International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 1889-1897, 2023; Article no.IJECC.104417
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Response of Different Level of Zinc and Boron on Growth, Flowering, Yield and Quality of Cherry Tomato (*Solanum lycopersicum* var. cerasiforme) cv. 'Pusa Cherry-1'

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102845

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/104417

Original Research Article

Received: 09/06/2023
Accepted: 13/08/2023
Published: 01/09/2023

ABSTRACT

This study investigates the effect of Zinc and Boron on the growth, yield, and quality of Cherry tomatoes. [*Solanum lycopersicum var. cerasiforme* (Alef.) Fosberg] cv. 'Pusa Cherry-1' in Prayagraj, India.The purpose of the study is to evaluate the plants in terms of various parameters such as plant height, number of branches, plant spread, days to first flowering, days to 50% flowering, days to fruit setting, days to fruit picking, number of flowers per cluster, number of fruit set per cluster, number of fruits per plant, fruit weight, total soluble solids (TSS), ascorbic acid, acidity and benefit-cost ratio.

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The nine treatments applied in the study include control, Zinc at different concentrations (50 ppm and 100 ppm), and Boron at different concentrations (50 ppm and 100 ppm). The results of the study indicate that the application of Zinc and Boron significantly improved the growth and yield of Cherry tomatoes. The highest fruit yield, fruit weight, TSS, and ascorbic acid content were observed in the plants treated with Zinc at a concentration of 100ppm added Boron at a concentration of 100ppm. The benefit-cost ratio was also found to be higher in the treated plants compared to the control. Overall, the study suggests that the application of Zinc and Boron can be an effective and sustainable method for enhancing the growth, yield, and quality of Cherry Tomatoes.

Keywords: Cherry tomato; Pusa Cherry-1'; zinc; boron; Prayagraj.

1. INTRODUCTION

Cherry tomato [*Solanum lycopersicum* L. *var. cerasiforme* (Alef.) Fosberg] are small, bite-sized tomatoes that have gained immense popularity in recent years. With their vibrant color, distinct flavor, and versatility in culinary applications, cherry tomatoes have become a staple in households and restaurants worldwide [1-4]. Exploring the nutritional composition, health benefits, and diverse culinary uses of cherry tomatoes not only enhances our understanding of this remarkable fruit but also sheds light on its potential contributions to nutrition and gastronomy. Cherry tomatoes possess a unique nutritional profile that contributes to their status as a healthy and flavorful food option [5]. They are a rich source of macronutrients, including carbohydrates, proteins, and dietary fiber. According to a study by [Eitenmiller and Landen Jr. (2019),] cherry tomatoes contain an average of 3 grams of fiber per 100 grams, which contributes to digestive health and aids in weight management. Furthermore, cherry tomatoes are packed with essential vitamins and minerals [6-9]. They are particularly abundant in vitamin C, an antioxidant known for its immune-boosting properties. A literature review by Combs (2017) highlights the importance of vitamin C in collagen synthesis, iron absorption, and overall immune function. Cherry tomatoes are also a significant source of vitamin A, potassium, and folate, which are vital for various physiological processes [10-12]. The consumption of cherry tomatoes has been associated with numerous health benefits, thanks to their nutritional composition and bioactive compounds [13-15]. The antioxidants present in cherry tomatoes, such as lycopene and beta-carotene, contribute to their potential in reducing oxidative stress and inflammation in the body [16]. A systematic review by Singh et al. [17] suggests that regular intake of lycopene-rich foods, including cherry tomatoes, may have protective effects against cardiovascular diseases by improving lipid profiles and reducing oxidative damage to blood vessels. Moreover, a study by Story et al. [18] indicates that the consumption of tomatoes, particularly those high in lycopene, may reduce the risk of certain types of cancers, including prostate, lung, and stomach cancers. Cherry tomatoes are incredibly versatile in the culinary world, offering a burst of flavor, color, and texture to a wide range of dishes. They are commonly used in salads and appetizers, where their vibrant hues and tangy-sweet flavor add freshness and visual appeal. A study by Aschoff et al. [19] explores the sensory attributes of cherry tomatoes and their role in enhancing the overall eating experience in salads. The study found that the unique combination of acidity, sweetness, and juiciness of cherry tomatoes positively influenced the perception of salad quality [20-24]. Zinc and boron are essential micronutrients that play a crucial role in the growth and development of plants [11]. They are required in small quantities but have a significant impact on various physiological processes. In the case of cherry tomatoes *(Solanum lycopersicum* var. cerasiforme c.v Pusa Cherry-1), the role of zinc and boron in influencing growth, flowering, yield, and fruit quality is of great importance. Understanding their effects on these parameters can help optimize cultivation practices and improve crop management strategies.

2. MATERIALS AND METHODS

The details pertaining to the materials used and the methods adopted in the investigation entitled "Response of different level of Zinc and Boron on Growth, Flowering, Yield and Quality of Cherry tomato (*Solanum lycopersicon*) cv. Pusa Cherry-1)" during January 2023 to March 2023 at the Horticultural Research Field, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, India. Prayagraj falls in central plain sub-zone of

Table 1. Details of treatment combination used

S. No.	Notation	Solution
1.	T0	CONTROL
2.	T1	Boron @ 50 ppm
3.	T2	Boron @ 50 ppm + Zinc @ 50 ppm
4.	T3	Boron @ 50 ppm + Zinc @ 100 ppm
5.	T4	Boron @ 100 ppm
6.	T5	Zinc @ 50 ppm
7.	T6	Zinc @ 50 ppm+ Boron @ 100 ppm
8.	T7	Zinc @ 100 ppm + Boron @ 100 ppm
9.	T8	Zinc @ 100 ppm

Agro-climatic zone V (Source: Perspective and Strategic Plan (PSP) for IWMP of Uttar Pradesh, Department of Land Development and Water Resources, Government of U.P.). The area is situated on the South of Prayagraj on the right bank of Yamuna at Rewa road at a distance of about 6 km from Prayagraj city. It is situated between the parallels of 20° 33' 40'' to 21° 50' North latitude and 73° 27' 58'' to 73° 56' 36'' East longitude and at an altitude of 98 meters above mean sea level (MASL).

The area of Prayagraj district comes under sub-tropical climate prevailing in the South-East part of U.P with both the extremes in temperature, i.e the winter and the summer. In cold winters, the temperature sometimes is as low as 4°C -5°C in the months of December- January and very hot summer with temperature reaching up to 46°C-48°C in the month of May and June. The relative humidity ranges between 20 to 94 per cent. During winter, frost and during summer, hot scorching winds are also not uncommon. The average rainfall is around 1014.4 mm. Most of the precipitation is received through south -west advancing monsoon with maximum concentration during July to September months with occasional showers in winter.

Observations were recorded at different stages of growth periods and studied for growth parameters like plant height, primary branches and plant spread, earliness parameters like days to first flowering, days to 50% flowering, days to fruit setting and days to first fruit picking, yield parameters like number of cluster per plant, number of flowers per cluster, number of fruit set per cluster, number of fruits per plant, fruit weight(gm), fruit yield per plant(kg), fruit yield per hectare(ton/ha) and quality parameters total soluble solid, ascorbic acid content and acidity content. The data were statistically analysed by the method suggested by [25]. The details of treatment combination used is given in Table 1. The height of five randomly selected plants from each plot was measured in cm with of a 100 cm meter scale from ground level to tip of the shoot. The numbers of primary branches per plant of five randomly selected plants arising from main shoot were counted and were averaged to represent numbers of primary branches per plant. The numbers of days taken from the date of sowing to the date at which first flower appeared in plants or date at which plants start flowering in whole plot were recorded as days to first flowering, similarly, was taken for days to first flowering and days to 50% flowering. The percentage of total soluble solids of the fruit was determined with the help of Portable Hand Refractometer. The sample of juice for this purpose was taken from the strained juice. The observed value of T.S.S. was recorded from the scale of the instrument (0-32 range). Vitamin C content or Ascorbic acid content in the pulp was estimated by using 2, 6 dichlorophenol indophenol dye as reported by Ranganna [26].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters (Table 2)

3.1.1 Plant height (cm)

The height of plant significantly varied among different treatment combinations. The maximum plant height (162.53cm) was observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T3 {Boron @ 50 ppm + Zinc @ 100 ppm} with 145.22 cm. Minimum plant height (86.46 cm) was observed in T0 (Control), while the remaining treatments are moderate in their growth habit.

Zinc and boron are essential micronutrients involved in hormone synthesis and regulation in plants. These hormones, such as auxins and gibberellins, play a crucial role in promoting cell division and elongation, which directly influence

Table 2. Growth and earliness parameters of cherry tomato under Prayagraj agro-climatic conditions

Treatment details	Plant height (cm)	Number of primary branches per plant	Plant spread (cm2)	Days to first flowering	Days to 50% flowering	Days to fruit setting	Days to first fruit picking
CONTROL(T0)	86.46	8.4	323.90	30.00	41.00	58.60	62.33
Boron @ 50 ppm(T1)	94.65	10.66	353.75	34.33	42.00	47.13	63.26
Boron @ 50 ppm + Zinc @ 50 ppm(T2)	113.72	12.06	548.02	42.33	45.00	53.73	66.37
Boron @ 50 ppm + Zinc @ 100 ppm(T3)	145.22	10.53	485.68	38.33	48.67	56.96	69.60
Boron @ 100 ppm(T4)	151.76	7.66	479.26	33.67	46.67	55.34	67.98
Zinc @ 50 ppm(T5)	138.14	11	460.07	39.33	42.67	51.42	64.06
Zinc @ 50 ppm+ Boron @ 100 ppm(T6)	113.84	9.6	378.63	35.33	49.67	46.02	59.77
Zinc @ 100 ppm + Boron @ 100 ppm(T7)	162.53	12.33	612.977	41.00	37.67	50.62	58.75
Zinc @ 100 ppm(T8)	120.82	10.86	332.87	31.00	38.67	49.69	71.37
F- Test	S	S	S	S	S	S	S
S.E.(m)	6.53	0.21	21.20	0.383	0.226	0.22	0.038
C.D. (5%)	19.77	0.66	64.12	1.158	0.682	0.12	0.116
C.V.	9.04	3.65	8.31	1.835	0.966	0.96	0.127

plant height. By ensuring an adequate supply of zinc and boron, the synthesis and proper functioning of these hormones are supported, leading to increased plant height. Similar findings were reported by Brown et al. [27].

3.1.2 Number of primary branches per plant

The number of primary branches of plant significantly varied among different treatment combinations. The maximum number primary branches (12.33) were observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T2 {Boron @ 50 ppm + Zinc @ 50 ppm} with 12.06. Minimum number of primary branches (8.4) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat.

Zinc and boron are required for the activation of certain enzymes involved in various metabolic processes in plants. These enzymes are essential for cellular processes such as protein synthesis and carbohydrate metabolism, which are crucial for the development and growth of primary branches. Similar findings were reported by Marschner, [28].

3.1.3 Plant spread (cm2)

Plant spread significantly varied among different treatment combinations. The maximum plant spread (612.97 cm^2) were observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T2 {Boron @ 50 ppm + Zinc @ 50 ppm} with 548.02 cm^2. Minimum plant spread (323.90 cm^2) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat. Similar findings were reported by Marschner, H. [28].

3.2 Earliness Parameter (Table 2)

3.2.1 Days to first flowering

Days to 1^{st} Flowering of plant significantly varied among different treatment combinations from 30.00 to 42.33 days. The maximum days to 1^{st} flowering (42.33) were observed with T2 {Zinc @ 50 ppm + Boron @ 50 ppm} followed by T7 {Boron @ 100 ppm + Zinc @ 100 ppm} with 41.00. Minimum days to 1^{st} flowering (30.00) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat. Similar findings were reported by Marschner, [28].

3.2.2 Days to 50% flowering

Days to 50% flowering of plant significantly varied among different treatment combinations from 37.67 to 49.67 days. The maximum days to 50% flowering (49.67) was observed in T6 treatment {Zinc @ 50 ppm+ Boron @ 100 ppm} followed by T3 {Boron @ 50 ppm + Zinc @ 100 ppm} with 48.67days. Minimum days to 50% flowering (37.67) was observed in T7 {Zinc @ 100 ppm + Boron @ 100 ppm}, while the remaining treatments are moderate in their growth habitat.

3.2.3 Days to fruit setting

Days to fruit setting of plant significantly varied among different treatment combinations from 37.67 to 49.67 days. The maximum days to fruit setting (59.96) were observed with T3 {Boron @ 50 ppm + Zinc @ 100 ppm} followed by T0 {Control} with 58.60. Minimum days to fruit setting (46.02) was observed in T6 (Zinc @ 50 ppm+ Boron @ 100 ppm) while the remaining treatments are moderate in their growth habitat.

3.2.4 Days to first fruit picking

Days to fruit picking of plant significantly varied among different treatment combinations from 58.60 to 46.02 days. The maximum days to fruit setting (71.37) was observed with T8 {Zinc @ 100 ppm} followed by T3 {Boron @ 50 ppm + Zinc @ 100 ppm} with 69.60days. Minimum days to fruit setting (58.75) was observed in T7 (Zinc @ 100 ppm + Boron @ 100 ppm) while the remaining treatments are moderate in their growth habitat.

3.3 Yield Parameter (Table 3)

3.3.1 Number of flowers per cluster

Number of flowers per cluster of plant significantly varied among different treatment combinations. The maximum number of flowers per cluster (9.27) was observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T2 {Boron @ 50 ppm +Zinc @ 50 ppm} with 9.20. Minimum number of flowers per cluster (7.13) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat.

Zinc and boron can influence the pollination process and fruit set in cherry tomatoes. Zinc is involved in pollen production and viability, while boron plays a role in pollen germination and pollen tube growth. Adequate levels of zinc and boron can enhance pollination efficiency and promote successful fertilization, resulting in improved flowers and fruit set and subsequently

Table 3. Yield parameters of cherry tomato under Prayagraj agro-climatic conditions

Treatment details	Number of flowers per cluster	Number of flower- clusters per plant	Fruit set per cluster	Weight of fruits (g)	Number of fruit per plant	Fruit yield per plant (Kg)	Fruit yield per hectare (t/ha)
CONTROL(T0)	7.13	6.53	5.52	27.92	39.60	1.73	10.45
Boron @ 50 ppm(T1)	7.73	6.93	5.68	38.72	48.53	2.02	16.55
Boron @ 50 ppm + Zinc @ 50 ppm(T2)	9.20	7.20	6.22	48.65	51.80	2.87	22.13
Boron @ 50 ppm + Zinc @ 100 ppm(T3)	8.47	6.13	5.95	23.87	51.13	1.87	21.33
Boron @ 100 ppm(T4)	9.00	6.93	6.06	41.88	45.20	2.71	12.76
Zinc @ 50 ppm(T5)	7.40	6.47	5.57	30.77	44.53	2.40	11.49
Zinc @ 50 ppm+ Boron @ 100 ppm(T6)	7.67	7.20	6.14	46.82	50.07	2.36	21.23
Zinc @ 100 ppm + Boron @ 100 ppm(T7)	9.27	7.20	6.33	52.37	53.60	2.90	23.00
Zinc @ 100 ppm(T8)	8.07	6.73	5.94	35.28	46.27	2.69	16.69
F- Test	S	S	S	S	S	S	S
S.E.(m)	0.07	0.25	2.263	0.01	2.02	0.04	0.91
C.D. (5%)	0.21	0.62	6.84	0.03	6.11	0.01	2.76
C.V.	1.48	7.32	4.52	0.04	7.32	0.31	9.09

more clusters per plant. Similar findings were reported by Broadley, et al. [29].

3.3.2 Number of fruit set per cluster

Number of fruit set per cluster of plant significantly varied among different treatment combinations. The maximum number of fruit set per cluster (6.33) was observed with T7{Zinc @ 100 ppm + Boron @ 100 ppm} followed by T2 {Boron @ 50 ppm +Zinc @ 50 ppm} with 6.22. Minimum number of fruit set per cluster (5.52) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat.

3.3.3 Fruit weight (g)

Fruit weight significantly varied among different treatment combinations. The maximum fruit weight (52.37g) was observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T2 {Boron @ 50 ppm +Zinc @ 50 ppm} with 48.65g. Minimum fruit weight (27.92g) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat.

3.3.4 Number of fruits per plant

Number of fruits per plant of plant significantly varied among different treatment combinations. The maximum number of fruits per plant (53.60) was observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T2 {Boron @ 50 ppm +Zinc @ 50 ppm} with 51.80. Minimum number of fruits per plant (39.60) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat.

Zinc and boron are involved in hormonal regulation within plants. They can influence the synthesis, transport, and activity of plant hormones such as auxins and cytokinins. Hormones play crucial roles in flower and fruit development, including the initiation, growth, and retention of fruits. By regulating hormonal balance, zinc and boron application can promote the formation and development of a greater number of fruits per plant.

3.3.5 Fruit yield per plant (kg)

Fruit yield per plant significantly varied among different treatment combinations. The maximum fruit yield (2.90 kg) was observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T2 {Boron @ 50 ppm +Zinc @ 50 ppm} with 2.87 kg. Minimum fruit yield per plant (1.73 kg) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat.

3.3.6 Fruit yield per hectare (tonnes/ha)

Fruit yield per hectare significantly varied among different treatment combinations. The maximum fruit yield per hectare (23.00 ton/ha) was observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T2 {Boron @ 50 ppm +Zinc @ 50 ppm} with 22.13 ton/ha. Minimum fruit yield per hectare (10.45 ton/ha) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat.

3.4 Quality Parameter (Table 4)

3.4.1 Total soluble solid (°Brix)

Total soluble solids significantly varied among different treatment combinations. The maximum total soluble solids (6.23^{0}Brix) was observed with T7 {Zinc @ 100 ppm + Boron @ 100 ppm} followed by T3 {Boron @ 50 ppm + Zinc @ 100 ppm} with 5.13^{0}Brix. Minimum total soluble solids TSS (2.83 ^{0}Brix) was observed in T4 (Boron @ 100 ppm), while the remaining treatments are moderate in their growth habitat.

3.4.2 Ascorbic acid content (mg/100g)

Ascorbic acid significantly varied among different treatment combinations. The maximum ascorbic acid (13.08 mg/100g) was observed with T8 {Zinc @ 100 ppm} followed by T3 {Boron @ 50 ppm + Zinc @ 100 ppm} with 12.89 mg/100g. Minimum ascorbic acid (9.64 mg/100g) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat.

3.4.3 Acidity content (%)

Acidity significantly varied among different treatment combinations. The maximum acidity (1.82%) was observed with T0 {Control} followed by T4 {Boron @ 100 ppm} with 1.51. Minimum acidity (0.42%) was observed in T7 (Zinc @ 100 ppm + Boron @ 100 ppm), while the remaining treatments are moderate in their growth habitat.

Table 4. Quality parameters of cherry tomato under Prayagraj agro-climatic conditions

Treatment details	Total soluble solid (^{0}Brix)	Ascorbic acid (mg/100g)	Acidity %
CONTROL(T0)	3.83	9.64	1.82
Boron @ 50 ppm(T1)	4.73	11.09	1.02
Boron @ 50 ppm + Zinc @ 50 ppm(T2)	3.69	11.00	0.53
Boron @ 50 ppm + Zinc @ 100 ppm(T3)	5.13	12.89	0.90
Boron @ 100 ppm(T4)	2.83	11.89	1.51
Zinc @ 50 ppm(T5)	3.81	10.17	1.30
Zinc @ 50 ppm+ Boron @ 100 ppm(T6)	4.31	11.70	0.91
Zinc @ 100 ppm + Boron @ 100 ppm(T7)	6.23	10.69	0.42
Zinc @ 100 ppm(T8)	4.15	13.08	1.33
F- Test	S	S	S
S.E.(m)	0.003	0.004	0.002
C.D. (5%)	0.008	0.013	0.001
C.V.	0.086	0.062	0.077

4. CONCLUSION

From the above experimental finding, it may be concluded that the treatment T7 {Zinc @ 100 ppm + Boron @ 100 ppm} was found to be best in terms of growth, yield and quality. Highest net return and benefit-cost ratio was found in the same T7 {Zinc @ 100 ppm + Boron @ 100 ppm}.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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