

INTERACTION EFFECT OF ZINC AND BORON ON THE GROWTH, YIELD, YIELD ATTRIBUTES OF TOMATO IN ACID SOILS OF MANIPUR

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 (Zn_{0.0}+B_{0.0}), T₂ (Zn_{2.5}+B_{1.0}), T₃ (Zn_{2.5}+B_{1.5}), T₄ (Zn_{2.5}+B_{2.0}), T₅ (Zn_{5.0}+B_{1.0}), T₆ (Zn_{5.0}+B_{1.5}), T₇ (Zn_{5.0}+B_{2.0}), T₈ (Zn₁₀+B_{1.0}), T₉ (Zn₁₀+B_{1.5}) and T₁₀ (Zn₁₀+B_{2.0}) with three replications were laid out by FRBD design. Combined effect of zinc and boron shown significant effect on 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+B_{2.0}) treatment exhibited significantly increased in number of fruits plant⁻¹ (35.83 in first year and 36.52 in second year), fruit weight plant⁻¹ (1.62 kg in first year and 1.76 kg in second year.), highest fruit yield (60.06 t ha⁻¹ in first year and in 65.1 t ha⁻¹ in second year) were produced from the treatment combination of 10 kg of Zn ha⁻¹ and 2.0 kg B ha⁻¹ in both years than control treatment (Zn_{0.0}+B_{0.0}).

Keywords: zinc×Boron interaction effect, Tomato, growth, yield attributes, Yield, Acid soil

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 (Wilcox *et al.*, 2003). Current studies propose that intake of tomato, either fresh or processed, lowers the risk of some cancers, especially prostate cancer (Campbell *et al.*, 2004). 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 (Aref, 2012).

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 (Kutman *et al.*, 2010). The yield of tomato has been declined due to micronutrient deficiency (Ejaz *et al.*, 2011).

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 (Hafeez *et al.*, 2013). 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 (Marschner, 1995). 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 (Romheld and Marschner, 1991). 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 (Marschner, 1995).

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 (Katyal and Singh, 1983). Boron is deposition of cell wall material by membrane altering property, and the lack of Boron causes the collapse of parenchymal cell wall (Marschner, 1995; Mahesh and Sen., 2004). 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.

Materials and methods

Field experiments were conducted in farm of the College of Agriculture, Department of Soil Science and Agricultural Chemistry at Central Agricultural University, 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.

Experimental design

The field experiment used a Factorial Randomized Block Design with three replicates. Ten treatments [T₁ (Zn_{0.0}+B_{0.0}), T₂ (Zn_{2.5}+B_{1.0}), T₃ (Zn_{2.5}+B_{1.5}), T₄ (Zn_{2.5}+B_{2.0}), T₅ (Zn_{5.0}+B_{1.0}), T₆ (Zn_{5.0}+B_{1.5}), T₇ (Zn_{5.0}+B_{2.0}), T₈ (Zn₁₀+B_{1.0}), T₉ (Zn₁₀+B_{1.5}) and T₁₀ (Zn₁₀+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 (ZnSO₄.7H₂O) and

borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$). 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 split-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}).

Data Collection Procedure

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.

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.

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.

Fruit yield ha⁻¹

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

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.

Result and discussion

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 ($\text{Zn}_{10}\text{B}_{2.0}$) producing the greatest results, followed by $\text{Zn}_{10}\text{B}_{1.5}$ and control (Zn_0B_0) producing the lowest (Fig.1).

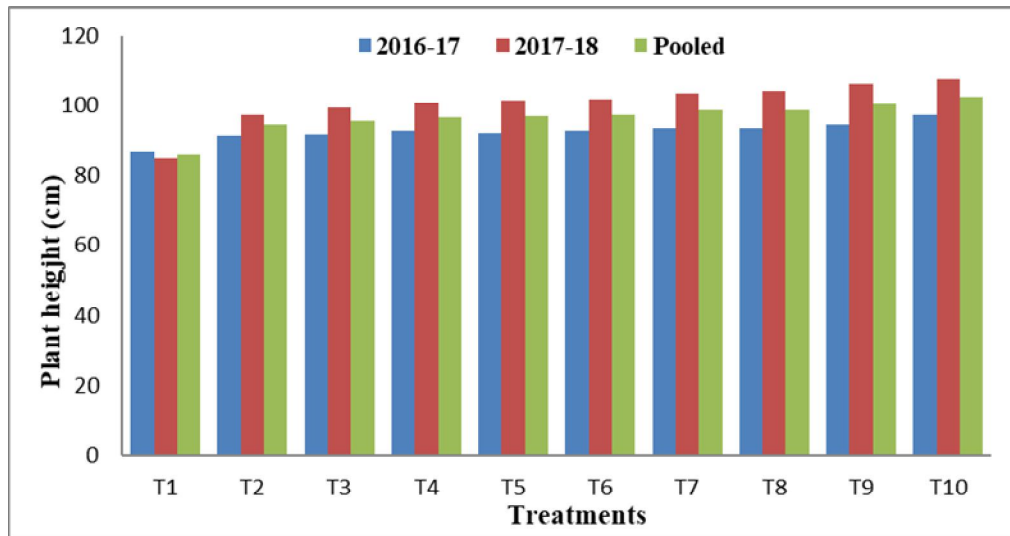


Figure 1. Interaction effect of zinc × Boron on the plant height (cm) of Tomato

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). T₁₀ (Zn₁₀B_{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 T₁ (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.* (2007), 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.

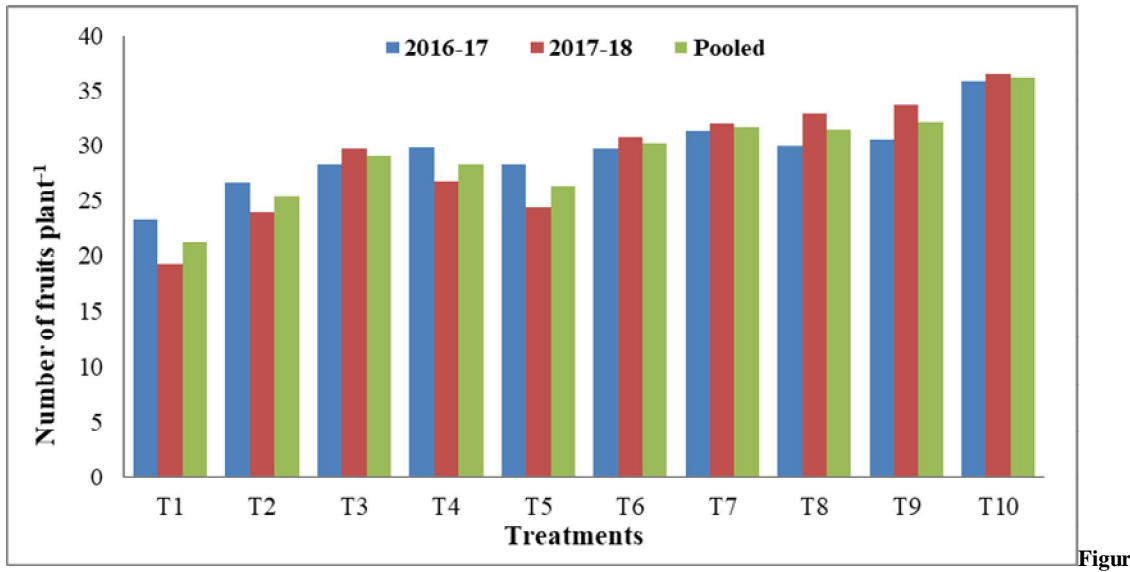


Figure 2. Interaction effect of zinc x Boron on the number of fruits plant⁻¹

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 (T₁). 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).

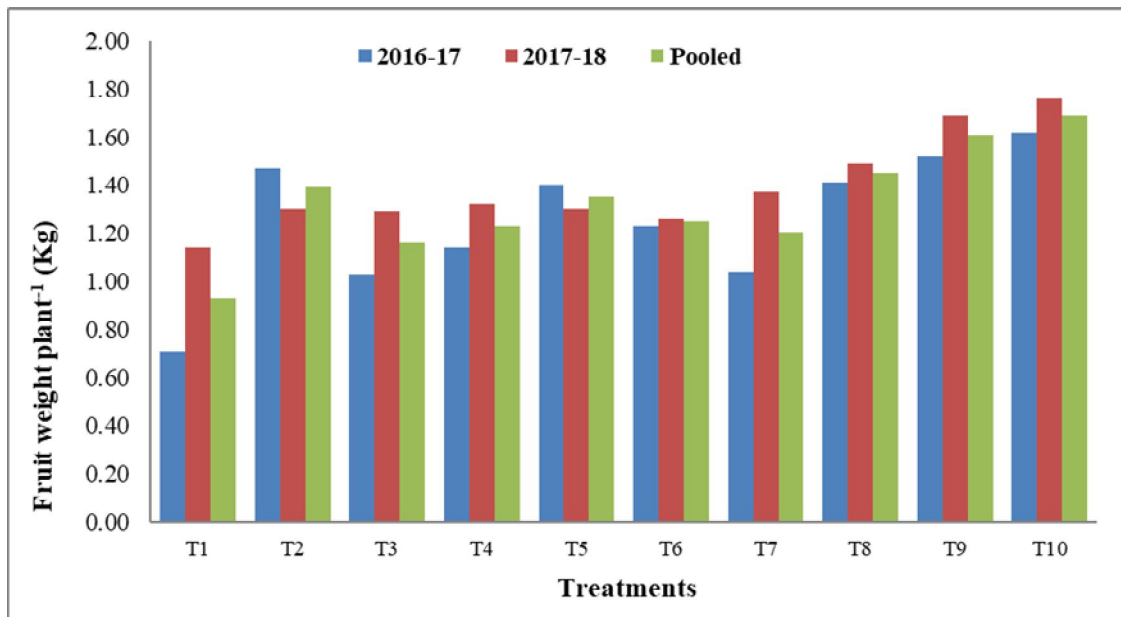


Figure 3. Interaction effect of zinc x Boron on the fruits weight plant⁻¹

Boron and Zinc supplementation may influence nutritional absorption and accumulation. Gauch and Dugger (1953), who has reported 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 (Brahmachari and Rani, 2001) 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 (Wojcik and Wojcik, 2003).

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 T₁₀ (Zn₁₀B_{2.0}). The next best treatments were observed (56.24 and 62.65 kg ha⁻¹ for the first and second year, respectively) in T₉ (Zn₁₀ B_{1.5}).

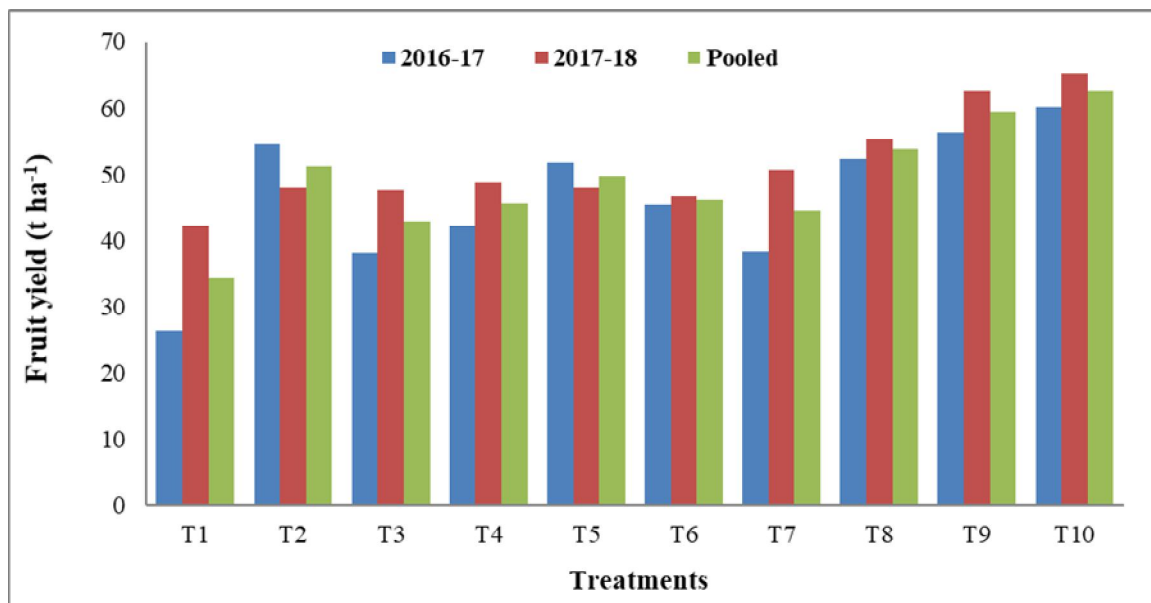


Figure 4. Interaction effect of zinc × Boron on the fruit yield ha⁻¹

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 (T₁). Gauch and Dugger (1953) 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 (Rath *et al.*, 1980).

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
T₁ (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
T₂ (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
T₃ (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
T₄ (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
T₅ (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
T₆ (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
T₇ (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
T₈ (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
T₉ (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
T₁₀ (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

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.

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