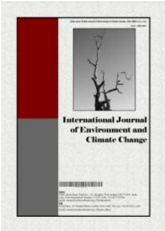

International Journal of Environment and Climate Change

12(11): 2693-2699, 2022; Article no.IJECC.91813
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Interaction Effect of Zinc and Boron on the Growth, Yield and Yield Attributes of Tomato in Acid Soils of Manipur

Dasari Gopal [a*] and Indira Sarangthem [a]

[a] *Department of Soil Science & Agricultural Chemistry, College of Agriculture, Central Agricultural University, Imphal-795004, Manipur, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i1131257

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/91813

Original Research Article

Received 08 July 2022
Accepted 17 September 2022
Published 22 September 2022

ABSTRACT

The field experiment was carried out at the Research farm of Central Agricultural University, Imphal, Manipur, during the rabi seasons of 2016-17 and 2017-18, to study the interaction effect of Zinc and Boron on growth, yield, and yield attributes of tomato (Pusa Ruby). There were ten treatments viz., T1 (Zn0.0+B0.0), T2 (Zn2.5+B1.0), T3 (Zn2.5+B1.5), T4 (Zn2.5+B2.0), T5 (Zn5.0+B1.0), T6 (Zn5.0+B1.5), T7 (Zn5.0+B2.0), T8 (Zn10+B1.0), T9 (Zn10+B1.5) and T10 (Zn10+B2.0) with three replications were laid out by FRBD design. The combined effect of zinc and boron showed a significant effect on the number of fruits plant-1, fruit weight plant-1, and yield ha-1, whereas there was no significant effect on plant growth parameters (plant height). Among the treatments, the T10 (Zn10+B2.0) treatment exhibited a significantly increased in the number of fruits plant-1 (35.83 in the first year and 36.52 in the second year), fruit weight plant-1 (1.62 kg in the first year and 1.76 kg in the second year.), highest fruit yield (60.06 t ha-1 in the first year and in 65.1 t ha-1 in the second year) was produced from the treatment combination of 10 kg of Zn ha-1 and 2.0 kg B ha-1 in both years than the control treatment (Zn0.0+B0.0).

Keywords: Zinc×Boron interaction effect; tomato; growth; yield attributes; yield; acid soil.

**Corresponding author: E-mail: gopalyadav8886464221@gmail.com;*

1. INTRODUCTION

"Tomato is one of the most popular vegetable crops all over the world. Tomato has an important role in human nutrition since it's a rich source of lycopene, minerals and vitamins such as ascorbic acid and β-carotene which are anti-oxidants and improve good health" [1]. "Current studies propose that intake of tomato, either fresh or processed, lowers the risk of some cancers, especially prostate cancer" [2]. Crop fertilization is an important factor in sustainable food production. Major (N, P and K) and micronutrient (Zn, Fe, Cu, Mn, B and Mo) are considered vital macronutrients for meristematic production and several physiological processes in plant. Among the micronutrients many plants respond to zinc and boron application either through soil or foliar [3].

"Zinc (Zn) deficiency is wide spread all over the world and adversely affects human health, due to low intake of Zn in our diet. This can be overcome by using food having high content of Zinc" [4]. The yield of tomato has been declined due to micronutrient deficiency [5].

Zinc is required for proper, healthy plant growth and reproduction. This element is necessary in trace levels to guarantee the structural and functional integrity of membranes as well as the appropriate function of numerous important plant physiological processes [6]. As a result, "Zinc is essential for growth control, enzyme activation, gene expression and regulation, phytohormone activity, protein synthesis, photosynthesis, carbohydrate metabolism, fertility, seed formation, and disease resistance" [7]. Zinc participates in carbohydrate metabolism through its effects on photosynthesis and sugar transformation. Decreased in photosynthesis due to Zn deficiency may be caused not only by changes in chloroplast structure, but also by decreased carbonic anhydrase (CA) activity, chloroplast photochemical activity, and chlorophyll concentration. Low carbonic anhydrase (CA) can constrain photosynthetic electron transport and consequently limit chlorophyll content [8]. Together with copper, zinc appears to have a catalytic role in superoxide dismutase enzymes, whereas copper appears to play a structural role. The activity of superoxide dismutase is reduced in zinc-deficient conditions and is associated with an increase in the toxic substance oxygen radicals (superoxide), which has detrimental effects on plant tissues through membrane lipid peroxidation and improved permeability [7].

Boron is an essential non-metallic micronutrient for optimal plant growth and development as it is an important non-metallic micronutrient characterized by its physiological metabolic activity. After zinc, boron is a second most deficient trace element worldwide. During the development of plants, boron plays a role in a number of physiological and biochemical processes directly or indirectly. Boron plays a very important role in seed production, even in cases of moderate deficiency plants cannot produce functional flowers or seeds [9]. Boron is deposition of cell wall material by membrane altering property, and the lack of Boron causes the collapse of parenchymal cell wall [7,10]. Keeping in view the importance of Zn and B and their synergistic effect the current study was targeted to evaluate the interaction effect of Zinc and Boron on growth, yield and yield attributes of tomato (Pusa Ruby) in acid soils.

2. MATERIALS AND METHODS

Field experiments were conducted in farm of the College of Agriculture, Department of Soil Science and Agricultural Chemistry at Central Agricultural Univeraity, Imphal, Manipur, India, during *rabi* seasons of 2016-17 and 2017-18 to study the interaction effect of zinc and boron on growth, yield and yield attributes of tomato (*Solanum lycopersicum* L.) in acid soils. Pusa Ruby variety of tomato seedlings were raised in shade net house at Central Agricultural University, Imphal, Manipur.

2.1 Experimental Design

The field experiment used a Factorial Randomized Block Design with three replicates. Ten treatments [T_1 ($Zn_{0.0}$+$B_{0.0}$), T_2 ($Zn_{2.5}$+$B_{1.0}$), T_3 ($Zn_{2.5}$+$B_{1.5}$), T_4 ($Zn_{2.5}$+$B_{2.0}$), T_5 ($Zn_{5.0}$+$B_{1.0}$), T_6 ($Zn_{5.0}$+$B_{1.5}$), T_7 ($Zn_{5.0}$+$B_{2.0}$), T_8 (Zn_{10}+$B_{1.0}$), T_9 (Zn_{10}+$B_{1.5}$) and T_{10} (Zn_{10}+$B_{2.0}$)] were established using the combinations of four levels of Zinc (0, 2.5, 5.0, 10.0 kg ha^{-1}) and four Boron rates (0, 1.0, 1.5, 2.0 kg ha^{-1}). Ten plants were randomly selected in each plot to record the data on growth and yield parameters. Soil application of zinc and boron were done in form of zinc sulphate ($ZnSO_4.7H_2O$) and borax ($Na_2B_4O_7 \cdot 10H_2O$). Each plot was treated with NPK fertilizers at 100- 60-180 kg ha^{-1} as per recommended dose. The sources of N, P_2O_5, and K_2O were urea (46%), single superphosphate (12% P_2O_5), and Muriate of potash (60% K_2O). Nitrogen fertilizer was spit-applied with 50% as basal and the remaining 50% applied as a topdressing at 30 DAT (25%) and 60 DAT (25%). All of the P_2O_5 and K_2O were applied as a basal dose. The early studies of the soil has shown high in organic carbon (2.3%), acidity in character with pH of 5.4, clay in texture, deficient in Boron (0.22 mg kg^{-1}), medium in Nitrogen (325.2 kg ha^{-1}), Phosphorus (18.5 kg ha^{-1}) and Potash (291 kg ha^{-1}).

2.2 Data Collection Procedure

2.2.1 Plant height

The height of the plant was measured with a meter scale taking ten plants randomly selected from a treatment plot when harvesting of fruits was completed. Average height was determined adding the total length of all the ten plants and dividing by ten.

2.2.2 Number of fruits plant^{-1}

The number of fruit plant^{-1} was recorded by counting all fruits harvested from ten plants randomly selected in each treatment plot and was divided by ten.

2.2.3 Weight of fruit plant^{-1}

The weight of fruit Plant^{-1} was determined by measuring the total fruit weight of ten randomly selected plants and the mean fruit weight plant^{-1} in kgs was recorded.

2.2.4 Fruit yield ha^{-1}

The weight of the fruits of each net plot was recorded in kg and converted into t ha^{-1}.

2.3 Statistical Analysis

Variance analyses of the Zinc, Boron and their interaction effects were performed using SPSS 18.0 (IBM) software. The difference between the means was determined using the least significant difference (LSD) test at the 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Interaction Effect of Zinc and Boron on Number of Fruits Plant^{-1}

Plant height did not change much as a result of the interaction (Zn x B) impact, despite the fact that combined application of both elements produced better outcomes than single application, which may have contributed to the yield (Table 1). The mean plant height ranged from 85.96cm to 102.34 cm, with ($Zn_{10}B_{2.0}$) producing the greatest results, followed by Zn_{10} $B_{1.5}$ and control (Zn_0B_0) producing the lowest (Fig. 1).

3.2 Interaction of Zinc and Boron on Number of Fruits Plant^{-1}

The interaction effect between zinc and boron was found statistically significant for the yield of number of fruits plant^{-1}. The mean of maximum number of fruits plant^{-1} (36.18), significantly superior than other treatments (Table 1 and Fig. 2). T_{10} ($Zn_{10}B_{2.0}$) had the highest production of mature fruits plant^{-1} (35.83 and 36.52 for the first, and second years, respectively), which was statistically higher than the control T_1 (23.30 and 19.27). Combined use of boron and zinc could help balance nutrient uptake and increase photosynthesis rate, resulting in more fruit per plant. These observations support the findings of Hosseini et al. [11], who have been investigated the interplay impact of boron and zinc on okra that probably helped higher pollen germination and increase of pollen tube and greater wide variety of fruit set. Boron helps reduce male sterility and increases normal fruit. Zinc is involved in the biochemical synthesis of the plant hormone IAA via a pathway converting tryptophan to IAA, which also improves yield and its properties.

3.3 Interaction Effect of Zinc and Boron on Fruits Weight Plant^{-1}

Combined effect of zinc and boron showed the significantly increase in fruit weight plant^{1}. The highest fruit weigh (1.62 and 1.76 for the first and second year, respectively) plant^{1} at combination of zinc @ 10 kg ha^{-1} and Boron @ 2.0 kg ha^{-1} through soil application as compared with the control (0.71 and 1.14 for the first, and second years, respectively) treatment (T_1). Combined effect of different doses of zinc and boron on the weight of fruits plant^{-1} (kg) was found to be statistically significant (Table 1 and Fig. 3).

Boron and Zinc supplementation may influence nutritional absorption and accumulation. Gauch and Dugger [12], who has repoted synergistic B and Zn interactions on maize (*Zea mays*) growth and accumulation of other nutrients including N, P, K, and Ca. Zinc and boron application boosts chilli weight because boron and zinc increased cells and cell division, and work in the volume of intercellular space in mesocarpic cells in addition to rapid metabolite translocation and sink fruits [13] and also aid in the preparation of tryptophan, which is an amino acid that aids in the manufacture of proteins, as well as auxins, which are plant growth regulators that result in improved fruit growth [14].

3.4 Interaction Effect of Zinc and Boron on Yield

The fruit yield or yield was significantly influenced due to various treatments (Table 1 and Fig. 4). The highest fruit yield (60.06 and 65.12 kg ha^{-1} for the first and second year, respectively) was recorded in T_{10} ($Zn_{10}B_{2.0}$). The next best treatments were observed (56.24and 62.65 kg ha^{-1} for the first and second year, respectively) in T_9 (Zn_{10} $B_{1.5}$).

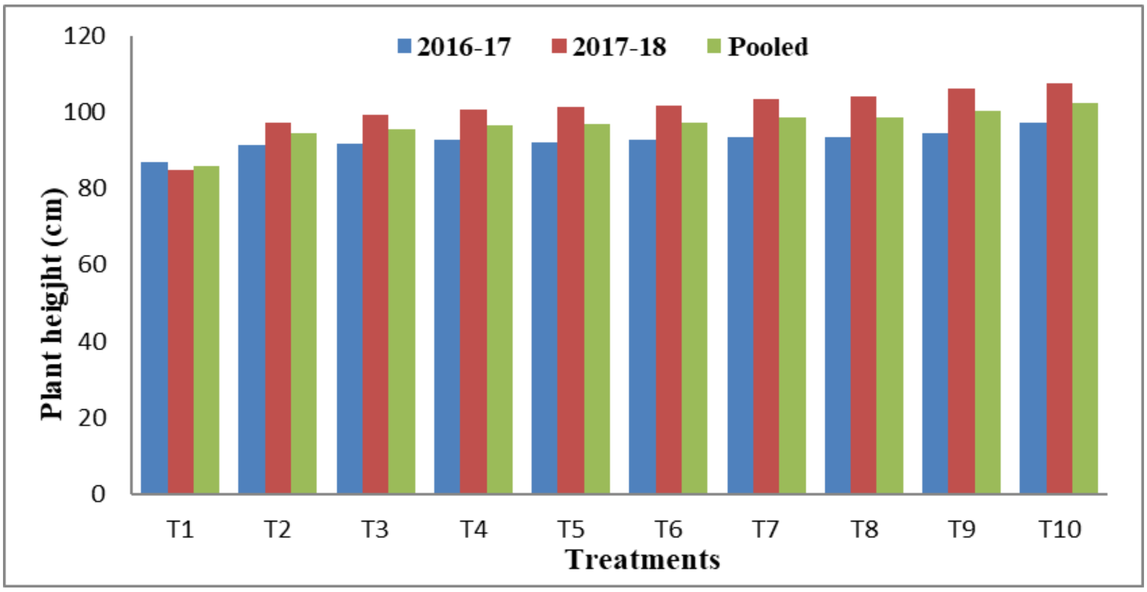

Fig. 1. Interaction effect of zinc × Boron on the plant height (cm) of Tomato

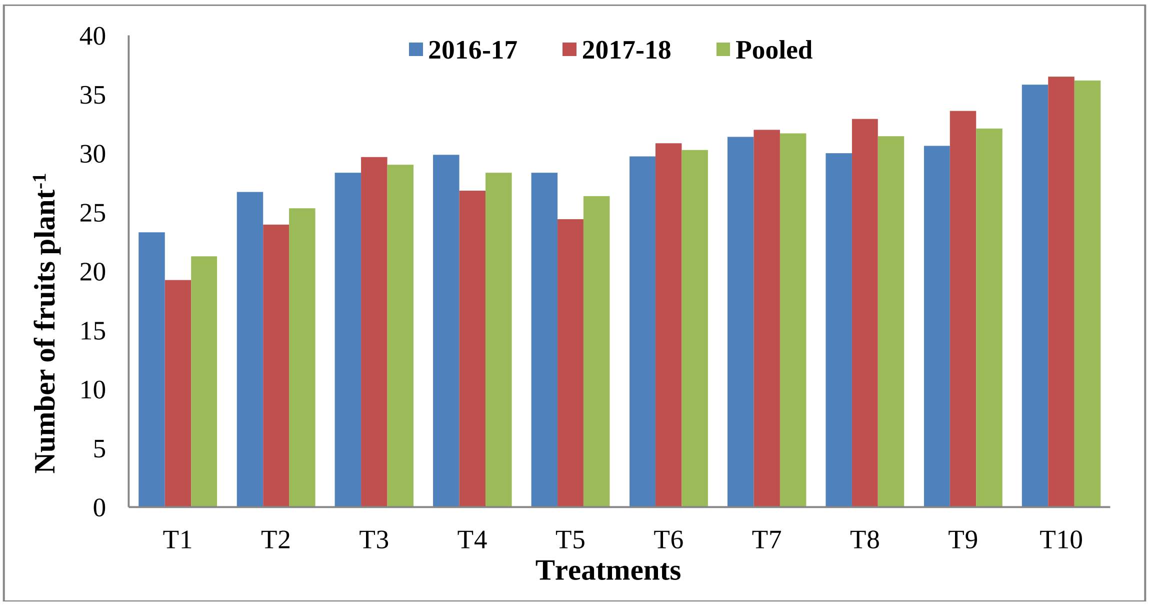

Fig. 2. Interaction effect of zinc × Boron on the number of fruits $plant^{-1}$

Table 1. Interaction effect of Zinc × Boron on the growth, yield and yield attributes of tomato (Pusa Ruby) crop in acid soil

Treatments combination (kg ha^{-1})	Plant height (cm)			Number of fruits $plant^{-1}$			Fruit weight per plant (Kg $plant^{-1}$)			Fruit yield (t ha^{-1})		
	2016-17	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2006-17**	**2017-18**	**Pooled**	**2006-17**	**2017-18**	**Pooled**
$\mathbf{T_1}$($Zn_{0.0}$ + $B_{0.0}$)	86.94	84.97	85.96	23.30	19.27	21.28	0.71	1.14	0.93	26.39	42.18	34.29
$\mathbf{T_2}$($Zn_{2.5}$ +$B_{1.0}$)	91.50	97.29	94.40	26.72	23.97	25.34	1.47	1.30	1.39	54.46	47.94	51.20
$\mathbf{T_3}$($Zn_{2.5}$ +$B_{1.5}$)	91.84	99.21	95.53	28.36	29.70	29.03	1.03	1.29	1.16	38.18	47.61	42.90
$\mathbf{T_4}$ ($Zn_{2.5}$ +$B_{2.0}$)	92.83	100.78	96.44	29.88	26.83	28.36	1.14	1.32	1.23	42.18	48.85	45.51
$\mathbf{T_5}$ ($Zn_{5.0}$ +$B_{1.0}$)	92.07	101.46	96.77	28.36	24.42	26.39	1.40	1.30	1.35	51.71	47.94	49.82
$\mathbf{T_6}$ ($Zn_{5.0}$ +$B_{1.5}$)	92.63	101.69	97.16	29.75	30.85	30.30	1.23	1.26	1.25	45.41	46.76	46.08
$\mathbf{T_7}$ ($Zn_{5.0}$ +$B_{2.0}$)	93.51	103.45	98.48	31.40	31.99	31.70	1.04	1.37	1.20	38.40	50.74	44.57
$\mathbf{T_8}$ (Zn_{10} +$B_{1.0}$)	93.37	104.17	98.77	30.01	32.93	31.47	1.41	1.49	1.45	52.29	55.13	53.71
$\mathbf{T_9}$ (Zn_{10} +$B_{1.5}$)	94.31	106.14	100.23	30.64	33.60	32.12	1.52	1.69	1.61	56.24	62.65	59.45
$\mathbf{T_{10}}$ (Zn_{10} +$B_{2.0}$)	97.16	107.52	102.34	35.83	36.52	36.18	1.62	1.76	1.69	60.06	65.12	62.59
S.Em ±	1.01	0.86	1.73	0.45	0.92	0.50	0.07	0.08	0.06	2.48	2.65	1.95
CD (0.05)	NS	NS	NS	0.93	1.88	1.02	0.14	0. 15	0.12	5.07	5.41	3.98

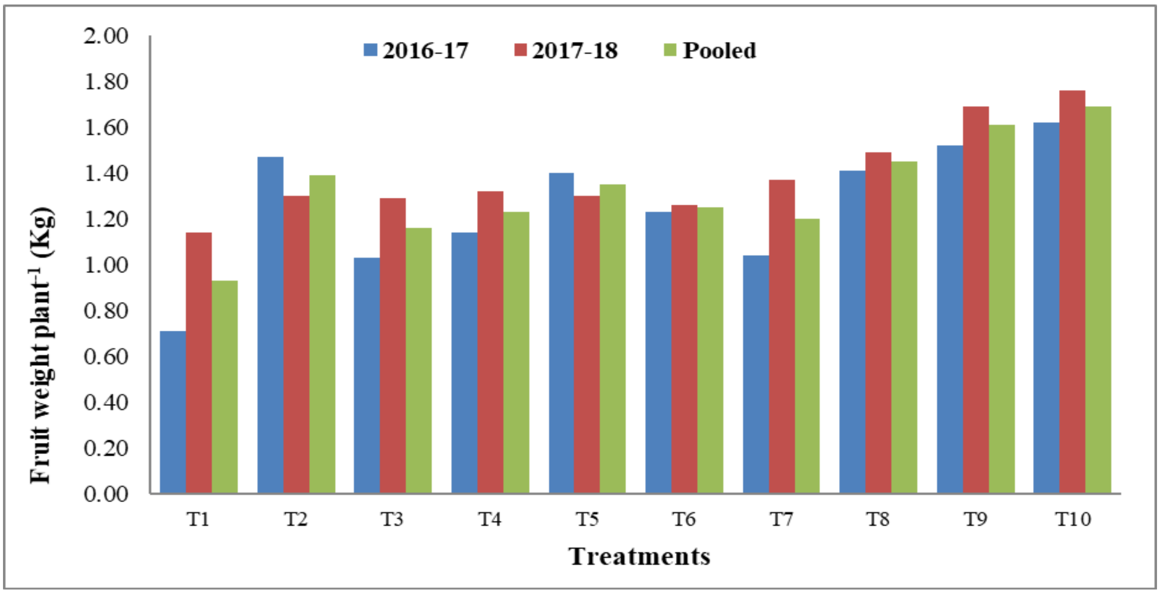

Fig. 3. Interaction effect of zinc × Boron on the fruits weight plant^{-1}

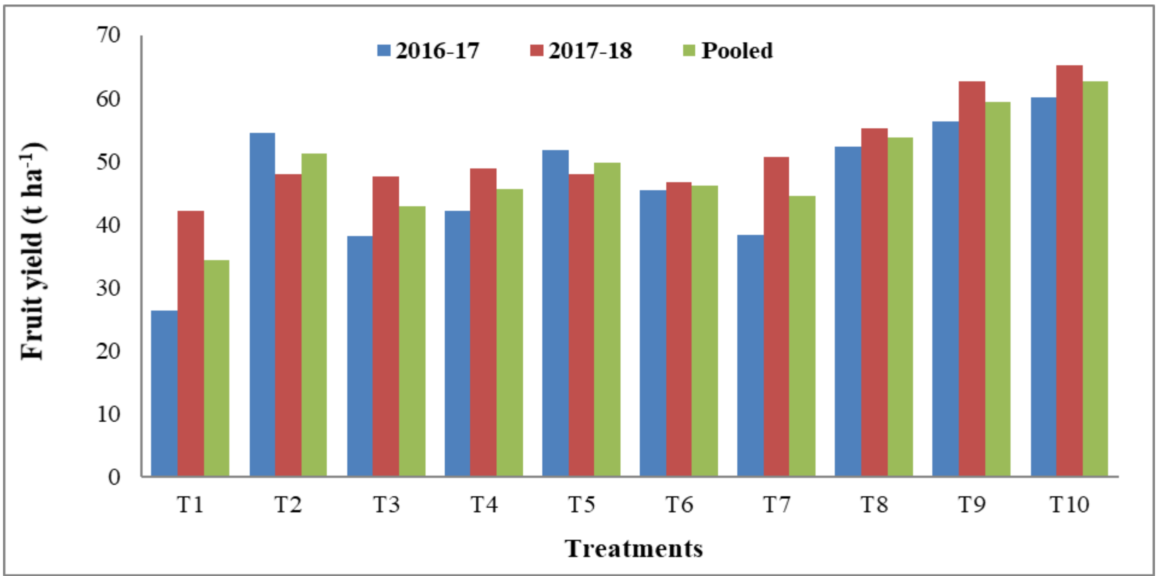

Fig. 4. Interaction effect of zinc × boron on the fruit yield ha^{-1}

The lowest fruit yield (26.3 and 42.18 kg ha^{-1} for the first and second year, respectively) was observed in plants which are not treated with zinc and boron (T_1). Gauch and Dugger [12] provided evidences which were indicative of participation of boron in sugar translocation in higher plants. They have reported that boron, by virtue of its ability to make complex with sugars facilitated the transport of sugars in plants. However, Zinc is important in the oxidation and reduction processes, which are important in the sugar metabolism [15].

4. CONCLUSION

The results of the present investigation clearly indicated that for increasing the yield and yield attributes of tomato, the treatment application of Zinc @10 kg ha^{-1}, Boron @ 2.0 kg ha^{-1} and RDF would be beneficial.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Wilcox J, Catignani G, Lazarus C. Tomatoes and cardiovascular health. Critical Reviews in Food Science and Nutrition. 2003;43(1):1-18.
2. Campbell JK, Canene-Adams K, Lindshield BL, Boileau TWM, Clinton SK, Erdman Jr JW. Tomato phytochemicals and prostate cancer risk. The Journal of Nutrition. 2004;134(12): 3486S-3492.
3. Aref F. Effect of different zinc and boron application methods on leaf nitrogen, phosphorus and potassium concentrations in maize grown on zinc and boron deficient calcareous soils. Journal of Soil and Nature. 2012;6(1):1-10.
4. Kutman UB, Yildiz B, Ozturk L, Cakmak I. Biofortification of durum wheat with zinc through soil and foliar applications of nitrogen. Cereal Chemistry. 2010;87(1): 1-9.
5. Ejaz M, Waqas R, Butt M, Rehman SU, Manan A. Role of macro-nutrients and micro-nutrients in enhancing the quality of tomato. International Journal for Agro Veterinary and Medical Sciences. 2011; 5:401-404.
6. Hafeez B, Khanif YM, Saleem M. Role of zinc in plant nutrition – a review. American Journal of Experimental Agriculture. 2013; 3(2):374-91.
7. Marschner H. Mineral nutrition of high plant. UK: Academic Press. 1995;330-55.
8. Romheld V, Marschner H. Function of micronutrients in plants. Micronutrients in Agriculture. 1991;4:297-328.
9. Katyal JC, Singh B. Availability of boron in the soil and its uptake by rice as influenced by soil moisture regimes. Oryza. 1983; 29:384–387.
10. Mahesh K, Sen NL. Interaction effect of zinc and boron on okra (*Abelmoschus esculentus* L. Moench) cv. Prabhani Kranti. Agricultural Science Digest. 2004; 24(4):307-308.
11. Hosseini SM, Maftoun M, Karimian N, Ronaghi A, Emam Y. Effect of zinc × boron interaction on plant growth and tissue nutrient concentration of corn. Journal of Plant Nutrition. 2007;30(5):773-781.
12. Gauch HG, Dugger WM. The role of boron in the translocation of sucrose. Plant Physiology. 1953;28:457-54.
13. Brahmachari VS, Rani R. Effect of growth substances on productivity cracking, ripening and quality of fruits of litchi. Orissa Journal of Horticulture. 2001;29:44-45.
14. Wojcik P, Wojcik M. Effects of boron fertilization on conference pear tree vigor, nutrition and fruit yield and storability. Plant and Soil. 2003;256:413-421.
15. Rath S, Sing RL, Sing DB. Effect of boron and zinc sprays on the physio-chemical composition of mango fruits. Punjab horticultural Journal. 1980;20:33-35.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/91813