Plant Archives Vol. 25, Supplement 1, 2025 pp.2770-2773 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.384

IMPACT OF BORON AND ZINC APPLICATIONS ON CROP GROWTH, YIELD, AND QUALITY: A COMPREHENSIVE REVIEW

Natasha Parvin*, Narendra Nath Hansda and Tanmoy Ghosh
Department of Vegetable Science, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, P.O. Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India.
*Corresponding author Email : natashapervin25@gmail.com
(Date of Receiving : 11-10-2024; Date of Acceptance : 31-12-2024)

ABSTRACT

Essential micronutrients for the growth of plants, boron (B) and zinc (Zn) are essential for the synthesis of cell walls, the metabolism of carbohydrates, enzyme activity, and reproductive development. Studies regarding how boron and zinc treatments influence a variety of crops, including cucurbits like bitter gourd and vegetables like broccoli, tomatoes, and onions, is presented in this review. The results illustrate how they can be implemented as soil supplements or foliar sprays to improve growth measurements, yield, and quality features. This review is a helpful resource for comprehending the wider ramifications of utilizing micronutrients to maximize crop production.
***Keywords* :** Boron, zinc, micronutrients, crop growth, yield, and quality.

Introduction

Proper plant nutrition is important for the successful production of vegetable crops. For high cropping intensity, the nutritional status of the soil decreases day by day, and the supply of micronutrients to crop continues to be negligible. Integrated supply of micronutrients with macronutrients in an adequate amount and suitable proportions is one in every of the foremost important factors that control plant growth and development. Micronutrients are usually required in minute quantities, nevertheless, are vital to the expansion of the plant. The judicious use of micronutrients is crucial for vegetable cultivation to urge the maximum yield of top-quality produces.

Essential micronutrients including zinc and boron possess significant effects on plant physiological functions such pollen tube production, cell division, enzyme activation, and nutrient transfer. Plant health can be adversely affected by their excess or deficiency, which reduces yield and quality. To consolidate knowledge for advantageous uses across different agricultural contexts, this review explores studies that concentrate on the effects of zinc and boron on productivity of crops.

Boron Application in Diverse Crops

Plants require boron, which is mainly taken up by the roots as boric acid. The activity of substances with cis-diol groups in the metabolism of plants depends on their stability (Brdar-Jokanovic, 2020). It assists to the regulation of various biological functions, including the development of roots and shoot meristems, as well as the safeguarding of the structural and membrane integrity of the cell wall and the membrane of the plasma (Pereira *et al.*, 2021). In accordance with Mondal and Ghosh (2023), a 0.25% boron foliar application at 60 days after transplanting and a 2 kg/ha boron soil treatment at 30 days after transplanting boosted the overall chlorophyll content of the leaves in tomato. The Rio Grand tomato cultivar exhibited highest number of flower clusters per plant, fruit set percentage, total yield, fruit weight loss, and total soluble solid content when 2 kg of boron was applied per hectare (Naz *et al.*, 2012).

In tomato, several studies highlighted boron's role in growth and fruit production. In the study by Meena *et al.* (2015), boron spraying at 100 ppm improved fruit yield (93.10 t/ha), branch number (16.17 per plant), and plant height (61.23 cm at 90 DAT). Additionally, early blooming, flower count (75.21), and physicochemical fruit quality (TSS: acid ratio of 10.98) were all elevated by a combined boron and zinc treatment. In a similar vein, Naresh (2002) found that adding 250 ppm of boron increased plant height, branching, and fruit chemical composition whereas yielding the highest tomato production (327.18 q/ha), more than two seasons, Boric acid at 100 ppm generated the highest fruit yield (30.50 t/ha), as reported by Patil *et al.* (2008).

Boron's influence on crop performance has been extensively studied in various crops. Manna and Maity (2016) examined the impact it had on onions and discovered that a 0.05% boron application rate raised plant height (63.93 cm), leaves per plant (7.25), yield (30.74 t/ha), and quality parameters like acidity (5.94 µmol/g) and total soluble solids (13.45 °B). Additionally, boron possessed notable impacts on the production of bitter gourds. Sultana *et al.* (2010) revealed that following the application of 1.25 kg/ha of boron was put down, the yield peaked at 14.1 t/ha, while the control condition produced 5 t/ha. Fruit weight, girth, size, and potassium and zinc absorption were all elevated by boron. Based to studies conducted by Saha *et al.* (2010), foliar borax spraying at 0.3% produced the highest total head production (13.37 t/ha) for broccoli, illustrating the positive benefits of boron. Firoz *et al.* (2009) concluded that applying 1 kg/ha of boron raised production from 445.4 g/plant (control) to 512.3 g/plant.

The nitrogen treatment with 120 kg/ha and the boron treatment with 10 kg/ha in radish experienced the highest plant height, plant spread, number of leaves, fresh weight of leaves, dry mass of leaves, area of leaves, leaf area index, root length, root width, root-to-shoot ratio, average yield (gm/per plant), root yield(kg per plot), root yield (quintal per hectare), TSS, ascorbic acid, and B: C ratio (Maurya *et al.,* 2019). Comparable outcomes were also seen by Tariq and Mott (2006), who stated that 0.5 mg/L of boron was added to the radish to obtain the highest yield and that there were significant impacts on the growth response of the plants. Malek and Rahim (2011) reported substantial rises in seed production in carrots. In comparison to the control yield of 1371.93 kg/ha, the maximum yield (1769.11 kg/ha) came about at 3 kg/ha of boron application. Similar findings were found in chilli, where a trial by Khan *et al.* (2022) indicated that foliar boron spray had significant effects on all chili parameters. The foliar spray of boron at 3 kg per hectares produced the highest number of fruits per plant (117.01), length of fruit (8.98 cm), weight of the fruit per plant (622.21 g), yield tons/ha (2.71 tons), and 1000 seed weight (3.47 g).

Zinc Application in Diverse Crops

One of the seventeen fundamental nutrients required for plants to grow and develop properly is zinc. It is one of the eight micronutrients that plants need. In plants, zinc serves as vital for enzymes and proteins involved in the metabolism of carbohydrates, synthesis of proteins, expression of genes, auxin (growth regulator) metabolic rate, pollen development, biological membrane maintenance, defence against heat stress and photooxidative damage, and resistance to infection by specific pathogens (Alloway 2008). Munish Sharma and Yashwant Singh (2018) concluded that foliar zinc sulphate application in combination with the recommended dose of NPK in onions brought about the highest benefit-to-cost ratio (2.63:1) and a substantial rise in yield (275 q/ha), as opposed to 231.25 q/ha and a B:C ratio of 2.19:1 in the recommended practice. Brinjal production could potentially be boosted by applying a soil treatment containing humic acid at a concentration of 30 kg/ha in addition to zinc sulphate at a rate of 50 kg/ha (Abbas *et al.,* 2021). In accordance with Tawab *et al.,* (2015), the brinjal plant treated with 0.2% zinc levels exhibited considerable benefits, with the highest plant height (131.89 cm), fruit weight (280.11 g), along with total yield (15.33 t/ha) reported.

Zinc provides a major effect on cabbage, as evidenced by Vinay Singh and Ranvir Singh (2017), who reported that feeding up to 6 kg/ha of zinc increased edible head yield by 38.4% above the control. Nutrient absorption was facilitated by successive zinc doses; the maximum recovery was noted at 4 kg/ha. With diminishing benefits after 8 kg/ha, zinc treatment significantly improved protein content, dry matter production, and utilization of nutrients efficiency. In a cauliflower experiment, Yadav *et al.,* (2015) found that 40 ppm of zinc significantly improved the dry weight, compactness, and production of the cauliflower curd.

In comparison to the control, foliar zinc treatment significantly raised the concentration of sulforaphane in broccoli florets by around 19.8–32.9 % at 750 g/ha and by 37.2–49.3 % when applied at 1.5 kg/ha (Slosár *et al.,* 2017). In the work of Nagar *et al.* (2022), increasing the concentration of zinc sulphate and sprays significantly enhanced tomato growth and yield, as evidenced by increases in plant height, branches, flowers, chlorophyll content, fruit weight, length, and number of fruits per plant, as well as fruit yield per plant and fruit yield per hectare. Ahmed *et al.,* (2023) noticed that foliar spraying 100 ppm ZnO-NPs generated the best outcomes for tomato growth parameters, physiological factors, yield attributes, and quality attributes. It was 100 ppm ZnO-NPs that had the highest nutritional absorption. Similarly, when zinc had been added at 100 ppm to tomatoes, Kumari (2012) observed that the ascorbic acid content climbed to 36.89% and that the total soluble solids improved. Zinc sprays improved seed production, 100-seed weight, and total pod number in bean plants, according to findings by Salehin and Rahman (2012). Okra green pod yield (93.70 q/ha) was dramatically increased by zinc levels of 60 ppm when coupled with boron and molybdenum (Singh *et al.,* 2009). Zinc application on bottle gourd at a rate of 7.5 kg per hectare generated an impressive rise in vine length, primary branch number node count, minimum number of days until the first female flower appeared, node on which the first male and female flowers appeared, maximum fruit length and girth, and number of seeds per fruit (Bairwa *et al.,* 2013).

Zinc with Boron Applications

Zinc and boron treated simultaneously showed synergistic effects on a variety of crops. According to Rahman *et al.,* (2020), foliar spraying of 0.2% borax and 0.2% zinc sulphate generated the maximum oil content (16%) and seed production (2.52 t/ha) in okra. Pairing 0.1% borax and 0.3% zinc sulphate significantly increased protein content (17.75%), suggesting that okra production is benefited by higher foliar application rates of zinc sulphate. In accordance with Osman *et al.,* (2019), tomato yield (83.50 t/ha) was significantly improved by applying 2kg H_3BO_3/ha and 2 kg $ZnSO_4$/ha. When compared to individual treatments, combined treatments led to higher plant height, more leaves, more branches, more flower clusters, and greater fruits. Tomato cultivars Arka Saurabh and Arka Vikas exhibited increased growth and yield parameters after undergoing three foliar sprays of boron and zinc at 250 ppm (Reddy *et al.,* 2018). The combination of 1.5 kg B/ha and 5 kg Zn/ha in cowpea was found to significantly enhance plant height, branches, and dry matter production by Debnath *et al.,* (2018).

In a study on water spinach, Sarkar *et al.,* (2017) reported that applying $ZnSO_4$ (15 kg/ha) and borax (25 kg/ha) increased seedling vigor, germination rates, and flower and seed production. With a B:C ratio of 2.60, this combination additionally turned out to be the most cost-effective. Similar advantages were found by Deepika and Pitagi (2015) in radish, where growth, seed recovery, and germination were improved by the combined application of borax (0.1%) and zinc sulphate (10 kg/ha). In a similar vein Shil *et al.,* (2013) demonstrated how a balanced zinc and boron treatment increased chili yield, recommending an optimal dose of Zn @ 3.91kg/ha and B @ 1.70 kg/ha for improved production.

Quality Improvements through Micronutrient Applications

Zinc and boron significantly enhance the quality of products. In the opinion of Patil *et al.* (2008), applying boron to tomatoes produced the highest yields and economic advantages. According to Sinha *et al.* (2006), tomatoes' lycopene and carbohydrate contents reduced during boron stress. Applications of zinc stimulated the production of dry matter and protein in cabbage. In a similar vein, boron increased the visual characteristics and seed quality of carrots, whereas Sultana *et al.* (2010) reported increased fruit weight and size in bitter gourds. Applications of zinc and boron collectively have demonstrated synergistic effects on improving crop quality and growth parameters.

Conclusion

Zinc and boron are necessary to boost crop quality, productivity, and growth in a variety of crops. However, there are differences in the most effective rates and techniques for application, foliar and soil-based treatments significantly increase productivity. However, overdose can end up in toxicity, therefore careful dosage management must be exercised. Future studies ought to focus on comprehending the long-term effects of zinc and boron on soil health, integrating their applications for crop-specific optimization, and exploring how they work in collaboration with other micronutrients. Their maximum efficiency can be achieved through concentrated application strategies, fostering high-yield and ecologically sound farming practices.

References

Abbas, Z., Mehdi, S. M., Nasir, M., Ashraf, M., Kausar, S., Iqbal, N., ... & Ahmad, I. (2021). Evaluation of best dose of micronutrients (Zinc, Iron and Boron) to combat malnutrition in brinjal (*Solanum melongena* L.). *Pakistan Journal of Agricultural Research*, ***34***(1), 164-168.

Ahmed, R., Uddin, M. K., Quddus, M. A., Samad, M. Y. A., Hossain, M. M., & Haque, A. N. A. (2023). Impact of foliar application of zinc and zinc oxide nanoparticles on growth, yield, nutrient uptake, and quality of tomato. *Horticulturae*, ***9***(2), 162.

Alloway, B. J. (2008). Zinc in Soils and Crop Nutrition. *International Zinc Association and International Fertilizer Association*, *16*.

Bairwa, L. N., Khandelwal, S. K., & Verma, H. (2013). Effect of zinc on growth, seed yield and nutrient content of bottle gourd seeds [*Lagenaria siceraria* (Mol.) Standl.]. *Progressive Horticulture*, ***45***(1), 218-221.

Brdar-Jokanović, M. (2020). Boron toxicity and deficiency in agricultural plants. *International journal of molecular sciences*, ***21***(4), 1424.

Debnath, P., Pattanaaik, S.K., Sah, D., Chandra, G., and Pandey, A.K. (2018). Effect of Boron and Zinc Fertilization on Growth and Yield of Cowpea (*Vigna unguiculata* Walp.) in Inceptisols of Arunachal Pradesh. *Journal of the Indian Society of Soil Science***, 66**(2), 229-234.

Deepika, C., & Pitagi, A. (2015). Effect of zinc and boron on growth, seed yield and quality of radish (*Raphanus sativus* L.) cv. Arka Nishanth. *Current Agriculture Research Journal*, ***3***(1), 85-89.

Faizus Salehin, F. S., & Shahedur Rahman, S. R. (2012). Effects of zinc and nitrogen fertilizer and their application method on yield and yield components of *Phaseolus vulgaris* L. *Agricultural Sciences***, 3**(1), 9-13.

Firoz, Z. A., Jaman, M. M., Alam, M. S., & Alam, M. K. (2008). Effect of boron application on the yield of different varieties of broccoli in hill valley. *Bangladesh Journal of Agricultural Research*, ***33***(4), 655-657.

Khan, M. N., Rab, A., Khan, M. W., ud Din, I., Khan, M. A., Khan, M. A., & Ahmad, M. (2022). Effect of zinc and boron on the growth and yield of chilli under the agro climatic condition of Swat. *Pure and Applied Biology*, ***11***(3), 835-842.

Kumari, S. (2012). Effect of micronutrients on quality of fruit and seed in tomato, *Solanum lycopersicum* L. *International journal of farm sciences*, ***2***(1), 43-46.

Malek, M. A., & Rahim, M. A. (2011). Effect of boron fertilizer on yield and quality seed production of two varieties of carrot. *Journal of Agro Forestry and Environment*, ***5***(1), 91-94.

Manna, D., & Maity, T. K. (2016). Growth, yield and bulb quality of onion (*Allium cepa* L.) in response to foliar application of boron and zinc. *Journal of plant nutrition*, ***39***(3), 438-441.

Maurya, K. R., Singh, A., Gupta, A., & Devi, B. (2019). Effect of nitrogen levels and boron on growth, yield and quality of Radish (*Raphanus sativus* L.) Cv. Pusa Reshmi. *Journal of Pharmacognosy and Phytochemistry*, ***8***(4), 1377-1380.

Meena, D. C., Maji, S., Meena, J. K., Kumawat, R., Meena, K. R., Kumar, S., & Sodh, K. (2015). Improvement of growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Azad T-6 with foliar application of zinc and boron. *International Journal of Bio-resource and Stress Management*, *6*(Oct, 5), 598-601.

Mondal, S., & Ghosh, G. K. (2023). Effect of zinc and boron on growth, yield and quality of Tomato (*Lycopersicon esculentum*) with different application methods in Alfisols of West Bengal. *The Pharma Innovation Journal*, ***12***(7), 896-902.

Nagar, V., Kumar, S., Khan, R., Bagri, U. K., and Bunker, R. R. (2022). *The Pharma Innovation Journal*, **11**(3), 933-937.

Naresh Babu, N. B. (2002). Response of foliar application of boron on vegetative growth, fruit yield and quality of tomato var. Pusa Ruby. **15**(1), 109-112**.**

Naz, R. M. M., Muhammad, S. A. H. F., Hamid, A., & Bibi, F. (2012). Effect of boron on the flowering and fruiting of tomato. *Sarhad Journal of Agriculture*, ***28***(1), 37-40.

Osman, I. M., Hussein, M. H., Ali, M. T., Mohamed, S. S., Kabir, M. A., & Halder, B. C. (2019). Effect of boron and zinc on the growth, yield and yield contributing traits of tomato. *Journal of Agriculture and Veterinary Science*, ***12***(2), 25-37.

Patil, B. C., Hosamani, R. M., Ajjappalavara, P. S., Naik, B. H., Smitha, R. P., & Ukkund, K. C. (2008). Effect of foliar application of micronutrients on growth and yield components of tomato (Lycopersicon esculentum Mill.). *Karnataka Journal of Agricultural Sciences*, ***21***(3). 428-430.

Pereira, G. L., Siqueira, J. A., Batista-Silva, W., Cardoso, F. B., Nunes-Nesi, A., & Araújo, W. L. (2021). Boron: More than an essential element for land plants? *Frontiers in Plant Science*, *11*, 610307.

Rahman, M. H., Quddus, M. A., Satter, M. A., Ali, M. R., Sarker, M. H., & Trina, T. N. (2020). Impact of foliar application of boron and zinc on growth, quality, and seed yield of Okra. *Journal of Energy and Natural Resources*, ***9***(1), 1-9.

Reddy, G. P. D., Reddy P. S. S., Reddy G. C., and Sivaram G. T. (2018). Effect of Foliar Application of Micronutrients on Growth and Yield Parameters in Tomato (*Solanum lycopersicon* L.). *Int. J. Pure App. Biosci*, **6**(2), 929-934.

Saha, P., Chatterjee, R., & Das, N. R. (2010). Effect of foliar application of boron and molybdenum in sprouting Broccoli (*Brassica oleracea* var italica Plenck) under Terai region of West Bengal. *Research Journal of Agricultural Sciences*, ***1***(4), 335-337.

Sarkar, R. K., Jana, J. C., and Datta. S. (2017). Effect of boron and zinc application on growth, seed yield and seed quality of water spinach (*Ipomoea reptans* Poir.) under terai region of West Bengal. *Journal of Applied and Natural Science*. **9**(3), 1696-1702.

Sharma, M., & Singh, Y. (2018). Effect of Foliar Application of Zinc Sulphate on Onion. *J Krishi Vigyan.* **6**(2), 43-45.

Shil, N. C., Noor, S., & Hossain, M. A. (2007). Effects of boron and molybdenum on the yield of chickpea. *Journal of Agriculture & Rural Development*, 17-24.

Singh, D. P., Dabbas, M. R., & Prakash, H. G. (2009). Effect of micro nutrients on growth, yield attributes and pod yield of okra (*Abelmoschus esculentus* (L.) Moench) in semi-arid zone of Uttar Pradesh. *Asian Journal of Horticulture*, **4**(2), 488-490.

Singh, V., & Singh, R. (2017). Effect of zinc nutrition on yield, quality, and uptake of nutrients in cabbage (*Brassica oleracea*). *Annals of Plant and Soil Research*, **19**(3): 299-302.

Sinha, P., Dube, B. K., Singh, M.V., Chatterjee, C. (2006). Effect of boron stress on yield, biochemical parameters, and quality of tomato. *Indian Journal of Horticulture*, **63**(1), 39-43.

Slosár, M., Mezeyová, I., Andrejiová, A. H., Kováčik, P., Lošák, T., Kopta, T., & Keutgen, A. J. (2017). Effect of zinc fertilisation on yield and selected qualitative parameters of broccoli.

Sultana, S., Niaz, A., Ahmed, Z. A., Anwer, S. A., Anjum, M. A., & Ilyas, M. (2017). Effect of boron application on growth, yield and quality of bitter gourd. *Science Letters*, ***5***(1), 1-7.

Tariq, M., & Mott, C. J. B. (2006). Effect of boron supply on the uptake of micronutrients by radish (*Raphanus sa*tivus L.). *Journal of agricultural and biological science*, ***1***(2), 1-8.

Tawab, S., Ayub, G., Tawab, F., Khan, O., Bostan, N., Ruby, G., ... & Afridi, U. K. (2015). Response of brinjal (*Solanum melongena* L.) cultivars to zinc levels. *J. Agric. Biol. Sci*, ***10***(5), 172-178.

Yadav, H. K., Rawat, T. S., Dogra, P., & Yadav, V. (2015). Effect of foliar application of nitrogen and zinc on quality of cauliflower (*Brassica oleracea* var. Botrytis L.) cv. Snowball-16. *Progressive Horticulture*, ***47***(2), 338-340.