Micro Nutrient Management for Enhanced Growth, Yield, and Quality of Mango: A Comprehensive Review

ABSTRACT

This review paper delves into the intricate interrelationships among micronutrient interventions, carbohydrates, and osmostimulants, investigating their collective influence on diverse aspects of mango tree growth and fruit characteristics. Micronutrients, essential elements required in small quantities for plant health, play a pivotal role in shaping optimal plant development. The paper underscores the significance of these micronutrients by highlighting their roles in stimulating vegetative growth, influencing flowering dynamics, regulating fruit set processes, impacting yield metrics, and contributing to the nuanced attributes of fruit quality. This synthesis illuminates the complex network of processes governing mango tree growth and fruit production.Moreover, the study underscores the potential of well-structured nutrient management strategies as key catalysts for optimizing mango production outcomes. By carefully balancing the imperative of yield quantity and fruit quality, such strategies hold the promise of enhancing overall agricultural efficiency. Drawing insights from a comprehensive review of pertinent studies, this research paper contributes to a holistic comprehension of the intricate interactions involving micronutrients, carbohydrates, and osmostimulants, intricately connected with the diverse growth and fruit parameters within mango trees.Through this endeavor, the paper provides valuable insights into the intricate interplay of micronutrients within mango cultivation, offering a knowledge foundation for informed agricultural practices geared towards sustainable and high-quality fruit production. The paramount importance of micronutrients in fostering robust crop health and productivity underscores the broader implications of these findings for contemporary agricultural methodologies.

Introduction

Mango (*Mangifera indica L.*) is a premier fruit crop of India considering its area, production and popularity among people and designated as "national fruit of India.Mango is considered the king of fruits in many countries (Purseglove, 1972). In mango many problems are associated with fruitset, yield and quality due to imbalance supply of nutrients and its results in poor health of plants are also prone to attacks of insect-pests and diseases.

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In spite of adequate flowering, low fruit yield in mango orchards have been experienced because of low initial fruit set and subsequently higher fruitlet abscission (Singh and Singh, 1995). Fruitlet abscission is a very complex physiological perocess, occurs in many cultivars of mango and at all stages of development, but it is particularly high during the fiarst 3-4 weeks after pollination and accounts for over 90 % loss of set fruitlets (Bains, et al., 1997 and Wahdan and Melouk, 2004).

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The use of growth substances and some chemical compounds may regulate fruit set in many fruit crops. Many investigators found that spraying mango trees with NAA at different concentrations (20, 25 and 40 ppm) increased fruit set percentages and fruit retention (Oksher et al., 1980 and Singh and Ram, 1983). Auxin is well known as inhibitors of ethylene action in a number of plants (Beyer, 1976). MotiSingh et al., (1987) with Langra and Dashehari cvs stated that NAA or GA3 each 5-25 ppm once sprayed at full bloom or twice at full bloom and at pea stage or thrice plus at marble stage increased fruit retention. Singh et al. (1991) found that the highest fruit retention and yield/tree were recorded on mango cv. (Amrapali) by spraying urea with 3 % at pea stage.

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. In plants, micronutrients are required for different physiological and metabolic processes, and their deficiency affects a number of processes including hindered plant growth, productivity, and quality (Berdanier and Berdanier 2015; Gurjar et al. 2015; Souri and Aslani 2018a; Souri and Bakhtiarizade 2019). The key role of micronutrients is in respiration and photosynthesis (Ahmed et al. 2009). Iron deficiency affected the yield, chlorophyll contents, fruit quality, and mineral nutrients in a number of fruit trees (Tagliavini et al. 2000; Souri et al. 2018). Iron is an essential micronutrient for plant growth and development. It plays a critical role in various physiological processes, including photosynthesis, respiration, and DNA synthesis. Iron is a component of many enzymes involved in redox reactions and electron transfer within the plant cells. (Sharma and Dietz 2019). Zinc is a crucial micronutrient required for the synthesis of enzymes and proteins in plants. It is involved in various enzymatic reactions, including those related to carbohydrate metabolism, auxin synthesis, and protein synthesis. Zinc also plays a role in DNA and RNA synthesis and is essential for proper root development. (Broadley et al. 2007, Yruela 2005). Boron is essential for cell wall formation and stability in plants. It plays a critical role in the synthesis of nucleic acids and proteins, as well as in the transport of sugars and

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Effect of Micronutrients on Various Parameters in Mango Trees

Microscopic nutrients, also known as micronutrients, play a crucial role in influencing various parameters of mango tree growth and development. Here, we explore the diverse effects of these nutrients on different aspects of mango trees' lifecycle:

1. **Vegetative Growth Enhancement:**

   The enhancement of vegetative growth in plants has been a subject of extensive research. Notably, Singh and Rajput (1976) conducted a study on mango trees, revealing the positive effects of varying levels of ZnSO4 on vegetative growth parameters. The application of zinc and boron led to increased terminal shoot length, leaf count, and leaf area per shoot, thereby influencing plant height, trunk girth, and young plant spread. In a similar vein, Masroor et al. (2016) highlighted the significance of zinc application, particularly a foliar spray of 1% ZnSO4, in elevating zinc levels within mango leaves. This innovative approach demonstrated the potential of targeted micronutrient application for stimulating vegetative growth.

   Moreover, the role of nano zinc oxide (nZnO) in influencing vegetative growth was investigated by Elsheery et al. (2020), who observed a significant increase in leaf area with the application of 100 units of nZnO. This study emphasized the efficacy of nano-based formulations in enhancing plant growth. Additionally, Kacha HL (2021) shed light on zinc's crucial involvement in starch formation, a process that subsequently contributes to increased plant weight and overall vegetative growth. These research findings collectively underscore the multifaceted contributions of zinc and its compounds to fostering robust vegetative growth in various plant species.

2. **Leaf Mineral Contents and Zn Foliar Spray:**

   Leaf mineral content and its association with Zn foliar spray have garnered significant attention in recent research endeavors. Elsheery et al. (2020) extended their investigations to delve into the effects of Zn foliar spray on leaf mineral content within

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mango trees. Their findings illuminated the positive impact of this application method on enriching the mineral content of leaves, thereby contributing to enhanced overall plant health. Similarly, Ahmad I et al. (2018) underlined the considerable influence of Zn foliar spray on leaf mineral content. This relationship between Zn application and leaf mineral composition holds promising implications for influencing not only mineral concentrations but also potentially exerting downstream effects on various vegetative parameters. The convergence of these research insights underscores the significance of Zn foliar spray as a viable strategy to manipulate leaf mineral content and subsequently impact plant vitality.

3. **Flowering and Fruit Set:**

The intricate relationship between micronutrients and flowering processes in plants has been a subject of focused investigation. Elsheery et al. (2020) conducted a study showcasing the potential benefits of applying ZnO and Si NPs via spraying on mango trees. This approach notably led to a reduction in floral malformation, consequently promoting an improved flowering process. This finding emphasizes the role of micronutrient supplementation in optimizing flower development.

Furthermore, the pivotal role of zinc in influencing flowering was illuminated by Masroor et al. (2016) and Kacha HL et al. (2021). Through their independent studies, both researchers emphasized the substantial impact of $ZnSO_4$ application on enhancing the number of flowers per panicle. These observations collectively underscore the vital contribution of micronutrients, particularly zinc-based applications, in modulating flowering outcomes in plants. The convergence of research findings highlights the potential for targeted nutrient management strategies to positively influence flowering and subsequent fruit set, thereby enhancing overall crop productivity.

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4. **Fruit Retention and Weight:**

The intricate interplay between micronutrients and fruit development has attracted considerable research attention. Ahmad I et al. (2018) conducted a study that yielded noteworthy outcomes in terms of high fruit retention percentages, employing specific micronutrient treatments. This finding suggests a potential role for micronutrients in enhancing the retention of fruits on trees.

Furthermore, the influence of zinc on fruit weight was demonstrated by Masroor et al. (2016) and Kacha HL et al. (2021). Their independent research endeavors elucidated how zinc application strategies, whether foliar or soil-based, could positively impact fruit weight. These studies collectively underscore the significant potential of targeted zinc treatments to influence fruit development and quality.

Expanding on this theme, RM Dheware (2020) delved into a comprehensive nutrient application strategy involving both soil and foliar applications. This holistic approach yielded substantial improvements in fruit weight and quality. The convergence of these research findings underscores the multifaceted influence of micronutrients, particularly zinc, in shaping the retention and weight of fruits. This insight holds considerable implications for the agricultural sector, suggesting avenues for optimizing crop yield and enhancing fruit characteristics through strategic nutrient management practices

5. **Total Soluble Solids, Sugar Content, and Vitamin C:**

The nexus between micronutrient applications and the biochemical composition of fruits has been a subject of keen exploration. RM Dheware (2020) provided insights into the influence of specific nutrient applications on fruit quality, unveiling an increase in Total Soluble Solids (TSS) content. This finding underscores the potential for targeted nutrient management to impact the composition of fruits.

In line with this, Patel RJ (2018) undertook research into novel organic liquid fertilizer treatments, which yielded multifaceted improvements in fruit quality. Notably, these treatments led to elevated TSS levels, along with increased sugar and vitamin C content. This discovery highlights the efficacy of innovative fertilization approaches in enhancing the nutritional attributes of fruits.

Collectively, the research of Dheware and Patel RJ reinforces the interconnectedness between micronutrient applications and key components of fruit quality, including TSS, sugar content, and vitamin C levels. These findings not only contribute to our understanding of nutrient-induced variations in fruit composition but also hold implications for promoting healthier and more nutrient-rich produce for consumers.

6. **Effects on Carbohydrates and Osmostimulants:**

The impact of micronutrient applications on carbohydrates and osmostimulants within plants has been a topic of interest and investigation. Elsheery et al. (2020) conducted research that yielded insightful results, indicating an improved total yield resulting from the application of Zn and Si NPs. This finding highlights the positive effect of osmostimulants in promoting overall plant productivity.

Kacha HL et al. (2021) contributed to this understanding by demonstrating how fruit yield per tree could be enhanced through soil application of Grade-V 400g, suggesting the influence of specific nutrient strategies on carbohydrate accumulation and subsequent yield.

RM Dheware (2020) further enriched this discourse by presenting evidence of increased fruit yield attributed to comprehensive micronutrient treatments, including the application of copper and Borax. These findings underscore the role of specific nutrients in influencing carbohydrate metabolism and, consequently, fruit production.

The research of UY Puranik (2019) supplements this narrative by reporting increased fruit yield resulting from specific nutrient treatments involving copper, boron, and molybdenum application. This observation lends credence to the notion that the manipulation of osmostimulants and carbohydrates through targeted micronutrient interventions can significantly impact plant productivity and yield. The collective findings of these studies contribute to a more comprehensive understanding of the intricate relationship between micronutrients, carbohydrates, and osmostimulants in influencing crop yield and overall plant performance.

7. **Yield Enhancement:**

Recent studies have advanced our understanding of how micronutrient applications can positively influence crop yield, shedding light on diverse strategies that can significantly enhance overall plant productivity. Elsheery et al. (2020) demonstrated the potential of nanomaterials by applying zinc (Zn) and silicon (Si) nanoparticles (NPs) to mango trees, resulting in a noteworthy improvement in total yield. This finding underscores the capacity of nanomaterials to exert a nanoscale impact on crop productivity. Similarly, Kacha HL et al. (2021) contributed to this discourse by highlighting the efficacy of soil interventions, showcasing that the application of Grade-V 400g significantly elevated fruit yield per tree. This approach accentuates the importance of nurturing the soil environment for substantial enhancements in crop productivity.

Furthermore, RM Dheware (2020) explored a holistic treatment strategy involving foliar spray of micronutrients such as zinc sulphate, copper sulphate, and Borax during critical growth stages. This meticulously timed application led to a higher number of fruits per tree, addressing issues related to fruit drop and concurrently elevating fruit weight. The cumulative effect resulted in a remarkable surge in overall fruit yield. Expanding on this theme, UY Puranik (2019) reported on the successful augmentation of fruit yield through a specific nutrient regimen encompassing copper, boron, and molybdenum application. The combined impact of these essential elements demonstrated their potential to collectively contribute to improved yield outcomes.

In conclusion, these studies collectively underscore the multifaceted avenues through which micronutrient interventions can substantially enhance crop yield. Whether through nanomaterials, soil amendments, or comprehensive treatments, these findings provide valuable insights for optimizing agricultural practices and ensuring sustainable food production in the face of evolving agricultural challenges.

8. **Fruit Quality Improvement:**

A comprehensive understanding of the impacts of micronutrient applications on fruit quality has been gleaned from recent research endeavors.

Ahmad I et al. (2018) illuminated the manifold benefits of zinc applications by emphasizing how both foliar and soil treatments led to significant enhancements in fruit yield and quality. Parameters such as fruit weight, volume, pulp recovery, Total Soluble Solids (TSS), and acidity witnessed notable improvements. This holistic improvement underscores the pivotal role of zinc in shaping fruit attributes.

Elsheery et al. (2020) delved into the intricacies of micronutrient combinations, revealing that the synergy between 50 mg/L of nano zinc oxide (nZnO) and 300 mg/L of nano silicon (nSi) resulted in the highest acidity in mangoes. Interestingly, this outcome could be attributed to the inhibitory effects of a high concentration of nSi on acidity levels. This insight provides a nuanced perspective on how different micronutrients' interactions can influence specific fruit attributes.

Furthermore, Patel RJ (2018) conducted research that showcased the diverse impact of foliar applications of 1% Grade-IV micronutrients. This approach led to an overall acceptability of the produce. This enhancement in fruit quality can be attributed to iron's contribution to flavor-protein development, the presence of adequate zinc improving auxin content, and zinc's catalytic role in oxidation-reduction processes within plants. These findings collectively underscore the intricate interplay between micronutrients and fruit quality, shedding light on the diverse pathways through which these elements influence the sensory and nutritional attributes of produce.

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Conclusion

In summary, the influence of micronutrients on various parameters in mango trees emerges as a multifaceted process. From promoting vegetative growth to affecting flowering, fruit set, and fruit quality, these findings underscore the indispensable role that micronutrients play in fine-tuning mango tree development. The combined influence of micronutrients, carbohydrates, and osmostimulants on mango tree growth and fruit parameters is evident across various studies. From enhancing vegetative growth to affecting flowering, fruit set, yield, and quality, these factors collectively shape mango cultivation practices. Proper nutrient management strategies hold promise for optimizing mango production, ensuring both quantity and quality in harvests. The review underscores the importance of micronutrients in influencing mango tree yield and fruit quality. The findings highlight the multifaceted impact of micronutrient applications, demonstrating their role in enhancing yield through fruit retention, increasing fruit numbers, and influencing fruit weight. Furthermore, the improvement in fruit quality, as evidenced by parameters like acidity and overall acceptability, emphasizes the potential of micronutrients to contribute to the overall success of mango cultivation. Collectively, these insights underline the intricate web of interactions between micronutrients, carbohydrates, osmostimulants, and various growth and fruit parameters in mango trees. These findings offer valuable insights for optimizing nutrient management strategies and practices, ensuring sustainable and high-quality mango production.

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