

Micronutrients: Hidden Drivers of Quality and Quantity in Plantation Crops

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ABSTRACT

Micronutrients are essential for optimal growth and productivity in plantation crops such as tea, coffee, rubber and coconut. These elements, including zinc, iron, manganese, copper, boron and molybdenum, serve as cofactors in enzymatic reactions and play critical roles in photosynthesis, nutrient assimilation and stress response mechanisms. Deficiencies disrupt metabolic pathways, leading to physiological disorders that compromise yield and crop quality. Scientific studies demonstrate that targeted micronutrient management-through soil amendments, foliar applications and precision fertilization, can significantly enhance nutrient use efficiency. Research indicates that optimized micronutrient regimens increase productivity by 15-30% while reducing environmental impacts associated with conventional fertilization. This synthesis highlights the importance of evidence-based micronutrient strategies to address the unique nutritional demands of perennial cropping systems under changing climatic conditions.

INTRODUCTION

Plantation crops such as tea, coffee, rubber and coconut play a vital role in the economy of many countries,

particularly in tropical and subtropical regions. These crops are major sources of income, employment and export revenue, contributing

significantly to agricultural sustainability and rural livelihoods. Given their long growth cycles and high economic value, maintaining their health and productivity is crucial for farmers and industries alike.

To achieve optimum growth and yield, plantation crops require a well-balanced supply of nutrients. While macronutrients like nitrogen, phosphorus and potassium are widely acknowledged for their significant role in plant development, micronutrients, despite being needed in smaller amounts, are equally vital. They play key roles in enzymatic reactions, metabolic processes and stress resistance, all of which contribute to the overall productivity and quality of the crops.

A deficiency in any essential micronutrient can lead to physiological disorders, reduced resistance to diseases and ultimately, lower yields and poor-quality produce (Jatav et al., 2020). With increasing concerns about soil degradation and nutrient depletion due to intensive farming, proper micronutrient management has become more critical than ever. Understanding the importance of micronutrients and their role in plantation crop production can help farmers adopt better fertilization practices, leading to healthier crops and sustainable agricultural output (Imtiaz et al., 2010).

What are micronutrients?

Micronutrients are essential minerals that plants need in trace amounts to complete their life cycle. Despite their minimal requirements, they have profound effects on plant health and development (Fig. 1). The primary micronutrients required for plantation crops include:

- **Zinc (Zn):** A fundamental component of various enzymes that regulate plant growth,

root development and resistance to environmental stress.

- **Iron (Fe):** Vital for chlorophyll synthesis, iron enables efficient photosynthesis and energy production, directly influencing plant vigour.
- **Manganese (Mn):** Plays a crucial role in nitrogen metabolism and photosynthetic reactions, promoting strong structural integrity in plants.
- **Copper (Cu):** Enhances reproductive growth by aiding in pollen formation and seed development while also contributing to enzyme activation.
- **Boron (B):** Supports cell wall strength, assists in carbohydrate transportation and plays an essential role in flower and fruit development.
- **Molybdenum (Mo):** Necessary for nitrogen fixation, Mo is indispensable for converting atmospheric nitrogen into forms usable by plants.

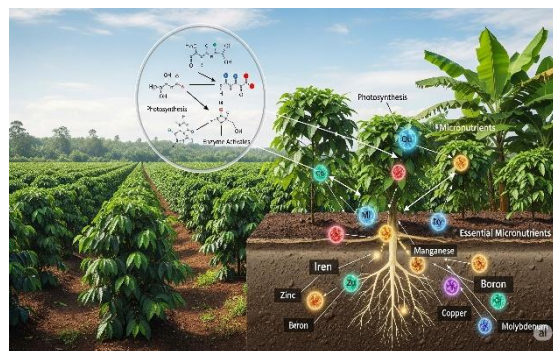


Fig. 1: Role of micronutrients

These micronutrients work synergistically to ensure healthy plant growth, improve resistance to pests and diseases and enhance overall crop quality (Tripathi et al., 2022). Deficiencies in any of these essential elements can significantly affect plant metabolism, leading to poor yield and inferior produce quality.

Why are micronutrients important for plantation crops?

Enhances crop growth and yield:

Micronutrients play a significant role in metabolic and physiological functions. Zinc and iron, for example, help in chlorophyll production, ensuring healthy photosynthesis and energy production.

Prevents nutrient deficiency disorders:

Deficiencies of micronutrients can lead to stunted growth, leaf chlorosis and poor flowering or fruiting. For instance:

- Iron deficiency causes yellowing of young leaves (chlorosis), affecting photosynthesis.
- Boron deficiency results in flower drop and reduced fruit setting.

Boosts disease resistance: Micronutrients like manganese and copper help in strengthening plant immunity. Manganese aids in the production of enzymes that help plants resist fungal infections, while copper strengthens cell walls, making them less vulnerable to pathogens.

Improves quality of produce: Adequate micronutrient supply enhances the quality of plantation crops. In coffee and tea, zinc and boron contribute to better bean and leaf quality, ensuring a premium taste and aroma. In rubber, micronutrients help in latex production and quality. Micronutrients like boron and zinc are vital for fruit formation and ripening. Calcium helps in strengthening cell walls, reducing post-harvest losses. Molybdenum is necessary for nitrogen assimilation, ensuring robust plant growth.

How to ensure adequate micronutrient supply?

- **Soil testing and foliar applications:** Regular soil and leaf testing help identify

deficiencies, allowing farmers to apply micronutrients through foliar sprays or soil amendments.

- **Use of organic manures and biofertilizers:** Incorporating compost, green manure and microbial fertilizers enhances micronutrient availability.
- **Balanced fertilization programs:** Applying micronutrient-enriched fertilizers ensures steady supply throughout the crop's life cycle.

CONCLUSION

Even in small quantities, micronutrients play a significant role in plantation crop's health and productivity. By adopting proper nutrient management strategies, farmers can enhance yields, improve quality and ensure sustainable production of plantation crops. Investing in micronutrient management is a small but crucial step toward long-term agricultural success.

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