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EFFECT OF BORON AND ZINC ON GROWTH, YIELD AND QUALITY OF TOMATO (*SOLANUM LYCOPERSICUM* L.) CV. 'ABHILASH'

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ABSTRACT

The experiment was carried out on tomato cv. 'Abhilash' at Agricultural Research Farm, Department of Horticulture, Suresh Gyan Vihar University, Jagatpura, Jaipur (Rajasthan) during *kharif* season on 8th July, 2023. The experiment was laid out in Factorial Randomized Block Design with three replications which comprises of sixteen treatment combinations included four different levels of Boron (0, 0.1, 0.2 and 0.3%) and four levels of Zinc (0, 0.1, 0.2 and 0.3%). The interaction effect of Boron @ 0.2 % + Zinc @ 0.2 % significantly influenced majority of vegetative characters, yield attributes and biochemical parameters. The highest plant height (39.17 cm), (72.11 cm) and (98.99 cm) at 45, 60 and 75 DAT, respectively, (162.30) leaves per plant, minimum (24.52 days) took to 50% flowering, maximum (10.17) flower clusters per plant, (5.41) fruits per cluster, (54.97) fruits per plant, (4.40 cm) fruit length, (5.54 cm) fruit diameter, (131.82 cm^3) fruit volume and (126.40 g) heaviest fruit weight, maximum (3.83 kg/plant) and (134.10 t/ha) fruit yield and highest (4.88) B: C ratio was recorded at Boron @ 0.2% + Zinc @ 0.2%. The maximum (5.58%) TSS, (19.64 mg/100g) ascorbic acid, (17.21 days) shelf-life and minimum (0.31%) acidity were recorded in foliar application of Boron @ 0.2% + Zinc @ 0.2% at 30 days after transplanting.

Key words : Tomato, Zinc and Boron.

Introduction

Tomato (*Solanum lycopersicum* L.) belongs to family solanaceae having chromosome number 2n=24. It is self-pollinated crop and one of the most popular and nutritious vegetable crop. It is grown worldwide because of its wider adaptability and high yielding potential. It is a tropical day neutral plant and ranked second position next to potato. The crop is native to Central and South America (Vavilov, 1951). It was first domesticated in Mexico and introduced by Portuguese in 1554. It is very popular among small and marginal farmers and good source of income and abundant source of nutrition of the consumer (Singh *et al.*, 2010).

The major tomato growing countries are China, India, USA, Turkey, Egypt and Italy. The world tomato production reached to nearly 186.82 million tonnes from total area of 5 million hectare with an average productivity of 36.97 t/ha in the world (FAO, 2022). The major Tomato producing States in India are Andhra Pradesh, Madhya Pradesh, Karnataka, Gujarat, Odisha, West Bengal, Maharashtra, Chhattisgarh, Bihar, Telangana, Uttar Pradesh, Haryana and Tamil Nadu. India is producing 20.33 million tonnes from 0.84 million ha area (NHB, 2022).

Tomato is considered as an important source of Vitamin A, C and minerals which are important ingredients for table purpose, chutney, pickles, ketchup, soup, juice, puree etc. (Sekhar *et al.*, 2010). The fruits are eaten either raw or cooked. It is used directly as raw vegetable in the sandwiches, juice, soup, salad, etc. (Joshi and Kohli, 2006). Fresh fruit of tomato are in great demand round the year throughout the country. These are the good source of potassium, folate and vitamin E, soluble and insoluble dietary fibers. Tomatoes are major contributors of antioxidants such as carotenoids, phenolics, ascorbic acid and small amounts of vitamin E in daily diets (Rai *et al*., 2012). Tomato is an important protective food. In terms of human diet, it is a major component of daily meals in many countries and constitutes an excellent source of health providing compounds due to balanced mixture of minerals and antioxidants including vitamin C and total carotenoids (Shankar *et al.,* 2012).

It is being realized that the productivity of crop is being affected in different areas due to deficiencies of micronutrients observed primarily due to intensive cropping and imbalanced fertilization (Bose and Tripathi, 1996). Micronutrients are vital to the growth of plants, acting as catalyst in promoting various organic reactions taking place within the plant. Tomato being a heavy feeder and exhaustive crop removes substantial number of micronutrients from soil. To maintain sustainability in its production and nutritive value, it is becoming essential to replenish the depleting reserve of the micronutrients in the soil or apply it through foliar spray to meet out the immediate need of micronutrients. Amongst the vegetables, tomato is very responsible to the application of micronutrients. The micronutrients improve the chemical composition of fruits and general condition of plants and are known to acts as catalyst in promoting organic reaction taking place in plants (Ranganathan and Perumal, 1995).

To improve the yield and quality of tomato fruits, it is necessary to pay attention to use the balanced use of nutrients through fertilizer application. Plants require mineral elements for normal growth and development. Plants requirements to essential for the normal life processes of plants and are needed in very small amounts are called micronutrients such as boron and zinc, etc. Boron plays an essential role in the development and growth of new cell in the plant meristem, improves the fruit quality and fruit set. Boron is needed by the crop plants for cell division, nucleic acid synthesis, and increase uptake of calcium and transport of carbohydrates. Boron also plays an important role in flowering and fruit formation. Boron deficiency affects the growing points of roots and youngest leaves and causes fruit cracking problem. The leaves become wrinkled and curled with light green colour. The deficiency of boron affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins. Similarly, zinc also one of the essential micronutrients in plants i.e. is necessary for plant growth and development and involved in many enzymatic activities and responsible for IAA formation in plants. Zinc increases flower numbers and improve fruit set (Sainju *et al.,* 2003).

Hence, to obtain a good quality produce and increase production, there is a need to cultivate tomato with proper supply of micronutrients. Growth, development, productivity and post-harvest quality parameters of tomato crop largely depend on the interaction between boron and zinc. Basically, tomato is a warm season crop and lacks adaptability to varied environmental conditions. The available information is not sufficient on micronutrients particularly boron and zinc. Therefore, present investigation on boron, zinc and their interaction effect studied to generate valuable information for famers to improve their socio-economic status.

Materials and Methods

The experiment was conducted at Agricultural Research Farm in the Department of Horticulture, School of Agriculture, Suresh Gyan Vihar university, Jaipur (Rajasthan) during *kharif* season of 2023. The geographical coordinates is 26^{o}51' North latitude, 75^{o}47' East longitudes and at altitudes of 390 m above mean sea level. The climate of study place is semi-arid characterized by aridity of the atmosphere and extremity of temperature both in summer (48.5°C) and winter (-1°C) and soil was sandy-loam with 7.2 pH. The experiment was laid out in Factorial Randomized Block Design which comprises of sixteen treatment combinations that includes four different levels of boron (0, 0.1, 0.2 and 0.3%) and four levels of zinc (0, 0.1, 0.2 and 0.3%) and treatments were replicated three times. The experiment was carried on totato cv. 'Abhilash' planted on 8th July, 2023 by following 60 cm row to row and 45 cm plant to plant spacing. The crop was irrigated twice a week through drip irrigation and intercultural operations were done regularly as per the package and practices. The crop was foliar sprayed with boric acid and zinc sulphate as per specified in treatments at 30 days after transplanting. All data were recorded from five randomly selected and tagged plants throughout the investigation and their mean value calculated and statistically analyzed by OPSTAT software (Sheoral *et al.,* 1998).

Vegetative growth parameters

Plant height (cm) : The height of randomly selected five plants was measured in cm from the soil surface up to the terminal top portion of the plant with the help of a meter scale at an interval of 30, 45 and 60 days after transplanting and their mean was calculated.

Number of leaves per plant : The numbers of leaves of five randomly selected plants were counted at an interval of 60 days after transplanting and mean value was calculated as the number of leaves plant^{-1}.

Number of primary branches per plant : The numbers of primary branches arising on the main stem in five randomly selected plants in each plot and tagged plants were recorded at 60 days after transplanting. The mean number of primary branches plant^{-1} was worked out and their average was calculated.

Days to 50% flowering : The numbers of days were counted from the date of transplanting to days of 50% plants were in flowering stage in five randomly selected and tagged plants. The mean number of days was counted and average was worked out and expressed in mean value.

Number of flower clusters per plant : The total number of flower clusters per plant was counted at first picking of tomato fruits on the five randomly selected and tagged plants in each plot. These numbers of flower clusters of each plant and average were worked out and expressed in mean value.

Number of flowers per cluster : The total number of flowers per clusters was counted on the five randomly selected and tagged plants in each plot. These numbers of flowers of each cluster were counted and average was worked out and expressed in mean value.

Yield attributing parameters

Number of fruits per plant : Total numbers of fruits in five selected plants were counted at each harvest the number of fruits of every picking were sum at end and averaged and expressed in number of fruits per plant.

Fruit diameter (cm) : The one fruit from each plant of five randomly selected and tagged plants from each treatment were selected at the harvesting stage and fruit diameter was measured in centimeter by using the vernier calipers and their mean values were calculated.

Fruit weight (g) : The fruit of five randomly selected and tagged plants from each treatment were selected and fresh fruit was weighed on electric scale and reading was taken in gram and their mean was calculated.

Yield parameters

Yield per plant (kg) : Picking of fruits were made in five selected plants of each treatment. The value was averaged and expressed in yield per plant in kilogram.

Yield per hectare (t/ha) : The tomato fruit yield per plant was converted on hectare basis to reflect the yield of tomato per hectare in tonnes.

Quality parameters

Shelf Life (days) : The fruits were picked early in the morning and kept at room temperature in plastic bag to observe their shelf-life. When the fruits started wilting, number of days were recorded. The exact numbers of days were calculated by referring back to the date of picking and average calculated.

Total soluble Solid (^{0}Brix) : Randomly selected fruits samples from each plot were crushed and one drop of extracted juice was put on hand refractometer for reading of total soluble solids and was expressed in %.

Acidity (%) : Acidity content of the extracted fruit for each plot was determined by titration of 10 ml of tomato juice against 0.1 NaOH using phenolphthalein as an indicator, Acidity is expressed in terms of percentage of anhydrous citric acid per 100 ml of tomato juice by using following formula:

Acid as Anhydrous Citric acid

$$= \frac{\text{Volume of titrate} \times \text{Normality of alkali} \times \text{Equivalent weight of acid} \times \text{Volume makeup}}{\text{Vol. of sample taken for estimation} \times \text{weight of sample taken}} \times 100$$

Ascorbic acid (mg/100 g) : This analysis was performed with composite (composited over 3 replications) samples of 16 treatments. Ascorbic acid content in fruit was estimated by volumetric method. 5 ml of standard ascorbic acid (100 µ g/ml) was taken in a conical flask containing 10 ml 4% oxalic acid and was titrated against the 2, 6-dichlorophenol indophenols dye. The appearance and persistence of pink colour was taken as end point. The amount of dye consumed (V_1 ml) is equivalent to the amount of ascorbic acid. 5 ml of sample (prepared by taking 2.5g of fruit in 100 ml 4% oxalic acid) was taken in a conical flask having 10 ml of 4% oxalic acid and titrated against the dye (V_2 ml). The amount of ascorbic acid was calculated using the formula,

Ascorbic acid (mg/100g)

$= (0.5 \text{ mg}/V_1 \text{ ml}) \times (V_2 /5\text{ml}) \times (100 \text{ ml / Wt. of sample}) \times 100$

Results and Discussion

Growth parameters

The foliar application of different concentration of boron and zinc had significant impact and remarkable increase in growth and yield characteristics of tomato was noticed. The significant increase in plant height at periodical growth was observed by all treatment combinations of the exogenous application of various micronutrients. The maximum (34.19 cm), (67.12 cm) and (89.50 cm) plant height was observed under boron @ 0.2% at 45, 60 and 75 DAT, respectively (Table 1). Boron plays an important role in activation of cell division and cell elongation. Therefore, boron enhances the number of metabolites necessary for building plant organs, consequently the vegetative growth of plants increased (Marschner, 1995). The tallest (34.79 cm), (67.73 cm) and (91.53 cm) plant height were recorded under zinc @ 0.2 % at 45, 60 and 75 DAT as against the smallest (28.01 cm), (60.94 cm) and (76.32 cm) plant height recorded under control (water spray). This attribute might be due to active synthesis of tryptophane; a precursor of auxin, besides the synergistic effect of zinc which may serve as a source of energy for the synthesis of auxin, the same could be attributed as one of the factor for the growth of plant (Raghav and Singh, 2004). In case of interaction effect, the tallest (39.17 cm), (72.11 cm) and (98.99 cm) plant height was observed under boron @ 0.2% + zinc @ 0.2% treatment at 45, 60 and 75 DAT, respectively. The treatment had significant effect on plant height over control. It might be due to synergistic effect of boron and zinc on vegetative parameters. The produced auxin promotes the apical dominance that ultimately enhances the plant height. The maximum (162.30) leaves per plant were observed in plant sprayed with boron @ 0.2% + zinc @ 0.2% was observed in plants sprayed with distilled water and it showed the significant effect (Table 1).

Reproductive Structures

The maximum (9.42) flower clusters per plant were recorded in boron @ 0.2% followed by (8.90) flower clusters under boron @ 0.1% treatment and both treatments were statistically at par. In zinc treatment, maximum (9.32) flower clusters per plant were recorded under zinc @ 0.2% treatment followed by (9.04) and (8.88) under 0.3% and 0.1% zinc spray (Table 1). The maximum (5.41) fruits per cluster were observed in plants sprayed with boron @ 0.2% + zinc @ 0.2% whereas, minimum (3.67) fruits per cluster were observed in control (Table 1). This might be due to synergistic effect of boron and zinc that necessary for building plant organs. The exogenous application of boron increases cell wall plasticity and elongation of cell wall (Yugandhar *et al.*, 2014). The increased in plant height with foliar application of boron may be produced more branches due to more available photosynthate. These results are in agreement with the findings of Mallick *et al.* (2021) and Mondal and Ghosh (2023). The minimum (24.52 days) was taken for 50% flowering under boron @ 0.2% + zinc @ 0.2% treatment followed by (25.52 days) under boron @ 0.2% + zinc @ 0.1% treatment. Whereas, the maximum (37.30 days) took under water sprayed plants (Table 1). These results are in close conformity with the results of Elankavi *et al.* (2009) who also observed that the exogenous application of boric acid significantly reduces the number of days for flowering. It might be due to application of boron and zinc which increases the fruit set and advances the flowering which ultimately reduces the number of days for first harvesting (Khatri *et al.*, 2022). These results are in conformation with the findings of Mallick *et al.* (2021); Das *et al.* (2023) and Tyagi *et al.* (2024).

Fruit set is one of the most key factors in fruit crops since it impacts the amount of fruit production and the total yield. Several factors including the formation of male and female flowers, pollination, germination of pollen grains on stigmatic surfaces, pollen tube growth, and finally complete fertilization, all influence fruit set. Fruit set increased dramatically with the spraying of low concentration of micronutrient in tomato (Nawaz *et al.*, 2011). Fruit set is a critical stage in the conversion of a flower into a fruit in order to get a high yield and maximize a grower's profits (Lovatt, 1999). It is apparent from the data presented in Table 2 revealed that the maximum (5.41) fruits per cluster were observed in plants sprayed with boron @ 0.2% + zinc @ 0.2% whereas, minimum (3.67) fruits per cluster were observed in control. The maximum (5.41) fruits per cluster and (54.97) fruits per plant were recorded in boron @ 0.2% + zinc @ 0.2% (Table 2). It might be due to micronutrients application that attributed to enhanced photosynthesis activity and increased production and accumulation of carbohydrates and it favours the vegetative growth and retention of flowers. These results are in accordance with the findings of Haleema *et al.* (2018); Singh *et al.* (2019) and Das *et al.* (2023).

Fruit drop is a major issue in tomato and it can be caused by a variety of factors including changes in temperature, a lack of water during flowering or fruiting season, and nutrient deficiency. Each of these aspects causes plant hormonal disparities (Modise *et al.*, 2009). The foliar spray of micronutrients was found to be most effective in reducing premature fruit drop (Chen *et al.*, 2005). It might be due to the sufficient application and the efficient absorption of foliar sprayed boron that promote the production of more photosynthesis required for good number of tomato fruits (Wójcik and Lewandowski, 2003). Similar results were also reported by Singh *et al.* (2019); Gopal and Sarangtham (2021) and Meriño-Gergichevich *et al.* (2021).

Yield Attributing parameters

Fruit size is not just a factor in productivity, but it also

Table 1 : Effect of boron and zinc on vegetative growth parameters of tomato cv. 'Abhilash'.

Treatments	Plant height (cm)			No. of leaves/ plant	Days to 50% flowering	No. of flower clusters/ plant
	45 DAT	60 DAT	75 DAT			
Control (Water)	24.60	57.53	68.16	138.86	37.30	7.24
Boron @ 0.1 %	28.70	61.63	77.96	143.00	34.53	7.80
Boron @ 0.2 %	29.64	62.58	80.22	146.50	33.87	8.70
Boron @ 0.3 %	29.10	62.03	78.92	144.30	32.64	8.24
Zinc @ 0.1 %	28.58	61.51	77.68	147.03	33.50	8.50
Zinc @ 0.2 %	31.94	64.88	85.72	150.23	31.53	8.64
Zinc @ 0.3 %	30.59	63.53	82.49	148.96	30.74	8.54
Boron @ 0.1 % + Zinc @ 0.1 %	30.64	63.57	82.60	153.60	30.44	8.84
Boron @ 0.1 % + Zinc @ 0.2 %	33.98	66.92	90.59	158.96	29.41	9.74
Boron @ 0.1 % + Zinc @ 0.3 %	30.00	62.93	81.07	158.13	25.75	9.24
Boron @ 0.2 % + Zinc @ 0.1 %	37.11	70.04	95.73	155.30	25.52	9.03
Boron @ 0.2 % + Zinc @ 0.2 %	39.17	72.11	98.99	162.30	24.52	10.17
Boron @ 0.2 % + Zinc @ 0.3 %	30.83	63.76	83.06	160.50	27.53	9.77
Boron @ 0.3 % + Zinc @ 0.1 %	31.91	65.51	85.63	156.30	27.75	9.17
Boron @ 0.3 % + Zinc @ 0.2 %	34.08	67.01	90.82	152.86	29.10	8.75
Boron @ 0.3 % + Zinc @ 0.3 %	32.84	65.78	87.87	151.46	30.40	8.62
Boron						
C.D. (p=0.05)	**0.09**	**1.42**	**0.83**	**N.S.**	**0.52**	**0.53**
Zinc						
C.D. (p=0.05)	**0.09**	**1.42**	**0.83**	**1.51**	**0.52**	**N.S.**
Interaction (Boron x Zinc)						
C.D. (p=0.05)	**0.18**	**2.85**	**1.66**	**3.02**	**1.04**	**N.S.**

influences customer demand of tomato fruit in the market. The micronutrients (H_3BO_3 and $ZnSO_4$) resulted in a considerable increase in fruit length, breadth, weight and volume (Kaur *et al.*, 2016). The role of boron in improving fruit quality namely, fruit weight and fruit size may be due to its role in increasing cell elongation and cell division (Eman *et al.*, 2007). The longest (4.40 cm) fruit was recorded in boron @ 0.2% + zinc @ 0.2% (Table 2). The increase in fruit length and fruit diameter might be due to more accumulation of photosynthesis which were synthesized in the leaf and translocated towards the fruit. The increased and accumulation of photosynthesis was probably due to more number of leaves that manufacture more food material (Mallick *et al.*, 2021 and Mondal and Ghosh, 2023). These results are in close conformity with the findings of Haleema *et al.* (2018); Singh *et al.* (2019).

The maximum (5.54 cm) fruit diameter was recorded in boron @ 0.2% + zinc @ 0.2% treatment. The interaction effect of boron @ 0.2% + zinc @ 0.2% treatment showed the significant effect of fruit diameter over other treatments (Fig. 1). It might be due to boron and zinc that promotes the photosynthesis rate and cell divisions that ultimately increases the fruit diameter (Singh and Tiwari, 2013 and Tyagi *et al.*, 2024). Boron and Zinc also help in the preparing tryptophan that is amino acids which helps in the biosynthesis of proteins and auxins that is plant growth regulators which result in the improving of fruit growth (Wojcik and Wojcik, 2003). These results are in accordance with the findings of Sultana *et al.* (2016); Mallick *et al.* (2021) and Das *et al.* (2023). The heaviest (116.62 g) fruit weight and highest (131.82 cm^3) fruit volume (Table 2) was recorded under boron @ 0.2% + zinc @ 0.2% treatment. This might be due to synergistic effect of boron and zinc that accumulates more food materials that increases fruit length and diameter that collectively increases fruit weight and volume. These results are in close conformity with the findings of These results are in close conformity with the findings of Osman *et al.* (2019); Mondal and Ghosh (2023) and Tyagi *et al.* (2024).

Yield and Economics

The date presented in Table 2 revealed that among the different concentrations of boron and zinc treatments and the highest (3.83 kg/plant) and (134.10 t/ha) fruit yield per plant were recorded in boron @ 0.2% + zinc @ 0.2% treatment which was significantly higher as

Table 2 : Effect of boron and zinc on yield and yield attributing characters of tomato cv. 'Abhilash'.

Treatments	**No. of flower clusters per plant**	**No. of fruits per flower cluster**	**No. of fruits per plant**	**Fruit length (cm)**	**Fruit diameter (cm)**	**Fruit weight (g)**	**Fruit volume (cm^3)**	**Yield per plant (kg)**	**Yield per hectare (tones)**	**B:C ratio**
Control (Water)	7.24	3.67	26.53	2.19	3.35	62.70	70.90	1.69	35.29	1.30
Boron @ 0.1 %	7.80	4.01	31.24	3.03	4.19	73.66	83.28	2.33	48.57	1.78
Boron @ 0.2 %	8.70	4.27	37.11	3.19	4.35	78.30	88.53	2.94	61.23	2.24
Boron @ 0.3 %	8.24	4.37	35.97	3.07	4.23	75.55	85.42	2.75	57.24	2.08
Zinc @ 0.1 %	8.50	4.46	37.87	3.14	4.30	72.99	82.53	2.79	58.21	2.14
Zinc @ 0.2 %	8.64	4.57	39.44	3.18	4.34	78.10	88.32	3.12	65.03	2.39
Zinc @ 0.3 %	8.54	4.32	36.85	3.35	4.51	75.56	85.43	2.81	58.64	2.15
Boron @ 0.1 % + Zinc @ 0.1 %	8.84	4.55	40.18	3.39	4.55	87.76	99.24	3.57	74.32	2.72
Boron @ 0.1 % + Zinc @ 0.2 %	9.74	4.76	46.31	3.78	4.94	94.87	107.25	4.42	92.09	3.37
Boron @ 0.1 % + Zinc @ 0.3 %	9.24	4.71	43.47	3.53	4.69	88.71	100.31	3.90	81.20	2.96
Boron @ 0.2 % + Zinc @ 0.1 %	9.03	4.28	38.62	3.77	4.93	108.69	122.87	4.23	88.15	3.22
Boron @ 0.2 % + Zinc @ 0.2 %	10.17	5.41	54.97	4.40	5.54	116.62	131.82	6.44	134.10	4.88
Boron @ 0.2 % + Zinc @ 0.3 %	9.77	5.01	48.90	3.96	5.12	105.43	119.18	5.19	108.03	3.93
Boron @ 0.3 % + Zinc @ 0.1 %	9.17	4.61	40.82	3.56	4.72	95.47	107.93	4.06	84.62	3.07
Boron @ 0.3 % + Zinc @ 0.2 %	8.75	4.67	42.23	3.46	4.62	98.85	111.77	4.08	84.92	3.08
Boron @ 0.3 % + Zinc @ 0.3 %	8.62	4.42	38.09	3.43	4.58	93.85	106.09	3.60	75.02	2.72
Boron										
C.D. (p=0.05)	**0.53**	**0.003**	**1.75**	**0.11**	**0.01**	**1.25**	**1.41**	**0.09**	**9.44**	
Zinc										
C.D. (p=0.05)	**N.S.**	**0.003**	**1.75**	**0.11**	**0.01**	**1.25**	**1.41**	**0.09**	**9.44**	
Interaction (Boron x Zinc)										
C.D. (p=0.05)	**N.S.**	**0.009**	**3.51**	**0.21**	**0.03**	**2.50**	**2.83**	**0.17**	**28.32**	

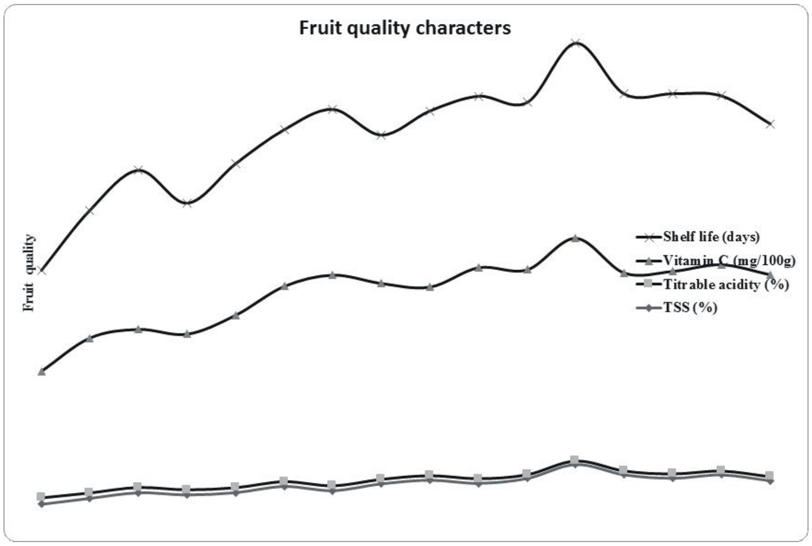

Fig. 1 : Effect of boron and zinc on fruit quality characters of tomato cv. 'Abhilash'.

compared to control (1.86 kg/plant) and (35.29 t/ha). Hence, boron @ 0.2% + zinc @ 0.2% treatment performed significantly superior over foliar spray of different concentrations of boron and zinc individually and in combinations. The foliar application of boron and zinc improves photosynthesis and other metabolic activities, which help in increasing of cell division and elongation (Hatwar *et al*., 2003). Foliar application of B and Zn increased the yield of tomato significantly as it enhanced the vegetative growth, retention of flowers and fruit set, speeds up the process of photosynthesis which resultantly increased the photosynthates (CH_2O) by the result of which it increased the number of fruits, length, diameter and weight of tomato fruits that ultimately increased the yield. The similar results were also clarified by (Sultan *et al*., 2016; Mondal and Ghosh, 2023 and Tyagi *et al.*, 2024).

The highest B: C ratio (4.88) of tomato production was recorded in Boron @ 0.2% + Zinc @ 0.2% treatment followed by (3.93) in Boron @ 0.2% + Zinc @ 0.3 % and (3.37) in Boron @ 0.1% + Zinc @ 0.2%. Whereas, the lowest B: C ratio (1.30) was recorded in water sprayed control (Table 2). It might be due to increasing fruit set, fruit retention, number of fruits per plant and minimized the fruit drop percentage in foliar application of boron and zinc that ultimately increased the yield per plant as well as per hectare. These results are in close conformity with the findings of Das *et al.* (2023) and Mondal and Ghosh (2023).

Quality Parameters

The data depicted in Fig. 1 revealed that the maximum (5.58%) TSS, minimum (0.31%) acidity and maximum (18.24 mg/100 g) vitamin – C content were recorded under boron @ 0.2% + zinc @ 0.2% whereas, the minimum (2.07%) TSS, maximum (0.57%) acidity and minimum (18.24 mg/100 g) vitamin – C content was recorded in control. The zinc increasing cation exchange capacity (CEC) of roots helped in increasing absorption of nutrient from the soil. Further, the boron and zinc synergistically enhanced the chlorophyll formation, regulating auxin concentration and its stimulatory effect on most of the physiological and metabolic processes of plants. This might be helped plants in absorption of greater amount of nutrients from the soil. Thus, the favourable effect of boron and zinc on photosynthesis and metabolic processes augmented the production of photosynthates and their translocation to different plant parts, which ultimately improved the quality of tomato fruits. Mallick *et al.* (2021) and Mondal and Ghosh (2023) also reported the similar findings in their study.

The longest (17.21 days) shelf-life of tomato fruits was recorded under boron @ 0.2% + zinc @ 0.2% treatment, whereas, the minimum (8.90 days) shelf-life was recorded under water sprayed plants (Fig. 1). Boron @ 0.2% + zinc @ 0.2% treatment performed significantly superior over other treatments. It might be due to enhanced the vegetative growth that increased photosynthesis which resultantly increased the photosynthates (CH_2O) that utilized during storage and ultimately increased the shelf-life of tomato. Almost similar results were also clarified by Haleema *et al.* (2018); Mallick *et al.* (2021) and Tyagi *et al.* (2024).

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