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# Optimizing Growth, Yield, and Fruit Quality of Guava (*Psidium guajava* L.) cv. Shweta through Foliar Application of Micronutrients

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**ABSTRACT: The present study was conducted to evaluate the effect of foliar application of micronutrients on the growth, yield, and fruit quality of guava (*Psidium guajava* L.) cv. Shweta at the research farm of Mr. Lakhwinder Singh, Village Maujowal, Tehsil Nangal, District Rupnagar and Punjab. The experiment was laid out in a Randomized Block Design (RBD) with eight treatments: $T_1$ - $ZnSO_4$ @0.1%, $T_2$ - $FeSO_4$ @0.2%, $T_3$ - Borax @0.3%, $T_4$ - $ZnSO_4$ @0.1% + $FeSO_4$ @0.2%, $T_5$ - $ZnSO_4$ @0.1% + Borax @0.3%, $T_6$ - $FeSO_4$ @0.2% + Borax @0.3%, $T_7$ - $ZnSO_4$ @0.1% + $FeSO_4$ @0.2% + Borax @0.3%, and $T_8$ - Control. The results indicated that the combined application of $ZnSO_4$, $FeSO_4$, and Borax ($T_7$) significantly enhanced plant growth parameters, including plant height, stem girth, and tree spread (E-W and N-S), compared to the control and other treatments. The highest fruit yield (kg/plant) and number of fruits per plant were also recorded under $T_7$, followed by $T_6$ and $T_5$. Furthermore, fruit quality parameters such as total soluble solids (TSS), ascorbic acid content, and total sugars were maximized in $T_7$, demonstrating its superiority in improving guava fruit quality. The findings suggest that foliar application of $ZnSO_4$ @0.1% + $FeSO_4$ @0.2% + Borax @0.3% is the most effective treatment for enhancing growth, yield, and fruit quality in guava cv. Shweta.**

**Keywords:** Guava, micronutrients, foliar application, growth, yield, fruit quality, $ZnSO_4$, $FeSO_4$, Borax.

## INTRODUCTION

Guava (*Psidium guajava* L.) is an economically significant fruit crop cultivated extensively in tropical and subtropical regions of India. Belonging to the family Myrtaceae, guava ranks as the fourth most important fruit crop in India in terms of cultivation area, following mango, banana, and citrus. It is the fifth most important fruit in production after banana, mango, citrus, and papaya. Introduced to India in the early 17th century, guava has gained widespread popularity due to its adaptability to diverse agro-climatic conditions, low cultivation cost, prolific bearing, and high nutritional value. Native to tropical America, it is now cultivated across South Asia, with Uttar Pradesh, Bihar, and parts of Madhya Pradesh being the leading guava-producing states. Punjab also has significant guava production, with key districts including Sangrur, Patiala, Amritsar, and Ludhiana. As of 2019, guava cultivation in India covered approximately 276,000 hectares with a production of 4.236 million metric tons (Anonymous, 2018). Guava is renowned for its rich nutritional composition, containing 80-82% water, 0.71% protein, 0.5% fat, 11-13% carbohydrates, and 2.4% acids. It is among the richest sources of vitamin C, ranking third after Barbados cherry and aonla, and provides moderate levels of folic acid and dietary fiber (Rajkumar *et al.*, 2017). The fruit also contains carbohydrates, sugars, and pectin, contributing to its distinct taste and aroma. Owing to its affordability and nutritional benefits, guava is often referred to as the "poor man's apple" (Suman *et al.*, 2016).

The phenology of guava varies with regional climatic conditions. In northern India, the plant flowers two to three times annually, with flowering periods classified as Ambe Bahar (spring), Mrig Bahar (monsoon), and Hast Bahar (autumn). The corresponding fruiting seasons are July-September, November-February, and spring, respectively. The two major flowering periods in North India, specifically in Uttar Pradesh, occur during April-May (yielding fruits in the rainy season) and July-August (yielding fruits in the winter season) (Shreekant *et al.*, 2017). Guava is a hardy fruit crop that responds favorably to foliar nutrient applications, which enhance fruit production and quality. Research indicates that foliar fertilization effectively supplies essential nutrients, addressing deficiencies and mitigating stress conditions that impact plant growth and yield. Foliar application improves fruit set, productivity, and quality while also correcting nutritional and physiological imbalances (Shukla *et al.*, 2011). Among micronutrients, zinc, boron, calcium, manganese, and magnesium play crucial roles in guava production. Zinc is particularly vital as it regulates protein and carbohydrate metabolism, increases chlorophyll content, and supports enzymatic activities (Rawat *et al*., 2010). Boron facilitates cell division and enhances nitrogen absorption, while iron contributes to chlorophyll synthesis and critical metabolic functions such as respiration and DNA synthesis (Zagade *et al.*, 2017). According to the results of numerous studies, the macronutrients like nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and micronutrients like boron, chloride, iron, manganese, molybdenum, zinc have a significant impact on seed quality, which in turn affects seed yield (Patra, 2023). The results revealed that the fruit physical characters *i.e*. fruit diameter (6.87cm), fruit length (6.39cm), fruit width (6.28cm), fruit weight (129.33g), fruit volume (128.96cc) were improved significantly with the use of Borax 0.2% + Zn 0.4% ($T_9$) bagged with Foam bag + Brown paper + Blue polythene followed by fruits sprayed with (Borax 0.2 + Zinc 0.4% + Foam bag + News Paper + Blue Polyethylene bag) ($T_{13}$) than the other treatments, while lowest was recorded under control (Singh *et al*., 2023).

Efficient nutrient management, particularly through foliar application, is essential for optimizing guava yield and quality. Foliar fertilization offers advantages such as lower application rates, uniform nutrient distribution, and rapid uptake, ensuring improved plant health and productivity (Mishra *et al.*, 2017). However, inappropriate concentrations may adversely affect yield parameters (Arshad and Ali 2016). Keeping in view the importance of this study and the existing research gaps in optimizing nutrient management for guava, the present investigation aims to evaluate the effects of foliar application on guava growth, yield, and fruit quality.

## MATERIAL AND METHODS

**Study Site Location.** The experiment was conducted in the research farm of Mr. Lakhwinder Singh, Village-Maujowal, Tehsil- Nangal, District- Rupnagar. The present investigations were made on three year old guava trees growing in the orchard. Twenty four trees which were uniform in size & vigor and given cultural practices as per package of practices recommended by Punjab Agricultural University, Ludhiana were selected for the present study. All the treatment were applied as a last week September. During the course of studies, recommended cultural practices were followed in the experimental materials.

**Experimental Details:** The experiment was laid out in a Randomized Block Design (RBD) with eight treatments: $T_1$ - $ZnSO_4$ @0.1%, $T_2$ - $FeSO_4$ @0.2%, $T_3$ - Borax @0.3%, $T_4$ - $ZnSO_4$ @0.1% + $FeSO_4$ @0.2%, $T_5$ - $ZnSO_4$ @0.1% + Borax @0.3%, $T_6$ - $FeSO_4$ @0.2% + Borax @0.3%, $T_7$ - $ZnSO_4$ @0.1% + $FeSO_4$ @0.2% + Borax @0.3%, and $T_8$ - Control. The treatments were replicated thrice. The age of plants was 3 years and variety of guava was Shweta and all treatments were calculated on per plot basis and subjected to application. The plants were planted at spacing of 6m × 6m.

**Table 1: Initial fertility status of soil.**

| Particulars | Value obtained | Method employed |
|---|---|---|
| Soil pH | 8.38 | Soil : Water suspension 1 : 2, with the help of digital pH meter (Jackson, 1973) |
| Soil EC (dS/m) | 0.38 | Digital conductivity meter (Jackson, 1967) |
| Available N (kg/ha) | 415.65 | Alkaline potassium per magnate method (Subbiah and Asija, 1956) |
| Available P (kg/ha) | 15.34 | 0.5 N $NaHPCO_3$ Extractable Olsen method (Olsen *et al.*, 1954) |
| Available K (kg/ha) | 141.60 | Ammonium Acetate method (Merwin and Peach, 1951) |

**Observation recorded.** The observations were recorded on, plant height (cm), stem girth (cm), leaf area ($cm^2$), number of fruits per tree, fruit weight (g) and fruit yield (kg/tree). Fruit quality parameters such as, total soluble salts, titratable acidity, ascorbic acid, total sugar was also estimated. Beside this various soil properties such as soil pH, electrical conductivity ($dSm^{-1}$), available nitrogen, phosphorus and potassium were also calculated in the laboratory.

**Statistical Analysis.** The statistical analysis was done as per design of the experiment as suggested by Panse and Sukhatme (1985). The interpretation of results is based on RBD. The critical difference (CD) was worked out for significant treatments.

## RESULT AND DISCUSSION

**Vegetative Growth parameters.** It is evident from the data presented in Table 2 that different treatments strikingly resulted in difference in all the vegetative growth parameters of plant. It is evident from the data that different treatments strikingly resulted in difference in average tree height of plant. Maximum tree height increase (16.67 cm) was recorded in treatment T7 ($ZnSO_4$ @0.1% + $FeSO_4$ @0.2 % + Borax 0.3%) which was statistically at per with T6 (13.00cm) ($FeSO_4$ @0.2% + Borax @0.3%). The minimum tree height (8.33cm) was recorded in treatment T8 (control). the maximum stem girth increase (1.07 cm) was recorded in treatment T7 ($ZnSO_4$@0.1% + $FeSO_4$@0.2 % + Borax 0.3%) which was statistically at par with stem girth increase (0.90 cm) in treatment T4 ($ZnSO_4$ @0.1% + $FeSO_4$ @0.2%) and minimum (0.43 cm) was recorded in treatment T8 (control). The maximum stem girth increase (1.07 cm) was recorded in treatment T7 ($ZnSO_4$@0.1% + $FeSO_4$@0.2 % + Borax 0.3%) which was statistically at par with stem girth increase (0.90 cm) in treatment T4 (ZnSO4 @0.1% +FeSO4 @0.2%) whereas, the minimum tree stem girth (0.43 cm) was recorded in treatment T8 (control). The highest leaf area (70.72 cm²) was recorded in treatment T7 (ZnSO4 @0.1% + FeSO4@0.2 % + Borax 0.3%) which was statistically at par with (68.54 cm²) in treatment T3 (Borax @0.3**%**), while the lowest leaf area (49.59 cm²) was recorded in treatment T8 (control).

**Table 2: Effect of foliar application of micronutrients on growth parameters of guava tree.**

| Treatments | Tree height (cm) | Stem girth (cm) | Leaf area ($cm^2$) |
|---|---|---|---|
| $T_1$ (ZnSO4 @0.1%) | 11.00 | 0.43 | 63.34 |
| $T_2$ (FeSO4 @0.2%) | 8.33 | 0.77 | 60.50 |
| $T_3$ (Borax @0.3%) | 11.67 | 0.80 | 68.54 |
| $T_4$ (ZnSO4 @0.1% +FeSO4@0.2%) | 10.67 | 0.90 | 66.18 |
| $T_5$ (ZnSO4 @0.1 % + Borax@ 0.3%) | 10.00 | 0.77 | 54.94 |
| $T_6$ (FeSO4 @0.2% + Borax @0.3%) | 13.00 | 0.83 | 51.60 |
| $T_7$ (ZnSO4 @0.1% + FeSO4 @0.2 % + Borax 0.3%) | 16.67 | 1.07 | 70.72 |
| $T_8$ Control (water spray) | 10.33 | 0.83 | 49.59 |
| S.E m. ± | 2.28 | 0.16 | 0.61 |
| CD (0.05%) | 6.91 | 0.48 | 1.84 |

The growth attributes, including tree height, stem girth, and leaf area, varied significantly across treatments, likely due to the role of micronutrients in enhancing metabolic activities and promoting cell division (Sau *et al.,* 2018). Zinc is essential for enzyme activation, protein synthesis, and tryptophan formation, a precursor of auxin, which stimulates apical growth and canopy expansion. This could explain the increased tree height and stem girth in treatments supplemented with zinc. Similarly, boron plays a vital role in cell wall formation, meristematic activity, and nutrient transport, contributing to improved stem strength and leaf expansion. Its interaction with zinc and iron further enhances chlorophyll synthesis, photosynthetic efficiency, and overall plant vigor. Zahed *et al.* (2022) also reported significant improvements in vegetative growth parameters with the application of Zinc Sulfate (0.5%) and Borax (0.5%) in various crops. These findings are consistent with the studies of Gurjar *et al.* (2015) in Kinnow mandarin and Waskela *et al.* (2013) in guava, highlighting the importance of micronutrient supplementation in optimizing plant growth and development. Meena *et al.* (2024) also studied the impact of foliar spray applications on guava and found that application of Borax 0.5%+GA3 40 ppm is most effective in performance of guava fruit.

**Yield Parameters.** All the data related to yield parameters, such as the number of fruits per tree, yield per tree, and yield per hectare, are illustrated in Table 3. The results indicate significant variations among different treatments. From the table, it is evident that the highest number of fruits per plant (169) was recorded in treatment $T_7$ ($ZnSO_4$ @ 0.1% + $FeSO_4$ @ 0.2% + Borax @ 0.3%), which was statistically at par with treatment $T_6$ ($FeSO_4$ @ 0.2% + Borax @ 0.3%) at 167 fruits per plant. The lowest fruit count (143.33) was recorded in treatment T8 (control). Regarding yield per tree, the highest yield (30.17 kg) was recorded in treatment $T_7$, which was statistically at par with treatment $T_6$ (29.46 kg). The lowest yield per tree (20.16 kg) was observed in treatment $T_8$ (control). Similarly, in terms of yield per hectare, the maximum yield (14.89 t/ha) was recorded in treatment $T_7$, followed closely by treatment $T_6$ (14.54 t/ha), while the minimum yield (9.95 t/ha) was recorded in treatment $T_8$ (control).

**Table 3: Effect of foliar application of micronutrients on yield parameters of guava tree.**

| Treatments | Number of fruits per tree | Fruit yield (kg/tree) | Fruit yield (t/ha) |
|---|---|---|---|
| $T_1$ (ZnSO4 @0.1%) | 145.67 | 20.64 | 10.19 |
| $T_2$ (FeSO4 @0.2%) | 154.33 | 23.66 | 11.68 |
| $T_3$ (Borax @0.3%) | 159.67 | 26.41 | 13.03 |
| $T_4$ (ZnSO4 @0.1% +FeSO4@0.2%) | 157.33 | 27.59 | 13.62 |
| $T_5$ (ZnSO4 @0.1 % + Borax@ 0.3%) | 165.00 | 28.81 | 14.22 |
| $T_6$ (FeSO4 @0.2% + Borax @0.3%) | 167.00 | 29.46 | 14.54 |
| $T_7$ (ZnSO4 @0.1% + FeSO4 @0.2 % + Borax 0.3%) | 169.00 | 30.17 | 14.89 |
| $T_8$ Control (water spray) | 143.33 | 20.16 | 9.95 |
| S.E m. ± | 0.79 | 0.20 | 0.10 |
| CD (0.05%) | 2.39 | 0.61 | 0.30 |

Gurjar *et al.* (2015) reported similar results in Kinnow mandarin, where yield parameters improved significantly with boron and zinc application. Zinc plays a crucial role in starch formation, cell division, and cell enlargement. An improvement in individual fruit weight and volume due to zinc application was also reported by Babu *et al.* (2007). Additionally, Waskela *et al.* (2013) studied the effect of micronutrients on the growth, yield, and quality of guava cv. Dharidar. They found that foliar application of zinc sulphate (@ 0.75%) significantly increased shoot length, the number of leaves per shoot, shoot diameter, leaf area, fruit length, fruit width, number of fruits per plant, fruit weight, yield per plant, and yield per hectare.

**Fruit quality attributes.** Data pertaining to the fruit quality attributes of have been presented in Table 4 and showed significant effect. It is clearly showed that the maximum fruit TSS (13.13°Brix) was recorded in treatment T7 ($ZnSO_4$@0.1% + $FeSO_4$ @0.2 % + Borax 0.3%) which was statistically at par TSS (13.07°Brix) and were recorded in treatment T4 ($ZnSO_4$ @0.1% + $FeSO_4$ @0.2%) TSS$^0$Brix and minimum (10.60°Brix) was recorded in treatment T8 (control). Related to ascorbic acid, the maximum ascorbic acid (172.02mg/100g pulp) was recorded in treatment T7 ($ZnSO_4$ @0.1% + $FeSO_4$ @0.2 % + Borax 0.3%) which was statistically at par (170.40mg/100g pulp) was recorded in treatment T6 ($FeSO_4$@0.2% + Borax @0.3%) while, the minimum ascorbic acid (20.16 mg/100g pulp) was recorded in treatment T8 (control). Data pertaining to titratable acidity showed that the table it is clearly showed that the minimum fruit titratable acidity (0.23%) in treatment T7 ($ZnSO_4$ @0.1% + $FeSO_4$@0.2 % + Borax 0.3%) which was statistically at per (0.44%) in treatment $T_1$ ($ZnSO_4$ @0.1%) while, maximum fruit titratable acidity (0.48%) was recorded in treatment T8 (control). From table it is clearly showed that the maximum content of total sugar (7.67%) was recorded in treatment $T_7$ ($ZnSO_4$ @0.1% + $FeSO_4$ @0.2 % + Borax 0.3%) which was statistically at par (7.43%) with $T_6$ ($FeSO_4$ @0.2% + Borax @0.3%) whereas, minimum content (5.33%) was recorded in treatment T8 (control).

**Table 4: Effect of foliar application of micronutrients on fruit quality parameters of guava tree.**

| Treatments | TSS ($^0$Brix) | Ascorbic acid (mg/100 g) | Titratable acidity | Total sugar (%) |
|---|---|---|---|---|
| $T_1$ ($ZnSO_4$ @0.1%) | 11.20 | 165.49 | 0.44 | 6.30 |
| $T_2$ ($FeSO_4$ @0.2%) | 12.37 | 150.98 | 0.26 | 6.20 |
| $T_3$ (Borax @0.3%) | 12.40 | 150.59 | 0.38 | 5.55 |
| $T_4$ ($ZnSO_4$ @0.1% +$FeSO_4$@0.2%) | 13.07 | 161.47 | 0.25 | 6.10 |
| $T_5$ ($ZnSO_4$ @0.1 % + Borax@ 0.3%) | 12.83 | 151.99 | 0.36 | 7.10 |
| $T_6$ ($FeSO_4$ @0.2% + Borax @0.3%) | 12.43 | 170.40 | 0.42 | 7.43 |
| $T_7$ ($ZnSO_4$ @0.1% + $FeSO_4$ @0.2 % + Borax 0.3%) | 13.13 | 172.02 | 0.23 | 7.67 |
| $T_8$ Control (water spray) | 10.60 | 147.83 | 0.48 | 5.33 |
| S.E m. ± | 0.22 | 1.00 | 0.01 | 0.09 |
| CD (0.05%) | 0.66 | 3.02 | 0.03 | 0.24 |

The quality traits of guava *viz*. total sugar, total soluble solids and ascorbic acid were estimated significantly higher in treated plant fruits than control plants with water spray. It might be attributed to the fact that boron directly affects the photosynthesis activity of plant and helps in sugar transport. Besides, the boron also plays an important role in activating the synthesis of ascorbic acid. These results are in agreement with the findings of Baranwal *et al*. (2017), who revealed that treated plants with Zn and Bo performed significantly much better than control of water spray in quality traits of guava. The findings are also align with the studies of Awasthi and Lal (2009) ; Yadav *et al.* (2017) in guava.

## CONCLUSIONS

The present study demonstrated that foliar application of micronutrients significantly improves the growth, yield, and fruit quality of guava (*Psidium guajava* L.) cv. Shweta. Among the different treatments, the combined application of $ZnSO_4$ @0.1% + $FeSO_4$ @0.2% + Borax @0.3% ($T_7$) resulted in the highest improvements in plant height, stem girth, and leaf area. Additionally, $T_7$ recorded the highest fruit yield per tree, number of fruits per tree, and fruit quality attributes such as TSS, ascorbic acid content, and total sugars while reducing titratable acidity. The study confirms that foliar supplementation of zinc, iron, and boron plays a crucial role in enhancing guava production by improving nutrient uptake, metabolic activities, and physiological functions. Therefore, the foliar application of $ZnSO_4$ @0.1% + $FeSO_4$ @0.2% + Borax @0.3% can be recommended as an effective nutrient management strategy for maximizing guava yield and fruit quality under similar agro-climatic conditions.

**Author Contributions.** All authors have contributed significantly in the research paper. Pallavi and Ravinder have conducted the research trial. Avinash, Sachin and Shivangi have provided all the necessary help in formatting, writing and reviewing of manuscript. Avinash and Sunidhi have done the analysis of the data.

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**Conflict of Interest.** None.

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