



Influence of foliar application of zinc, boron, and iron on the quality parameters of cucumber (*Cucumis sativus* L.)

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Abstract

A field experiment was conducted during 2023–2024 at the main experimental field of the Department of Horticulture, Udai Pratap (Autonomous) College, Varanasi, U.P., to evaluate the effect of micronutrient foliar application on the quality parameters of cucumber (*Cucumis sativus* L.). The experiment was laid out in a randomized block design with three replications, comprising seven treatments with different concentrations of zinc sulfate (ZnSO₄), iron sulphate (FeSO₄), and boric acid. Results indicated that micronutrient applications significantly improved cucumber quality parameters. Among the treatments, boric acid at 50 ppm resulted in the highest total soluble solids (TSS), ascorbic acid, and total sugar content while reducing titratable acidity. ZnSO₄ at 50 ppm was most effective in increasing chlorophyll content, minimizing physiological weight loss, and extending shelf life. Both boron and zinc treatments significantly enhanced cucumber quality, with boron improving sweetness and nutritional value, whereas zinc contributed to better chlorophyll retention and prolonged shelf life. These findings highlight the crucial role of micronutrient foliar application in optimizing cucumber quality, providing valuable insights for growers aiming to enhance nutrient management for improved yield and marketability.

Keywords: Cucumber, fruit, ppm, quality, yields etc.

Introduction

Cucumber (*Cucumis sativus* L.) is a widely cultivated vegetable known for its refreshing taste and high water content. It is rich in essential nutrients, including vitamins, minerals, and antioxidants, making it a popular choice for salads, pickles, and other culinary uses. Globally, cucumber is an important crop, with major producers including China, Turkey, and India. India contributes approximately 1.6 million metric tons annually to global cucumber production (FAO, 2022), with Karnataka, Tamil Nadu, and Maharashtra being key production regions. However, cucumber productivity in India often remains below optimal levels due to micronutrient deficiencies in the soil. Micronutrients such as zinc (Zn), boron (B), and iron (Fe) play crucial roles in plant growth and development. Zinc is vital for enzyme activation and protein synthesis, boron influences cell wall formation and reproductive growth, while iron is essential for chlorophyll synthesis and energy transfer within plants (Havlin *et al.*, 2014) [5]. Deficiencies in these micronutrients can result in stunted growth, reduced flowering, and poor fruit quality in cucumbers (Sharma *et al.*, 2018) [25, 26]. Foliar application of micronutrients has emerged as an effective method to address these deficiencies. This technique involves applying nutrients directly to the leaves, allowing for rapid absorption and utilization by the plant (Kumar & Singh, 2019). Previous studies have shown that foliar feeding improves not only plant growth and yield but also quality attributes such as fruit size, shape, color, and nutritional content (Patel *et al.*, 2020) [16, 17]. This study aims to evaluate the effect of foliar application of zinc, boron, and iron on cucumber quality parameters, focusing on both yield improvement and fruit quality enhancement. The findings will help farmers adopt better nutrient management practices for producing high-quality cucumbers.

Materials and Methods

The experiment was conducted at the experimental field of the Horticulture Department, Udai Pratap Autonomous College, Varanasi (U.P.), during the 2023–24 growing season. The study aimed to evaluate the effect of foliar application of micronutrients on the quality parameters of cucumber (*Cucumis sativus* L.) cv Vinayak. The experiment was designed as a Randomized Block Design (RBD) with three replications, incorporating seven treatments comprising different concentrations of Zinc sulphate (25 and 50 ppm), Iron sulphate (50 and 100 ppm), and Boric acid (25 and 50 ppm), along with a control. Foliar sprays were applied at 25 and 45 days after sowing (DAS). The quality parameters assessed included total soluble solids (TSS), ascorbic acid content, titratable acidity, chlorophyll content, sugar content, physiological weight loss (PLW), and shelf life. TSS was measured using a hand refractometer (Erma) with a range of 0–32%, and values were corrected at 20°C, expressed as percentage TSS of fruit juice (Ranganna, 1978) [20]. Ascorbic acid content was determined following the procedure outlined by Ranganna (1997) [21], while titratable acidity was measured using the standard titration method (AOAC). The quantitative estimation of chlorophyll-a, chlorophyll-b, and total chlorophyll was conducted as per Arnon's method (1949). Sugar content was determined using the Fehling's 'A' and 'B' solution method by Lane and Eynon (1943) [11]. Physiological weight loss (PLW) was calculated as the percentage of weight loss in relation to the initial weight. Shelf life was assessed by storing fruits at ambient room temperature until they shrunk and became unsuitable for consumption. The collected data on quality parameters were subjected to statistical analysis.

Results and Discussion

The results of the study on the influence of foliar application of zinc, boron, and iron on the quality parameters of

cucumber (*Cucumis sativus* L.) cv. Vinayak are presented in Table 1, along with relevant discussions. Total Soluble Solids (TSS) in cucumber fruit were significantly influenced by foliar application of micronutrients. The highest TSS content (3.11 °Brix) were recorded in T6 (Boric acid @50 ppm), followed by T5 (Boric acid @25 ppm) and T2 (ZnSO₄ @50 ppm). The lowest TSS (2.31 °Brix) was observed in the control treatment (water spray). Furthermore, T1 (ZnSO₄ @25 ppm) was statistically at par with T4 (FeSO₄ @100 ppm) and T3 (FeSO₄ @50 ppm). Total soluble solids (TSS) are a key indicator of sweetness and overall flavor in cucumbers, and the results suggest that foliar application of boron and zinc significantly enhances TSS levels. The superiority of T6 (Boric acid @50 ppm) in increasing TSS highlights its effectiveness in improving fruit quality. Similar findings have been reported by Banjade (2022) [1], Seraji (2021) [24], Sidhu *et al.*, (2020) [27], and Kavitha *et al.*, (2000) [7], further supporting the positive impact of micronutrient foliar applications on cucumber TSS content.

The ascorbic acid content of cucumber fruit was significantly influenced by the foliar application of micronutrients. The highest ascorbic acid content (5.74 mg/100 g) was recorded with T6 (Boric acid @50 ppm), followed by T5 (Boric acid @25 ppm) and T2 (ZnSO₄ @50 ppm). The lowest ascorbic acid content (4.75 mg/100 g) was observed in the control treatment (water spray). Furthermore, T1 (ZnSO₄ @25 ppm) was statistically at par with T4 (FeSO₄ @100 ppm) and T3 (FeSO₄ @50 ppm), indicating comparable effectiveness. Ascorbic acid (vitamin C) is a crucial quality parameter that enhances the nutritional value of cucumbers. Research has shown that foliar application of micronutrients, particularly zinc, boron, and iron, can significantly increase ascorbic acid content. Kumar *et al.*, (2019) [8, 9, 10] reported a 20% increase in ascorbic acid with zinc sulphate application, while Patel and Sharma (2020) [16, 17] observed a similar effect with iron supplementation. This improvement is attributed to the role of these micronutrients in the biosynthesis of vitamin C. The findings of the present study align with those of Mufti (2021) [13], Muradi *et al.*, (2020) [14], Kumar *et al.*, (2019) [8, 9, 10], and Sharma *et al.*, (2018) [25, 26], confirming the positive impact of micronutrient foliar applications on ascorbic acid content in cucumbers.

Titrateable acidity plays a crucial role in determining the taste, flavour balance, and preservation qualities of cucumbers. The reduction in acidity due to micronutrient application enhances fruit sweetness and improves overall quality. Rao and Patel (2019) [22] reported that foliar sprays of boron and manganese resulted in slight acidity modulation, contributing to an improved flavour profile and extended shelf life of cucumbers. The lowest titrateable acidity (0.09%) was recorded under T6 (Boric acid @50 ppm), whereas the highest titrateable acidity (0.23%) was observed in the control treatment. The data presented in table 1 clearly indicate that the foliar application of T6 (Boric acid @50 ppm) was statistically at par with T5 (Boric acid @25 ppm), followed by T2 (ZnSO₄ @50 ppm) and T1 (ZnSO₄ @25 ppm), indicating their comparable effectiveness in acidity reduction. The remaining treatments also showed significant effects and were found to be beneficial in reducing titrateable acidity. The present findings are consistent with those of Razzag *et al.*, (2013) [23], further

confirming that micronutrient foliar applications effectively reduce titrateable acidity in cucumbers.

Chlorophyll content is a key indicator of photosynthetic efficiency and overall plant health. Micronutrient foliar applications, particularly zinc, iron, and boron, play a crucial role in improving chlorophyll a, chlorophyll b, and total chlorophyll content. Mehta and Verma (2019) [12] reported an increase in total chlorophyll content following iron application, indicating improved photosynthetic capacity and plant vigour. These enhancements contribute to better fruit quality and overall plant productivity. The data presented in table 1 clearly indicate that the foliar application of T2 (ZnSO₄ @50 ppm) resulted in the highest chlorophyll a content (4.77 µg/mg), followed by T1 (ZnSO₄ @25 ppm) and T6 (Boric acid @50 ppm). The lowest chlorophyll a content (2.82 µg/mg) was recorded in the control treatment (water spray). Similarly, data reveal that the foliar application of T2 (ZnSO₄ @50 ppm) also led to the highest chlorophyll b content (2.43 µg/mg), followed by T1 (ZnSO₄ @25 ppm) and T6 (Boric acid @50 ppm). The lowest chlorophyll b content (1.38 µg/mg) was recorded in the control treatment. The total chlorophyll content, followed a similar trend, with T2 (ZnSO₄ @50 ppm) recording the highest total chlorophyll content (7.20 µg/mg), followed by T1 (ZnSO₄ @25 ppm) and T6 (Boric acid @50 ppm). The lowest total chlorophyll content (4.19 µg/mg) was observed in the control treatment (water spray). The present findings align with those of Rao and Patel (2019) [22], further confirming the effectiveness of foliar-applied micronutrients in enhancing chlorophyll content in cucumbers.

The sugar composition of cucumbers, including reducing, non-reducing, and total sugars, is a critical factor influencing taste, sweetness, and consumer preference. Foliar application of micronutrients, particularly zinc and boron, plays a crucial role in carbohydrate metabolism and enzymatic activities related to sugar synthesis. Gupta and Verma (2020) [4] reported an increase in sugar content, following micronutrient foliar sprays, attributing these improvements to enhanced carbohydrate metabolism. The present study confirms that the foliar application of T6 (Boric acid @50 ppm) resulted in the highest sugar content, while the control treatment recorded the lowest values. The data presented in table 1 indicate that all treatments significantly improved reducing sugar content compared to the control. The highest reducing sugar content (0.87%) was recorded with the foliar application of T6 (Boric acid @50 ppm), followed by T5 (Boric acid @25 ppm) and T2 (ZnSO₄ @50 ppm). The lowest reducing sugar content (0.48%) was observed in the control treatment (water spray). Similarly, data show that the maximum non-reducing sugar content (2.73%) was recorded with T6 (Boric acid @50 ppm), followed by T5 (Boric acid @25 ppm) and T2 (ZnSO₄ @50 ppm). The lowest non-reducing sugar content (1.60%) was recorded in the control treatment. The total sugar content, followed a similar trend. The highest total sugar content (3.60%) was recorded in T6 (Boric acid @50 ppm), followed by T5 (Boric acid @25 ppm) and T2 (ZnSO₄ @50 ppm). The lowest total sugar content (2.08%) was observed in the control treatment. These findings are in agreement with those of Singh and Verma (2020), Kazemi (2013) [6], and Sindhu *et al.*, (2020),

reinforcing the significant role of micronutrient application in improving the sugar content and overall fruit quality in cucumbers.

Physiological loss in weight and shelf life are crucial post-harvest parameters affecting cucumber fruit quality and marketability. Studies have demonstrated that foliar applications of micronutrients, particularly zinc and boron, effectively reduce PLW and enhance shelf life. Patel and Sharma (2018)^[25, 26] reported that micronutrients application reduced Physiological loss in weight (PLW) and extended shelf life of cucumber. These effects can be attributed to the role of zinc in maintaining membrane permeability and boron in enhancing calcium mobility, which strengthens cell walls and reduces respiration rates, thereby slowing weight loss and prolonging freshness. The data presented in table 1 clearly indicate that foliar application of T2 (ZnSO₄ @50 ppm) resulted in the lowest physiological loss in weight (PLW) (18.07%), followed by T1 (ZnSO₄ @25 ppm) and T6 (Boric acid @50 ppm). In contrast, the highest physiological

loss in weight (23.88%) was observed in the control treatment (water spray). Similarly, table 1 indicate that T2 (ZnSO₄ @50 ppm) recorded the longest shelf life (7.33 days), followed by T1 (ZnSO₄ @25 ppm) and T6 (Boric acid @50 ppm). The shortest shelf life (4.00 days) was recorded in the control. The present study confirms that the lowest physiological loss in weight and the highest shelf life were observed with the foliar application of T2 (ZnSO₄ @50 ppm), whereas the control treatment exhibited the highest PLW and shortest shelf life. These findings align with the results of Rana *et al.*, (2021)^[19]. Furthermore, the combination of salicylic acid, boron, and zinc has been found to enhance cucumber fruit quality by delaying deterioration and preserving freshness. The results are consistent with the findings of Preciado-Rangel *et al.*, (2019)^[18], Nada and El-Hady (2019)^[15], Bommesh *et al.*, (2016)^[2] in cucumber, Yadav *et al.*, (2022)^[28] in pointed gourd, Yadav *et al.*, (2020)^[29] in bitter gourd, and Yadav *et al.*, (2019)^[30] in bottle gourd.

Table 1: Influence of Foliar Application of Zinc, Boron, and Iron on the Quality Parameters of Cucumber (*Cucumis sativus* L.).

S.No.	Treatments	Total soluble solids (°Brix)	Ascorbic acid content (mg/100g)	Titrateable acidity (%)	Chlorophyll a content (µg/mg)	Chlorophyll b content (µg/mg)	Total Chlorophyll content (µg/mg)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Physiological loss in weight (PLW %)	Shelf life (days)
1	T1	2.78	5.41	0.16	4.48	2.24	6.72	0.69	2.25	2.94	19.96	6.33
2	T2	2.89	5.54	0.14	4.77	2.43	7.20	0.76	2.33	3.09	18.07	7.33
3	T3	2.52	5.05	0.21	3.23	1.55	4.78	0.55	1.81	2.36	22.20	4.33
4	T4	2.69	5.16	0.18	3.64	1.72	5.36	0.60	2.04	2.63	21.52	4.67
5	T5	2.97	5.65	0.11	3.81	1.88	5.69	0.82	2.53	3.35	21.12	5.00
6	T6	3.11	5.74	0.09	4.08	2.02	6.10	0.87	2.73	3.60	20.62	5.67
7	T7	2.31	4.75	0.23	2.82	1.38	4.19	0.48	1.60	2.08	23.88	4.00
	CV (%)	4.0	3.7	20.6	8.5	5.7	6.6	9.2	6.3	5.5	4.4	14.3
	SEm±	0.06	0.11	0.02	0.19	0.06	0.22	0.04	0.08	0.09	0.54	0.44
	CD (P=0.05)	0.19	0.35	0.06	0.58	0.19	0.67	0.11	0.24	0.28	1.66	1.35

Conclusion

This study demonstrates that foliar application of micronutrients significantly enhances the quality parameters of cucumber. Among the treatments, Boric acid @50 ppm resulted in the highest TSS, ascorbic acid, and total sugar content, while reducing titrateable acidity. On the other hand, ZnSO₄ @50 ppm was most effective in increasing chlorophyll content, minimizing physiological weight loss, and extending shelf life. Both boron and zinc treatments significantly improved cucumber quality. While boron enhanced sweetness and nutritional value, zinc contributed to longer shelf life and better chlorophyll retention. These findings highlight the importance of micronutrient foliar applications in improving cucumber quality, offering valuable insights for growers seeking to optimize nutrient management for high-quality produce.

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