



Impact of nutrient management on growth and quality of hybrid chilli (*Capsicum annuum*) in Typic Haplustalf

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ABSTRACT

The study was carried out during 2021–22 and 2022–23 at Sivapuri, Chidhambaram taluk, Cuddalore district of Tamil Nadu to evaluate the impact of micronutrient (zinc and boron) fertilization on the growth characters, dry matter production and quality parameters of hybrid chilli (*Capsicum annuum* Linn.) ‘Mahyco Sierra’. The experiment was laid out in a randomized block design (RBD) with nine treatments and three replications. The treatment included recommended dose of NPK fertilizers (30:60:30 kg N, P₂O₅ and K₂O/ha) combined with zinc and boron fertilizers in different combinations, viz. T₁, Control [100% recommended dose of fertilizer (RDF) alone]; T₂, RDF + 15 kg ZnSO₄/ha; T₃, RDF + 30 kg ZnSO₄/ha; T₄, RDF + 3 kg borax/ha; T₅, RDF + 6 kg borax/ha; T₆, RDF + 15 kg ZnSO₄/ha + 3 kg borax/ha; T₇, RDF + 15 kg ZnSO₄/ha + 6 kg borax/ha; T₈, RDF + 30 kg ZnSO₄/ha + 3 kg borax/ha; T₉, RDF + 30 kg ZnSO₄/ha + 6 kg borax/ha. The experiment took place on sandy clay loam soil (Typic Haplustalf). Uniform macronutrient fertilizers like nitrogen through urea, phosphorus through single super phosphate and potassium through muriate of potash were applied to all the treated plots. The zinc and boron fertilizers were added as soil application as per the treatment. The findings revealed that the maximum values of growth parameters, viz. plant height, number of leaves/plant, number of branches/plant, leaf area index, chlorophyll content and dry matter production (DMP) and quality attributes viz. ascorbic acid content, TSS (total soluble solids) and capsaicin content in fruit were recorded in the treatment of ZnSO₄ @30 kg/ha and borax @3 kg/ha (T₈) as soil application in both years. However, the control treatment (without micronutrient), the minimum growth characters, dry matter production of plants, and quality parameters in fruit samples were recorded during both the years.

Keywords: Boron, Growth, Hybrid chilli, Quality, Zinc

Among India's major spices and vegetable crops, chilli (*Capsicum annuum* Linn.) under the family Solanaceae stands out as a highly valuable crop. It has great demand in outside countries for various culinary preparations. Red chillies have particularly high content of vitamin C and pro-vitamin A. On the other hand, unripe fruit, or green fruit chillies have much less of both. Red chilli fruit contains 50 mg/100 g vitamin C, 31.6% carbohydrate, 15.9% protein and minimum quantities of vitamin A, B and E (Khan *et al.* 2022). Applying zinc and boron to chillies can make them more sensitive, particularly during the *rabi* season, when low temperatures are expected to significantly

restrict zinc availability (Sharmin 2020). Zinc is a crucial micronutrient that is a part of several enzymes that catalyse a variety of plant metabolic processes. Additionally, it is important for photosynthesis, cell membrane integrity, pollen development, plant resistance to disease, protein synthesis, and the production of chlorophyll in plant tissues. It also raises the concentration of antioxidant enzymes in plant systems (Hussain *et al.* 2015). Another important micronutrient is boron which plays a significant role in influencing cell wall development, cell wall strength, fruit enlargement, seed development, cell division, sugar transport and hormone production. Some functions of boron were interrelating with macronutrients such as nitrogen, potassium, phosphorus and calcium in plant growth. Moreover, boron is believed to have a structural role in the growth of plant cell walls and to either stimulate or inhibit particular metabolic pathways (Ahmad *et al.* 2009, Yadav *et al.* 2023a). However, since chilli is a very exhaustive crop, effective nutrition management is necessary for it to reach its genetic production potential. Inadequate micronutrient availability has an impact on crop development in addition

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to macronutrients (Kumar *et al.* 2020). For this reason, depending on higher production and soil quality, applying micronutrients in addition to major nutrients is frequently crucial. Therefore, the present research aimed to assess the effects of boron and zinc fertilisation on growth, dry matter production, and quality indices of hybrid chilli.

MATERIALS AND METHODS

The study was carried out during 2021–22 and 2022–23 at Sivapuri, Chidambaram taluk, Cuddalore district of Tamil Nadu. The chilli hybrid ‘Mahyco Sierra’ is used as a test crop. The experiment was conducted in sandy clay loam textured (Typic Haplustalf) soil. The initial soil has pH of 6.10 and electrical conductivity (EC) of 0.38 dS/m. The boron and zinc were deficient in experimental soil and also has low status in available nitrogen (220 kg/ha), and medium status in available phosphorus (15 kg/ha) and potassium (136 kg/ha). The nine treatments were replicated thrice in a randomized block design (RBD). The treatments comprise T₁, Control [100% recommended dose of fertilizer (RDF) i.e. 30:60:30 kg N, P₂O₅ and K₂O/ha alone]; T₂, RDF + 15 kg ZnSO₄/ha; T₃, RDF + 30 kg ZnSO₄/ha; T₄, RDF + 3 kg borax/ha; T₅, RDF + 6 kg borax/ha; T₆, RDF + 15 kg ZnSO₄/ha + 3 kg borax/ha; T₇, RDF + 15 kg ZnSO₄/ha + 6 kg borax/ha; T₈, RDF + 30 kg ZnSO₄/ha + 3 kg borax/ha; T₉, RDF + 30 kg ZnSO₄/ha + 6 kg borax/ha. As per the treatment schedule, zinc and boron were applied as soil application. The growth attributes like plant height, number of leaves/plant, number of branches/plant, leaf area index, chlorophyll content and dry matter production were recorded at harvest stage. The quality attributes like ascorbic acid content, TSS (total soluble solids) and capsaicin content were analysed in fruit samples after harvest. The collected data were statistically analysed at a 5% probability level (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Growth parameters: At harvest, the plant height, number of leaves/plant, number of branches/plant, leaf area index

and chlorophyll content of hybrid chilli were significantly responded by application of zinc and boron fertilization in both years (Table 1 and 2). Among the treatments, the supply of a recommended dosage of NPK fertilizer along with ZnSO₄ at 30 kg/ha and borax at 3 kg/ha (T₈) as soil application registered the highest plant height (116.3 and 117.4 cm), number of leaves/plant (119.8 and 123.4), number of branches/plant (18.5 and 18.9), leaf area index (1.96 and 1.98) and chlorophyll content (67.6 and 69.3 SPAD readings) during 2021–22 and 2022–23 respectively. This was followed by combination of ZnSO₄ @30 kg/ha and borax @6 kg/ha along with NPK fertilizers. The lowest plant height (77.6 and 77.4 cm), number of leaves/plant (78.3 and 78.5), number of branches/plant (9.9 and 9.6), leaf area index (1.34 and 1.33) and chlorophyll content (45.8 and 46.3 SPAD readings) during 2021–22 and 2022–23, respectively were registered in control treatment (100% recommended dosage of NPK alone).

With a combination of boron and zinc, the growth characteristics of chilli were statistically increased with the supply of the primary nutrients which was earlier reported by Deore *et al.* (2010) and Harris *et al.* (2018). Mineral nutrition had a good effect on the growth attributes of hybrid chilli, because zinc and boron are physiologically significant, they are required for enhancing the growth and yield of vegetable crops because they are essential for the metabolism of nitrogen and phosphorus, flowering, and fertilisation of chillies (Salim *et al.* 2019, Yadav *et al.* 2023b). The solubility and consequent distribution of nutrients may have contributed to the increases in chilli plant height caused by water soluble fertilisers, such as potassium, phosphorus, and nitrogen. Harris and Mathuma (2015) also observed that the application of boron caused an increase in plant height.

Nitrogen is a crucial component of chlorophyll and aids in the production of proteins. It may also contribute to increased plant height and leaf count per plant when enough nitrogen is supplied. Similar findings were repeated by Khan *et al.* (2014). It is possible that applying micronutrients to

Table 1 Effect of zinc and boron on plant height, number of branches/plant and number of leaves/plant of hybrid chilli

Treatment	Plant height (cm)		Number of branches/plant		Number of leaves/plant	
	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23
T ₁	77.6	77.4	9.9	9.6	78.3	78.5
T ₂	86.9	87.7	11.9	12.0	87.6	88.7
T ₃	81.8	82.5	11.1	11.2	82.9	84.4
T ₄	95.8	96.3	14.2	14.6	97.7	99.5
T ₅	90.3	91.4	13.2	13.4	93.1	95.6
T ₆	104.2	105.9	16.5	16.8	107.9	110.3
T ₇	99.8	100.3	15.5	15.9	103.2	105.7
T ₈	116.3	117.4	18.5	18.9	119.8	123.4
T ₉	110.0	112.1	17.3	17.6	113.4	115.2
SEm	1.32	1.33	0.22	0.23	1.41	1.44
CD (<i>P</i> =0.05)	3.91	3.97	0.59	0.61	3.92	4.12

Treatment details are given under Materials and Methods.

the soil enhanced their absorption and transport, which aided in accelerating cellular activity or promoting chlorophyll synthesis. It may have improved the quality of the chilli as a result of increasing photosynthesis. The enhanced availability of nutrients and the consequent rise in cellular activity could be attributed to the observed improvement (Yadav *et al.* 2023a).

Other crucial macro elements for the proper growth and development of plants are phosphorus and potassium. The effect of phosphorus on the formation and translocation of carbohydrates, root development, growth, number of leaves/plant and dry matter production are well recognized. Potassium is essential for the activation of hybrid chilli growth features (Islam *et al.* 2018). The solubility and staggered release of nutrients from fertilisers may have enhanced the availability of applied nutrients in the root zone, which could be the cause of the increased development of chilli leaves (Krishnamoorthi and Noorjehan 2014). The combination of boron and zinc was shown to be much more successful in raising the number of branches than applying each nutrient alone, which likely contributed to the growth-attributing characteristics (Panova *et al.* 2023).

The study revealed that chilli can respond well to optimal quantities of zinc and boron treatment, which is adequate to optimise the plant's growth features. In second season, the residual effect of fertilizer nutrient may be responsible for higher growth of hybrid chilli (Shil *et al.* 2013, Tyagi *et al.* 2024). Moreover, the availability of micronutrients in soils might be influenced by various factors, including soil pH, microbial activity, cation exchange capacity and clay concentrations in soil (Pandev *et al.* 2016).

From the Table 2 and Fig.1, it is clear that the supply of boron and zinc fertilizers and their combinations with macronutrients fertilizers had a significant influence on dry matter production of hybrid chilli. Significantly maximum dry matter production of 3996 and 4032 kg/ha during 2021–2022 and 2022–2023, respectively were observed in treatment supplied with of 30 kg ZnSO₄/ha + 3 kg borax/

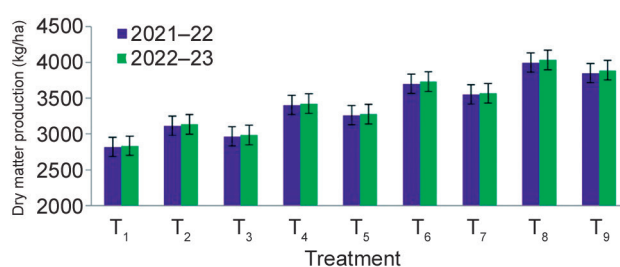


Fig. 1 Effect of zinc and boron on dry matter production of hybrid chilli.

Treatment details are given under Materials and Methods.

ha combined with a recommended dose of fertilizers. Treatment (T₈) was followed by T₉ (RDF + combination of 30 kg ZnSO₄/ha + 6 kg Borax/ha) which received 3848 and 3889 kg/ha dry matter during 2021–22 and 2022–23, respectively. The treatments next in order were T₆, T₇, T₄, T₅, T₂, and T₃. The lowest dry matter production of 2821 and 2835 kg/ha were recorded in control treatment (T₁) which received NPK fertilizers alone. The application of zinc and boron sources resulted in an increase in the dry matter content, as revealed by the observations. Better growth, increased translocation of photosynthates towards the sink, and enhanced dry matter production resulted from the addition of zinc, leading to a larger accumulation of dry matter in plants (Tyagi *et al.* 2024). Zinc application plays a significant part in protein metabolism, starch production, sucrose and photosynthesis (Masud *et al.* 2009, Rudani *et al.* 2018). Enhancing leaf production and leading to higher dry matter production, boron is considered an essential element for actively growing parts of plants such as new leaf, bud and root tips development (Ahmad *et al.* 2009). Furthermore, boron is especially needed in meristematic cells development than in mature tissues. The findings of Salam *et al.* (2010) revealed that the application of NPK, combined with zinc sulphate and borax as per recommendation, favourably influenced dry matter production (Yadav *et al.* 2023a).

Quality parameters: The quality attributes of hybrid chilli were significantly enhanced by the addition of boron

Table 2 Effect of zinc and boron on leaf area index, chlorophyll content (SPAD readings) and dry matter production of hybrid chilli

Treatment	Leaf area index		Chlorophyll content (SPAD reading)		Dry matter production (kg/ha)	
	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23
T ₁	1.34	1.33	45.8	46.3	2821	2835
T ₂	1.51	1.54	52.7	54.1	3114	3135
T ₃	1.42	1.45	49.5	50.8	2968	2988
T ₄	1.64	1.65	57.3	58.0	3407	3423
T ₅	1.57	1.59	53.6	54.6	3261	3278
T ₆	1.79	1.81	61.6	63.1	3700	3733
T ₇	1.71	1.73	59.7	60.1	3553	3567
T ₈	1.96	1.98	67.6	69.3	3996	4032
T ₉	1.87	1.89	64.2	66.4	3848	3889
SEm	0.02	0.02	0.76	0.94	47.1	47.8
CD (<i>P</i> =0.05)	0.07	0.08	2.37	2.85	139.1	141.5

Treatment details are given under Materials and Methods.

Table 3 Effect of zinc and boron on quality attributes and economics of hybrid chilli

Treatment	Ascorbic acid content (mg/100 g)		TSS (%)		Capsaicin content (%)	
	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23
T ₁	68.7	69.4	11.1	11.2	0.47	0.48
T ₂	80.3	82.5	12.4	12.4	0.55	0.57
T ₃	74.8	76.2	11.8	11.8	0.52	0.55
T ₄	91.3	93.7	13.6	13.6	0.62	0.65
T ₅	86.2	87.4	12.9	13.0	0.58	0.61
T ₆	103.5	105.2	14.8	14.8	0.69	0.70
T ₇	98.2	100.1	14.2	14.2	0.65	0.65
T ₈	115.3	116.5	16.0	16.1	0.78	0.79
T ₉	109.1	111.2	15.3	15.4	0.72	0.74
SEm	0.81	0.95	0.22	0.23	0.01	0.01
CD (<i>P</i> =0.05)	2.22	2.58	0.56	0.57	0.02	0.02

Treatment details are given under Materials and Methods.

and zinc fertilizers, in combination with NPK fertilizers (Table 3). Among the different combinations of zinc and boron, the highest ascorbic acid content (115.3 and 116.5 mg/100 g), total soluble solids (16.0 and 16.1%) and capsaicin content (0.78 and 0.79%) of fruits were observed in supply of 30 kg ZnSO₄/ha + 3 kg borax/ha (T₈) during 2021–22 and 2022–23, respectively. This was followed by the supply of 30 kg ZnSO₄/ha and 6 kg borax/ha along with recommended application of NPK fertilizers. The minimum ascorbic acid content (68.7 and 69.4 mg/100 g), TSS (11.12 and 11.15%) and capsaicin content (0.47 and 0.48%) of fruits were recorded with the supplementation of a recommended dosage of NPK fertilizer alone (control) during 2021–22 and 2022–23, respectively. These increases might result from the maximum release of boron and zinc in soil which actively participates in plant metabolic processes such as photosynthesis process, respiration, chlorophyll formation, nitrogen fixation and enzyme activity. Finally, it increases quality attributes like ascorbic acid content (Malik *et al.* 2020). The increases in ascorbic acid content by supply of NPK along with micronutrients *viz.*, zinc and boron might be due to enhanced metabolic activity and photosynthetic activity (Sidhu *et al.* 2019), which resulted in a synthesis of glucose. Glucose, thus produced might have contributed to the synthesis of ascorbic acid (Ahmed *et al.* 2021).

The findings are in line with Jatav *et al.* (2020) and Khan *et al.* (2022) who reported that there is a conversion of sugar into ascorbic acid. The alkaloid capsaicin is important component for the pungency of chilli (Gokul *et al.* 2021), which is a digestive stimulant. These findings were earlier reported by Malik *et al.* (2020). Particularly in chilli, micronutrients are increasingly significant, not only for enhancing productivity but also for improving quality attributes. The similar reports were observed by Ahmed *et al.* (2024). The slow but steady supply of all major and micronutrients from applied fertilizers may have contributed

to the digestion of carbohydrates and subsequent ascorbic acid synthesis, which may have explained the increase in ascorbic acid (Khan *et al.* 2022). The enhanced application of nutrients from various micronutrient sources, which raises nutrient efficiency, may have contributed to improvement of fruit quality.

The benefit-cost ratio was worked out under the field experiment for different treatment combinations, which revealed that combined application of zinc sulphate @30 kg/ha + borax @3 kg/ha (T₈) along with recommended dose of fertilizers registered the maximum B:C ratio of 2.60–2.64 during 2021–22 and 2022–23, respectively (Fig. 2).

Based on two year findings, it can be concluded that supply of 30 kg ZnSO₄/ha and 3 kg borax/ha combined with recommended dosage of NPK fertilizers was the one that promoted better growth and fruit quality of hybrid chilli. Due to their superior nutritional support and ability to guarantee an increased harvest, micronutrients are steadily gaining popularity among vegetable crops. The results confirmed that the growth and quality improvement in hybrid chilli, the farmers can adopt with application of NPK along with 30 kg ZnSO₄/ha and 3 kg borax/ha.

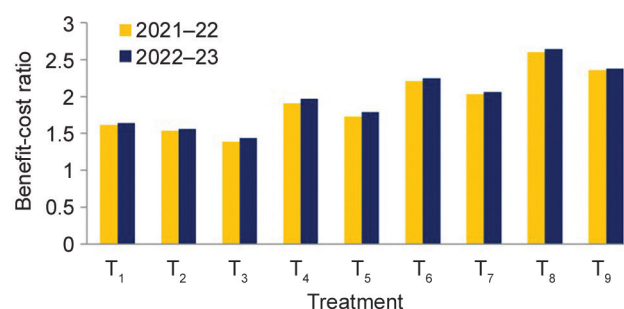


Fig. 2 Effect of zinc and boron on benefit-cost ratio of hybrid chilli.

Treatment details are given under Materials and Methods.

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