment T9 consistently matched the fruit yield of T6 (77.1 kg per tree), T8 (75.4 kg per tree) and T7 (74 kg per tree). The enhanced yield associated with T9 is attributed to micronutrients, known for their roles in plant development, flowering, growth and photosynthesis. This finding aligns with previous studies on mangoes (Singh *et al*., 2003; Saran and Kumar, 2011; Nehete, 2011; Singh and Varma, 2011; Bhatt, 2012; Bhowmick, 2012) and guavas (Jat and Kacha, 2014; Gaur *et al*., 2014).

## CONCLUSION

This experiment showed that treatment (T9), which involved applying 125 g of borax to each tree's soil and then applying 0.2% borax foliarly, produced the best results in fruit weight, ascorbic acid content, shelf life and yield. These results are important for mango farmers in Rajasthan and other locations with comparable soil and climate. This study's vitamin application methods may help mango producers enhance their socioeconomic standing. To determine the best mango tree application methods, future micronutrient studies should concentrate on diverse mango species. This study offers mango farmers, academics and policymakers' practical advice on improving mango fruit quality and productivity in Rajasthan and beyond. The outcomes of this study will spur additional research and enhance mango agriculture in India and worldwide.

**Conflict of Interest**

On the behalf of the all authors, I declare no conflicts of interest relevant to this manuscript.

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