



Combined Effect of Zinc and Boron with Fruit Thinning on the Quality Seed Production of Tomato

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KK and TM planned the experiment and lead the research. Authors KK, TM and JA designed and carried out the research. Authors MEH and MMH performed the statistical analysis. Authors JA and MUH carried out the research on the field. Authors JA, MMH and MUH collected the data. Authors KK and MEH wrote the manuscript. Authors MEH, TM and JA managed the literature searches. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2017 to April 2018. The present research was aimed to study effect of combinations of zinc and boron with fruit thinning on the quality seed production of tomato. There were four combination of zinc and boron viz. $T_0 = Zn_0 \text{ kg} B_0 \text{ kg/ha}$, $T_1 = Zn_2 \text{ kg } B_{1.5} \text{ kg/ha}$, $T_2 = Zn_4 \text{ kg } B_2 \text{ kg/ha}$, $T_3 = Zn_6 B_{2.5} \text{ kg/ha}$ and four levels of fruit thinning viz. $P_0 =$ control (without fruit thinning), $P_1 = 10$ fruits were retained per plant, $P_2 = 20$ fruits were retained per plant and $P_3 = 30$ fruits were retained per plant. The experiment was laid out in a Randomized Complete Block Design with 3 replications and there were altogether 48 plots. Application of micronutrients with fruit thinning

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significantly influenced the growth and seed yield of tomato. The highest seed yield (297.82 kg/ha) was found from T_3 and the lowest yield (260.69 kg/ha) was obtained from T_0 . Due to the fruit thinning, the highest seed yield (337.41 kg/ha) was obtained from P_3 and lowest yield (190.69 kg/ha) was recorded from P_1 . In case of combined effect, the highest yield (360.39 kg/ha) was found from T_3P_3 and lowest yield (180.39 kg/ha) was found from T_0P_1 . So, application of Zn_6 kg $B_{2.5}$ kg/ha along with 30 fruits were retained per plant was the best for yield of tomato seed.

Keywords: Zinc; boron; fruit thinning; seed; tomato.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) belonging to the family Solanaceae. It is one of the most popular, important and nutritious vegetable grown in Bangladesh mainly during the Rabi season. The food value of tomato is very high because of higher contents of vitamins (A, B, C), minerals and carotene [1]. The demand of tomato in both domestic and foreign markets increased manifold in recent years. Adequate supply of nutrient can increase the quality fruit and seed yield. For harnessing the higher seed yield, supplementation of micronutrients is essential. Amongst the vegetables, tomato is very responsible to the application of micronutrients. It is realized that productivity of crop is being adversely affected in different areas due to deficiencies of micronutrients [2]. In Bangladesh, majority of the growers do not get high quality fruit and higher seed yield because of their ignorance about proper thinning practices. Tomato fruit thinning practice may give good result for getting uniform sized quality fruit, increased yield and less infestation of insects and diseases. An increase in total number of flowers and fruits has been shown to increase competition for photosynthesis and thus, decrease fruit size [3]. Yield and quality size of tomatoes are influenced by many factors, including fruit pruning [4]. Hanna, 2019 [5] found that pruning clusters to three fruits significantly increased total marketable fruit and seed yield. For successful production of quality tomato seed determination of actual number of fruit thinning is needed. Although, micronutrients and fruit thinning is important factor for growth, yield potentiality and quality seed production of tomato.

Seed is the basis of agricultural production. Quality of seed not to speak of hybrids, contributes to about 25% increases in crop yield remaining all other factors of production constant [6]. For sustainable crop production, good quality seed is very important. If the seed is not of

standard quality, use of other inputs is less useful and economic loss is incurred. According to [7] seeds are the focal points which strategies to boost crop yield. So, there is a strong demand for higher quality seed. In developing countries like Bangladesh, the unavailability of good seed is a major problem due to the absence of good variety, inadequate technology for seed production, poor quality control, post handle seed handling etc. The seeds are mainly collected by the farmers/ traders from the leftover of tomato crop, which cannot fetch better price. So quality seed is obligatory in this situation to maximize tomato production. In this regard application of zinc, boron with fruit thinning can be effective in seed production. At present situation of Bangladesh, there is a great need to information about micronutrients application and optimum number of fruit per plant for quality seed production of tomato. These factors, if taken into consideration, may lead to production of quality tomato seed within the country. So the research was conducted to investigate the best treatment combination of zinc boron and fruit thinning of tomato for quality seed yield.

2. MATERIALS AND METHODS

2.1 Climate and Soil of the Experimental Area

The experiment was conducted at Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of October 2017 to April, 2018. The location of the experimental site was at $23^{\circ}46'$ N latitude and $90^{\circ}22'$ E longitudes with an elevation of 8.24 meter from sea level. The experimental area is characterized by subtropical rainfall during the month of May to September and scattered rainfall during the rest of the year. Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8-6.5, ECE-25.28 [8]. The analytical data of the soil sample collected from the

experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka.

2.2 Layout and Design of the Experiment

The tomato variety used in the experiment was "BARI Tomato-15". This is a high yielding semi-indeterminate type variety. The seeds were collected from Olericulture division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) Joydebpur, Gazipur. The two factorial (Factor A & Factor B) experiment was laid out in a Randomized Complete Block Design with three replications. The whole experimental area was divided into three blocks, representing three replications. Each block was further subdivided into 16 unit plots. The four levels of Zn and Boron nutrients combinations and four levels of fruit thinning formed sixteen (16) treatments. The plots were raised by 15 cm from the ground level. Unit plot size was 2 m × 1.5 m accommodating 12 plants in each plots having row to row and plant to plant spacing 50 cm × 50 cm respectively. The unit plots and blocks both were separated by 100 cm and 50 cm respectively.

2.3 Data Collection

Six plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data were recorded on plant height (cm), number of leaves per plant, number of branches per plant, days to first flowering, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, fruit length (cm), fruit diameter (cm), individual fruit weight (g), fruit yield per plant (kg), fruit yield per plot (kg), number of seeds per fruit, seed yield per plant (g), seed yield per plot (g), seed yield per hectare

(t), from sample plants during the course of experiment.

2.4 Percentage of Seed Germination

One hundred seeds were taken from each treatment and placed in the petri-dishes for germination. Sprouting of seeds were from 3 DAS and continued up to 10 DAS. The germination percentage was calculated as

$$\% \text{ seed germination} = \frac{\text{No of germinated seeds}}{\text{No of seeds placed for germination}} \times 100$$

2.5 Seed Vigor Index (SVI)

The vigor of seeds of various treatments were calculated by determining the germination percentage and seedling length prescribed by [9]. Fifty seeds each in 4 replications were taken from each treatment sample and placed for germination. At the time of final counting of germinated seedlings, the length of five randomly selected seedlings from the normal seedlings were measured and seed vigor index was calculated as:

$$\text{SIV\%} = \% \text{ germination} \times \text{seedling length (root to shoot tip)}$$

2.6 Statistical Analysis

Collected data were statistically analyzed using MSTAT-C computer package program. Mean for every treatments were calculated and analysis of variance for each one of characters was performed by F-test (Variance Ratio). Different between treatments was assessed by Least Significant Difference (LSD) test at 5% level of significance [10].

Factor. A (4 levels of zinc and boron combinations)

Treatments	Micronutrients (kg/ha)	Source of Micronutrients Dose (kg/ha)
T ₀ = Zn _{0 kg} B _{0 kg/ha}	0 kg Zn+0 kg B	(0 kg zinc sulphate + 0 kg boric acid
T ₁ = Zn _{2 kg} B _{1.5 kg/ha}	2 kg Zn+1.5 kg B	(5.71kg zinc sulphate +8.82 kg boric acid /ha)
T ₂ = Zn _{4.0 kg} B _{2.0kg/ha}	4 kg Zn+2.0 kg B	(11.42 kg zinc sulphate +11.76 kg boric acid /ha)
T ₃ = Zn _{6kg} B _{2.5kg/ha}	6 kg Zn+2.5 kg B	(17.14 kg zinc sulphate +14.70 kg boric acid /ha)

Factor: B. (4 levels of fruit thinning)

T₀= without fruit thinning (Control)
 T₁= 10 fruits were retained per plant
 T₂= 20 fruits were retained per plant
 T₃=30 fruits were retained per plant

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height is an important parameter which reflects the vegetative growth of plant. It was measured at 20 days interval starting from 20 days after transplanting, and continued up to 80 days after transplanting. During the growth period, plant height was gradually increased with time and reached to the maximum at 80 DAT (Table 1). Plant height was significantly influenced by zinc and boron application. The results of the study demonstrated that, at each stage, plant height increased with increase in zinc and boron level.

At 80 DAT, and the highest plant height (103.86 cm) was observed from the T_3 ($Zn_{6kg} B_{2.5} kg/ha$) treatment and followed by T_2 (99.44cm) treatment, while it was the lowest (90.97cm) was found from T_0 (control) treatment which is statistically similar T_1 ($Zn_2 kg B_{1.5} kg/ha$) treatment. This might be due to the fact that the increase in plant height could be due to balanced absorption of nutrients, increased rate of photosynthesis and stimulation of root system. This finding of present study is in close conformity with the results of [9]. Zinc application also helps in increasing the uptake of nitrogen and potash [11]. Davis et al. [12] noticed that the total uptake of N, K, Mg and Ca by tomato plant increased with the application of boron. Makhan et al. [13] reported that Zinc may serve as source of energy for synthesis of auxin which helps in elongation of stem. Ali et al. [14] conducted an experiment to increase the yield of BARI hybrid tomato 4, cultivated in summer season of Bangladesh, foliar application of zinc and boron and supported the similar results.

The fruit thinning of tomato plant for seed production had significant effect on plant height (Table 2). At 80 DAT the tallest plant obtained from P_2 (97.94 cm) treatments where 20 fruits retained for seed production, which was statistically similar to P_3 (97.83 cm) treatment and shortest plant was observed from P_0 (93.43 cm) treatment. These results differed with that of [15] who reported that green fruit thinning had no effect on plant height. This might be due to the variation in growing environment and management practices. The combined effect of zinc and boron application with fruit thinning on the plant height at different days after transplanting was found statistically significant on all dates of observation (Table 3). At 80 DAT the

maximum plant height (108.27 cm) was measured from T_3P_2 treatment, which is statistically similar (104.00 cm and 103.00 cm) to T_3P_3 and T_3P_1 treatment combinations respectively. The lowest plant height (88.23 cm) was observed from T_0S_0 treatment. Hence, it may be inferred that the increase in plant height could be due to balanced absorption of nutrients, increased rate of photosynthesis and stimulation of root system. The findings of the present study are in close conformity with the results of [9].

3.2 Number of Branches per Plant

The significant difference was observed on number of branches $plant^{-1}$ due to the application of different levels of zinc and boron combination (Table 4). The maximum number of branches per plant (7.83) was obtained from T_3 ($Zn_{6kg} B_{2.5} kg/ha$) treatment and followed by (7.26) T_2 ($Zn_{4.0} kg B_{2.0} kg/ha$) treatment. On the other hand, the minimum number of branches per plant (5.19) was recorded from T_0 (control) treatment. Ullah et al. [16] found among different levels of Zn 0.4% showed significant increased in number of branches $plant^{-1}$ and yield ($t ha^{-1}$). Boron also significantly affected growth and yield components. Shnain et al. [17] supported the results.

The number of branches per plant was varied significantly among the treatments due to the fruit thinning at different levels (Table 5). The branch per plant was the lowest (6.26) in the plants where no fruits were thinning from P_0 (without fruit thinning) treatment and was statistically different from the plants where fruit thinning was made as per treatment. The number of branch per plant was the maximum (7.02) in the plants where 20 fruits retained for seed production which was statistically identical with P_3 (30 fruits retained) treatment. The result indicates that fruit thinning encouraged branching in plants.

The combined effect of zinc and boron application with fruit thinning was found significantly influenced on the number of branches per plant (Table 6). The maximum number of branches (8.50) per plant was observed from T_3P_2 treatment, which is statistically similar (8.00 and 7.76) to T_3P_3 and T_3P_1 treatment combinations respectively. The minimum number of branches (4.56) was observed from T_0P_0 treatment. Without zinc and boron might have reduced the efficiency of plants in uptaking the nutrients for normal growth.

Table 1. Effect of zinc and boron on plant height at different growth stages of tomato

Treatments	Plant height (cm)			
	20 DAT	40 DAT	60 DAT	80 DAT
T ₀	25.79 c	62.20 c	77.17 d	90.97 c
T ₁	26.84 c	69.49 b	82.57 c	91.01 c
T ₂	29.81 b	71.90 ab	85.92 b	99.44 b
T ₃	32.17 a	72.52 a	92.17 a	103.86 a
CV (%)	6.81	5.88	6.39	7.31
LSD _(0.05)	1.51	2.47	2.06	2.63

Means in a column followed by the same letter do not differ significantly at 5% level;
 Here, T₀ = Zn 0 kg B 0 kg/ha, T₁ = Zn 2 kg B 1.5 kg/ha, T₂ = Zn 4.0 kg B 2.0 kg/ha and T₃ = Zn 6 kg B 2.5 kg/ha

Table 2. Effect of fruit thinning on plant height (cm) at different growth stages of tomato

Treatments	Plant height (cm) at			
	20 DAT	40 DAT	60 DAT	80 DAT
P ₀	27.43 b	66.95 b	82.61 b	93.43 b
P ₁	28.63 ab	69.15 ab	81.87 b	96.06 b
P ₂	29.42 a	70.31 a	86.72 a	97.94 a
P ₃	29.13 a	69.708 a	86.63 a	97.83 a
CV (%)	6.81	5.88	6.39	7.31
LSD _(0.05)	1.01	1.32	2.55	1.25

Means in a column followed by the same letter do not differ significantly at 5% level;
 Here, Pruning P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂ = 20 fruits were retained/plant and P₃ = 30 fruits were retained/plant.

Table 3. Combined effects of zinc and boron nutrients with fruit thinning on plant height (cm) at different growth stages of tomato

Treatments	Plant height (cm) at			
	20 DAT	40 DAT	60 DAT	80 DAT
T ₀ P ₀	25.53 g	60.33 e	75.23 gh	88.23 fg
T ₀ P ₁	25.13 g	62.50 de	74.46 h	89.30 fg
T ₀ P ₂	25.43 g	63.46 de	79.56 f-h	91.93 fg
T ₀ P ₃	27.06 efg	62.53 de	79.43 f-h	93.50 efg
T ₁ P ₀	25.46 g	66.40 cd	80.60 e-g	89.30 g
T ₁ P ₁	27.33 efg	70.53 bc	80.86 e-g	90.93 fg
T ₁ P ₂	26.83 fg	70.50 bc	82.60 def	90.93 fg
T ₁ P ₃	27.73 d-g	70.53 bc	86.23 b-e	93.77 d-g
T ₂ P ₀	29.13 c-f	71.26 abc	84.40 cdef	96.03 c-f
T ₂ P ₁	29.60 c-f	72.20 ab	81.53 ef	101.03 b-d
T ₂ P ₂	30.53 b-d	71.46 ab	88.20 bcd	100.63 c-e
T ₂ P ₃	30.00 b-e	72.66 ab	89.56 bc	100.07 c-e
T ₃ P ₀	29.60 c-f	69.80 bc	90.23 bc	100.17 c-e
T ₃ P ₁	32.46 ab	71.36 ab	90.63 ab	103.00 a-c
T ₃ P ₂	34.90 a	75.83 a	96.53 a	108.27 a
T ₃ P ₃	31.73 bc	73.10 ab	91.30 ab	104.00 ab
CV (%)	6.81	5.88	6.39	7.31
LSD _(0.05)	3.03	4.94	4.12	5.27

Means in a column followed by the same letter do not differ significantly at 5% level;
 Here, T₀ = Zn 0 kg B 0 kg/ha, T₁ = Zn 2 kg B 1.5 kg/ha, T₂ = Zn 4.0 kg B 2.0 kg/ha and T₃ = Zn 6 kg B 2.5 kg/ha
 and P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂ = 20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

Table 4. Effect of zinc and boron nutrients on number of branches per plant and first flower of tomato

Treatments	Number of branches per plant	Days to first flowering
T ₀	5.19 d	37.44 a
T ₁	6.54 c	35.42 b
T ₂	7.26 b	30.77 c
T ₃	7.83 a	31.81 c
CV (%)	11.25	10.63
LSD _(0.05)	0.42	1.21

Means in a column followed by the same letter do not differ significantly at 5% level;
Here, T₀ = Zn₀ kg B₀ kg/ha, T₁ = Zn 2 kg B_{1.5} kg/ha, T₂ = Zn 4.0 kg B_{2.0} kg/ha and T₃ = Zn 6kg B_{2.5} kg/ha

Table 5. Effect of fruit thinning on branches per plant and days to first flowering of tomato

Treatments	Number of branches per plant	Days to first flowering
P ₀	6.26 b	35.80
P ₁	6.52 b	33.29
P ₂	7.02 a	33.39
P ₃	7.01 a	32.96
CV (%)	11.25	10.63
LSD _(0.05)	0.34	---

Means in a column followed by the same letter do not differ significantly at 5% level;
And P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂ = 20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

Table 6. Combined effect of zinc and boron with fruit thinning on number of branches per plant and days to first flowering of tomato

Treatments	Number of branches per plant	Days to first flowering
T ₀ P ₀	4.56 j	39.51 a
T ₀ P ₁	5.00 ij	38.13 ab
T ₀ P ₂	5.46 hi	37.31 abc
T ₀ P ₃	5.73 ghi	34.82 cd
T ₁ P ₀	6.56 fg	37.39 abc
T ₁ P ₁	6.30 fgh	31.70 e
T ₁ P ₂	6.66 ef	36.11 bc
T ₁ P ₃	6.63 ef	36.47 bc
T ₂ P ₀	6.86 def	30.86 ef
T ₂ P ₁	7.03 cdef	31.19 ef
T ₂ P ₂	7.46 bcde	31.51 ef
T ₂ P ₃	7.70 abcd	29.52 ef
T ₃ P ₀	7.06 cdef	35.43 bc
T ₃ P ₁	7.76 abc	32.14 de
T ₃ P ₂	8.50 a	28.63 f
T ₃ P ₃	8.00 ab	31.04 ef
CV (%)	11.25	10.63
LSD _(0.05)	0.84	2.02

Means in a column followed by the same letter do not differ significantly at 5% level;
Here, T₀ = Zn₀ kg B₀ kg/ha, T₁ = Zn 2 kg B_{1.5} kg/ha, T₂ = Zn 4.0 kg B_{2.0} kg/ha and T₃ = Zn 6kg B_{2.5} kg/ha.
and P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂ = 20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

In most cases the number of branches per plant increased with the increasing levels of zinc and boron. This might be due to the fact that zinc and boron influence the cell division, meristematic

activity of tissue expansion of cell and formation of cell wall and helps in increasing the uptake of other nutrients especially nitrogen and potash. Yadiv et al. [11] obtained maximum secondary

branches with the application of 7.5 ppm zinc and 100 ppm boron.

3.3 Days to First Flowering

The significant difference was observed on days to first flowering due to the application of zinc and boron on days to first flowering (Table 4). The maximum days required to first flowering (37.44 days) was found from T_0 (control) treatment and followed by T_1 (35.42 days) treatment. The period was maximum when no zinc and no boron were applied. This result is in agreement with the findings of [18] and [19]. On the other hand, the minimum days required to first flowering (30.77 days) was recorded from T_2 treatment which is statistically identical to T_3 treatment. This might be due to a positive role of regulating the zinc and boron helps in balanced absorption of nutrients leading to favorable C: N ratio. Patil et al. [20] obtained the minimum number of days for initiation of flowering and 50% flowering with Boron 50ppm and 100ppm application, while the maximum number of days was recorded in control.

The fruit thinning treatments had no significant effect on the days to first flowering (Table 5). The number of days took by the plants for first flowering ranged from 32.96 (in which 30 fruits were retained) to 35.80 days (in plants where without fruit thinning). The longest period for first flowering took by the P_0 treatment and was comparable to that of other treatments. The combined effect of zinc and boron application with fruit thinning was found significantly influenced on the days required to first flowering per plant (Table 6). The maximum days to first flowering 39.51 days was observed from T_0P_0 treatment, which is statistically similar 38.13, 37.31 and 37.39 days to T_0P_1 , T_0P_2 and T_1P_0 treatment combinations respectively. The minimum (28.63) days was observed from T_3P_2 treatment.

3.4 Number of Clusters per Plant at 60 DAT

The significant difference was observed on number of clusters per plant at 60 DAT due to the application of zinc and boron micro nutrients (Table 7). The maximum number of clusters per plant (24.15) was obtained from T_3 ($Zn_{6kg} B_{2.5kg/ha}$) treatment which was statistically identical to T_2 (22.55) treatment .On the other hand, the minimum number of clusters per plant (15.24) was recorded from T_0 (control) treatment which is statistically similar to T_1 treatment. Lack of Zn, B renders the plants incapable of up taking the nutrients for normal growth and development. This might lead to poor growth. The optimum dose of micronutrients probably leads to better performance of the crop resulting in the production of maximum number of cluster. Ullah et al. [16] found among different levels of Zn 0.4% showed significant increased in number of flowers cluster per plant, number of flowers per cluster, number of fruits per cluster and yield ($t ha^{-1}$). Boron also significantly affected growth and yield components.

Data presented in Table 7 showed that number of clusters per plant at 60 DAT differed significantly due to fruit thinning. It was revealed that number of cluster was increased with the increasing zinc and boron levels. The highest number of cluster (21.80) was observed from P_2 (20 fruits were retained/plant) treatment which was statistically identical (21.56) with P_3 (30 fruits were retained/plant) treatment and lowest number of cluster (19.24) per plant was observed from P_0 (without fruit thinning/plant) treatment. The combined effect of zinc and boron application with fruit thinning was found significantly influenced on the number clusters per plant at 60 DAT (Table 7). The highest number of clusters per plant was observed from T_3P_2 (26.20) treatment, which is statistically

Table 7. Effect of zinc and boron on cluster per plant at 60 DAT, flower per plant, flower per cluster of tomato

Treatments	Number of cluster per plant at 60 DAT	Number of flowers per plant	Number of flowers per cluster
T_0	15.24 c	41.57 c	3.95 d
T_1	21.00 b	54.63 b	5.41 c
T_2	22.55 ab	65.72 a	6.60 b
T_3	24.15 a	66.26 a	7.11 a
CV (%)	11.93	7.68	8.82
LSD _(0.05)	1.75	4.34	0.21

Means in a column followed by the same letter do not differ significantly at 5% level;
Here, $T_0 = Zn_0 kg B_0 kg/ha$, $T_1 = Zn_2 kg B_{1.5} kg/ha$, $T_2 = Zn_{4.0} kg B_{2.0} kg/ha$ and $T_3 = Zn_{6kg} B_{2.5} kg/ha$

Table 8. Effect of fruit thinning on number of cluster per plant at 60 DAT, number of flowers per plant and number of flowers per cluster of tomato

Treatments	Number of cluster per plant at 60 DAT	Number of flowers per plant	Number of flowers per cluster
P ₀	19.24 b	53.59 d	5.40
P ₁	20.33 ab	56.50 c	5.78
P ₂	21.80 a	59.87 b	5.95
P ₃	21.56 a	58.23 a	5.94
CV (%)	11.93	7.68	8.82
LSD _(0.05)	0.72	1.08	---

Means in a column followed by the same letter do not differ significantly at 5% level;

And P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂ = 20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

similar to T₃P₁, T₂P₃, T₃P₃ and T₃P₀ treatment combinations respectively. The minimum number of clusters (14.20) per plant was observed from T₀P₀ treatment. This might be fact that the combination of zinc, boron provides good physical soil condition for better growth as well as supplies sufficient nutrients to the plant that help than to produce maximum number of cluster per plant.

3.5 Number of Flowers per Plant

The significant variation was observed in respect of number of flowers per plant due to the application of different levels of zinc and boron (Table 7). The maximum number of flowers per plant (66.26) was found from T₃ (Zn₆ B_{2.5} kg/ha) treatment which is statistically similar (65.72) to T₂ (Zn_{4.0} kg B_{2.0} kg/ha) treatment. On the other hand, the minimum number of flowers (41.57) was recorded from T₀(control) treatment. Katyal and Randhawa [21] stated that boron increases the stability of plant cells and is involved in the reproductive process of plants and its inadequacy is often associated with sterility and malformation of reproductive organs. Sivaiah et al. [22] found combined application of micronutrients produced the maximum fruit yield followed by application of boron and zinc.

The fruit thinning treatments had no significant effect on the number of flowers per plant (Table 8). The number of flowers per plant ranged from 53.59 to 59.87. The maximum number of flowers per plant (59.87) was found from P₂ (20 fruits were retained/plant) treatment and the minimum number of flowers (53.59) per cluster was recorded from P₀ (without fruit thinning).

The combined effect of zinc and boron application with fruit thinning was found significantly influenced on the on the number of

flowers per plant (Table 9). The maximum number of flowers per cluster (70.70) was observed from T₃P₂ treatment, which is statistically identical (69.03 and 68.20) to T₃P₃ and T₂P₃ treatment combinations and similar to T₂P₁, T₂P₂, T₃P₁ and T₂P₀ respectively. The minimum number of flowers per plant (34.36) was observed from T₀P₀ treatment.

3.6 Number of Flowers per Cluster

The number of flowers per cluster increased significantly with an increase in zinc and boron levels (Table 7). The maximum number of flowers per cluster (7.11) was found from T₃ (Zn₆ kg B_{2.5} kg/ha.) treatment and followed (6.60) by T₂ (Zn_{4.0} kg B_{2.0} kg/ha). On the other hand, the minimum number of flowers (3.95) per cluster was recorded from T₀ (control). Similar observation was reported by [16]. The fruit thinning treatments had no significant effect on the number of flowers per cluster (Table 8). The number of flowers per cluster ranged from 5.40 to 5.95. The maximum number of flowers per cluster (5.95) was found from P₂ (20 fruits were retained/plant) treatment and the minimum number of flowers (5.40) per cluster was recorded from P₀ (without fruit thinning). The combined effect of zinc and boron application with fruit thinning was found significantly influenced on the on the number of flowers per cluster (Table 9). The maximum number of flowers per cluster (7.56) was observed from T₃P₂ treatment, which is statistically similar (7.23) to T₃P₃ treatment combinations respectively. The minimum number of flowers per cluster (3.46) was observed from T₀P₀ treatment.

3.7 Fruit Length (cm)

The length of fruit was found to vary significantly due to the effect of zinc and boron application

Table 9. Combined effect of zinc, boron and fruit thinning on number of cluster per plant at 60 DAT, number of flowers per plant and number of flowers per cluster of tomato

Treatments	Number of cluster per plant at 60 DAT	Number of flowers per plant	Number of flowers per cluster
T ₀ P ₀	14.20 e	38.56 gh	3.46 l
T ₀ P ₁	14.96 e	43.76 f-h	3.73 kl
T ₀ P ₂	15.30 e	49.60 e-g	4.03 k
T ₀ P ₃	16.50 de	34.36 h	4.60 j
T ₁ P ₀	19.43 cd	50.93 d-g	4.86 ij
T ₁ P ₁	20.50 bc	52.06 c-f	5.16 hi
T ₁ P ₂	22.03 bc	54.20 c-f	5.53 gh
T ₁ P ₃	22.03 bc	61.33 b-e	6.10 f
T ₂ P ₀	20.66 bc	63.60 a-d	6.73 c-e
T ₂ P ₁	21.96 bc	66.10 ab	7.13 bc
T ₂ P ₂	23.70 ab	65.00 ab	6.70 de
T ₂ P ₃	23.90 ab	68.20 a	5.83 fg
T ₃ P ₀	22.66 a-c	61.26 b-e	6.56 e
T ₃ P ₁	23.90 ab	64.067 a-c	7.10 b-d
T ₃ P ₂	26.20 a	70.70 a	7.56 a
T ₃ P ₃	23.83 ab	69.03 a	7.23 ab
CV (%)	11.93	7.68	8.82
LSD _(0.05)	2.90	8.69	0.43

Means in a column followed by the same letter do not differ significantly at 5% level;

Here, T₀ = Zn_{0 kg}B_{0 kg/ha}, T₁ = Zn_{2 kg}B_{1.5 kg/ha}, T₂ = Zn_{4.0 kg}B_{2.0 kg/ha} and T₃ = Zn_{6 kg} B_{2.5 kg/ha}.

And P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂ = 20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

Table 10. Effect of zinc and boron on fruit length, fruit diameter, individual fruit weight and fruit yield per plot of tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Fruit yield/plot (kg)
T ₀	5.93 d	5.30	93.21 c	10.80 d
T ₁	6.20 c	5.55	106.47 b	12.70 c
T ₂	6.51 b	5.49	107.48 b	14.63 b
T ₃	6.72 a	5.68	112.74 a	19.05 a
CV (%)	9.26	10.05	11.25	10.63
LSD _(0.05)	0.18	---	2.39	1.22

Means in a column followed by the same letter do not differ significantly at 5% level;

Here, T₀ = Zn_{0 kg}B_{0 kg/ha}, T₁ = Zn_{2 kg}B_{1.5 kg/ha}, T₂ = Zn_{4.0 kg}B_{2.0 kg/ha} and T₃ = Zn_{6 kg} B_{2.5 kg/ha}

Table 11. Effect of fruit thinning on fruit length, fruit diameter, individual fruit weight and fruit yield per plot of tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Fruit yield/plot (kg)
P ₀	6.08 c	5.18	97.87 c	10.91 c
P ₁	6.59 a	5.76	111.05 a	13.98 b
P ₂	6.35 b	5.67	107.21 ab	15.71 a
P ₃	6.34 b	5.40	103.77 b	16.54 a
CV (%)	9.26	10.05	11.25	10.63
LSD _(0.05)	0.19	---	4.12	1.67

Means in a column followed by the same letter do not differ significantly at 5% level;

P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂ = 20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

(Table 10) and increased with the increased dose of zinc and boron. The maximum length of fruit (6.72 cm) was found from T₃ (Zn₆ B_{2.5} kg/ha) treatment and followed by (6.51 cm) T₂ (Zn₄ B₂ kg/ ha) treatment while, the minimum length of fruit (5.93cm) was recorded from T₀ (control) treatment. The increase in fruit length was associated with increase in size of fruit, and was probably due to increased photosynthesis and translocation of food materials. Similar observation was reported by [23]. Luis et al., 2012 [24] also supported the similar results.

The fruit thinning treatments was found significant effect in this respect (Table 11). The maximum fruit length (6.59 cm) was found from P₁ (10 fruits were retained/plant) treatment and the minimum length (6.08 cm) was recorded from P₀ (without fruit thinning). The combined effect of zinc and boron application with fruit thinning was found significantly influenced on the on the length of fruit (Table 12). The maximum fruit length (7.06 cm) was observed from T₃P₁ treatment, which is statistically similar to T₃P₂, T₃P₃ and T₂P₁ treatment combinations respectively. The minimum fruit length (5.83cm) was observed from T₀P₀ treatment.

3.8 Fruit Diameter (cm)

There was no significant variation among the treatments in respect of fruit diameter, which range from 5.30 cm under control to 5.68 cm in 6 kg zinc and 2.5 kg boron/ha. (Table 10). The fruit thinning treatments had no significant effect in this respect (Table 11). The fruit diameter ranged from 5.18cm to 5.40cm. The maximum diameter (5.40cm) was found from P₂ (20 fruits were retained/plant) treatment and the minimum was recorded from P₀ (without fruit thinning). The combined effect of zinc and boron application with fruit thinning was found no significant variation on diameter of fruit (Table 12). The maximum diameter of fruit (6.06cm) was observed from T₃P₁ treatment and the minimum diameter (5.10cm) was observed from T₀P₀ treatment.

3.9 Individual Fruit Weight (g)

Distinct variation was observed among the treatments due to the application of different levels of zinc and boron. (Table 10). It was found that individual weight of fruit increased with an increase in zinc and boron levels. The highest fruit weight (112.74 g) was recorded from T₃

Table 12. Combined effect of zinc and boron with fruit thinning on fruit length, fruit diameter, individual fruit weight and fruit yield per plot of tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Fruit yield/plot (kg)
T ₀ P ₀	5.83 f	5.10	83.90 h	7.97 h
T ₀ P ₁	6.10 ef	5.13	97.63 efg	9.75 gh
T ₀ P ₂	5.93 f	5.43	94.87 g	12.55 de
T ₀ P ₃	5.86 f	5.53	96.43 fg	12.92 de
T ₁ P ₀	5.93 f	5.30	106.27 c-f	10.60 fg
T ₁ P ₁	6.46 cde	5.66	107.87 b-e	13.31 de
T ₁ P ₂	6.20 def	5.93	108.93 b-d	13.41 de
T ₁ P ₃	6.20 def	5.30	102.80 d-g	13.48 d
T ₂ P ₀	6.36 cde	5.16	97.60 efg	11.64 ef
T ₂ P ₁	6.73 abc	5.80	117.07 ab	13.31 de
T ₂ P ₂	6.40 cde	5.46	110.03 b-d	16.22 c
T ₂ P ₃	6.56 bcd	5.53	105.23d-g	17.37 c
T ₃ P ₀	6.20 def	5.13	103.70 d-g	13.41 de
T ₃ P ₁	7.06 a	6.06	121.63 a	19.55 b
T ₃ P ₂	6.90 ab	5.86	115.00 a-c	20.68 ab
T ₃ P ₃	6.73 abc	5.66	110.63 b-d	22.37 a
CV (%)	9.26	10.05	11.25	10.63
LSD _(0.05)	0.37	---	8.79	1.78

Means in a column followed by the same letter do not differ significantly at 5% level;

Here, T₀ = Zn₀ kg B₀ kg/ha, T₁ = Zn₂ kg B_{1.5} kg/ha, T₂ = Zn_{4.0} kg B_{2.0} kg/ha and T₃ = Zn₆ kg B_{2.5} kg/ha.

And P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂ = 20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

(Zn₆ B_{2.5} kg /ha) treatment and followed by (107.48 g) T₂ and T₁ treatments, while the lowest weight of fruit (93.21 g) was recorded from T₀ (control) treatment. It may be possible that zinc and boron did accelerate the photosynthetic process and translocation of food materials. Huang and Snapp, 2009 [25] and Nada *et al.*, 2010 [26] supported the similar results. The treatments of fruit thinning per plant differed significantly in respect of fruit weight (Table 11). The treatment P₁ (10 fruits were retained/plant) produced the highest weight (111.05g) of individual fruit, which was statistically similar (107.21g) to P₂ (20 fruits were retained/plan) treatment. The minimum weight (97.87 g) was recorded from P₀ (without fruit thinning) treatment.

The combined effect of zinc and boron application with fruit thinning was found significant variation on weight of individual fruit (Table 12). The maximum weight (121.63g) of individual fruit was observed from T₃P₁ treatment, which was statistically similar to T₃P₂ (115.00 g) treatment and the minimum weight (83.90 g) was observed from T₀P₀ treatment. It was observed that the highest weight of individual fruit produced plants receiving more zinc and boron level with minimum number of fruits were retained. On the other hand minimum weight of individual fruit was obtained from the plants receiving no zinc and boron with without fruit thinning. This might be due to zinc and boron increased photosynthesis and translocation of food materials in fruits. Paithankar *et al.*, 2004 [27] reported in tomato highest number of fruits and weight due to micro nutrient application.

3.10 Fruit Yield per Plot (kg)

A significant difference in yield of tomato fruits per plot among the treatments of zinc and boron was observed (Table 10). The highest fruit yield per plot (19.05 kg) was found from T₃ (Zn₆ B_{2.5} kg /ha) treatment and followed by (14.63 kg) T₂ (Zn₄ B₂ kg/ ha) treatment. On the other hand, the lowest fruit yield per plot (10.80kg) was recorded from T₀ (control) treatment. Ali *et al.*, 2015 [14] conducted an experiment to increase the yield of BARI hybrid tomato 4, cultivated in the summer season of Bangladesh, foliar application of zinc and boron and supported the similar results. Naz *et al.*, 2012 [28] conducted a study to observe the effect of Boron on physiological growth on tomato. They reported that boron also plays an important role in production of any crop in terms

of yield, quality and control of some diseases and increase the yield.

The treatments of fruit thinning per plant differed significantly in respect of fruit yield per plot (Table 11). The treatment P₃ (30 fruits were retained/plant) produced the highest fruit yield (16.54kg) of tomato per plot, which was statistically similar (15.71 kg) to P₂ (20 fruits were retained/plan) treatment. The minimum yield (10.91 kg) per plot was recorded from P₀ (without fruit thinning) treatment. The combined effect of zinc and boron application with fruit thinning was found significant variation on fruit yield per plot (Table 12). The maximum fruit yield (22.37 kg) of tomato per plot was observed from T₃P₃ treatment, which was statistically similar to T₃P₂ (20.68 kg) treatment and the minimum yield (7.97 kg) per plot was observed from T₀P₀ treatment. Paithankar *et al.*, 2004 [27] reported in tomato highest number of fruits and weight due to micro nutrient application.

3.11 Number of Seeds per Fruit

The significant difference was observed on number of seeds per tomato fruit due to the application of different micro nutrients (Table 13). The maximum number of seeds per fruit (138.42) was found from T₃ (Zn₆ B_{2.5} kg /ha) treatment and followed by (133.25) T₂ (Zn₄ B₂ kg/ ha) treatment. On the other hand, the lowest (124.08) was recorded from T₀ (control) treatment. The results revealed that number of seeds per fruit increased with the increasing dose of micronutrients but without micro nutrients it decreased. Possibly zinc and boron increased the photosynthetic rate and translocation of food materials to seed resulting increased number of seeds per fruit. Kumari, 2005 [19] suggested that 100 ppm boron spray 30 days after transplanting and repeated at 10 days interval twice in tomato could result in maximum seed yield.

The treatments of fruit thinning per plant differed significantly in respect of number of seeds per fruit of tomato (Table 14).The treatment P₃ (30 fruits were retained/plant) produced the highest number of seeds (151.17) per fruit. The minimum number of seeds (98.83) per fruit was recorded from P₀ (without fruit thinning) treatment. The combined effect of zinc and boron application with fruit thinning was found significant variation on number of seeds per fruit (Table 15). The maximum seeds per fruit (163.67) was observed from T₃P₃ treatment, which was statistically similar to T₁P₁ (155.67), T₁P₁ (155.33) and

Table 13. Effect of zinc and boron on number of seeds per fruit, seed weight per fruit and seed yield per plot of tomato

Treatments	Number of seeds /fruit	Weight of seeds per fruit (g)	Seed yield/plant (g)	Seed yield/plot (g)
T ₀	124.08 c	0.496 c	5.54 c	78.21 d
T ₁	132.08 b	0.528 b	5.91 bc	83.76 c
T ₂	133.25 b	0.533 b	6.30 ab	86.23 b
T ₃	138.42 a	0.557 a	6.41 a	89.35 a
CV (%)	6.46	7.46	9.65	8.54
LSD _(0.05)	3.61	0.015	0.38	2.28

Means in a column followed by the same letter do not differ significantly at 5% level,
Here, T₀ = Zn_{0 kg}B_{0 kg/ha}, T₁ = Zn_{2 kg}B_{1.5 kg/ha}, T₂ = Zn_{4.0 kg}B_{2.0kg/ha} and T₃ = Zn_{6kg} B_{2.5kg/ha}

Table 14. Effect of fruit thinning on number of seeds per fruit, seed weight per fruit and seed yield per plot of tomato

Treatments	Number of Seeds/fruit	Weight of seeds/fruit (g)	Seed yield/plant (g)	Seed yield/plot (g)
P ₀	98.83 c	0.395 c	7.31 b	98.14 b
P ₁	136.25 b	0.545 b	3.02 d	57.21 d
P ₂	141.58 b	0.566 b	5.66 c	80.97 c
P ₃	151.17 a	0.604 a	8.17 a	101.22 a
CV (%)	6.46	7.46	9.65	8.54
LSD _(0.05)	7.45	0.034	0.74	2.68

Means in a column followed by the same letter do not differ significantly at 5% level;
And P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂=20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

Table 15. Combined effect of zinc and boron with fruit thinning on number of seeds per fruit, seed weight per fruit, seed yield per plot and seed yield per hectare of tomato

Treatments	Number of Seeds/fruit	weight of seeds/fruit (g)	Seed yield/plant (g)	Seed yield/plot (g)	Seed yield /hectare (kg)
T ₀ P ₀	97.67 f	0.397 f	6.25 d	86.25 d	287.49 d
T ₀ P ₁	134.00 de	0.530 de	2.68 f	54.12 f	180.39 f
T ₀ P ₂	131.00 de	0.520 de	5.24 e	77.16 e	257.19 e
T ₀ P ₃	133.67 de	0.537 de	6.32 d	95.31 c	317.69 c
T ₁ P ₀	103.67 f	0.417 f	7.25 c	102.18 bc	340.59 bc
T ₁ P ₁	155.67 ab	0.540 c-e	3.11 f	58.02 f	193.39 f
T ₁ P ₂	143.00 b-d	0.570 b-d	5.72 de	79.32 de	264.39 de
T ₁ P ₃	126.00 e	0.500 e	5.48 de	95.52 c	286.39d
T ₂ P ₀	93.33 f	0.373 f	7.28 c	98.04 bc	326.79 bc
T ₂ P ₁	144.67 b-d	0.570 b-d	3.27 f	59.46 f	198.19 f
T ₂ P ₂	155.33 ab	0.620 ab	6.21 d	81.48 de	271.59 de
T ₂ P ₃	140.67 b-e	0.602 a-c	7.56 bc	85.92d	318.39 c
T ₃ P ₀	100.67 f	0.401 f	7.35 c	106.12 b	345.73 bc
T ₃ P ₁	137.00 c-e	0.560 b-e	3.02 f	57.24 f	190.79 f
T ₃ P ₂	151.33 a-c	0.620 ab	8.44 ab	105.96 b	353.19 b
T ₃ P ₃	163.67 a	0.654 a	8.68 a	108.12 a	360.39 a
CV (%)	6.46	7.46	9.65	8.54	10.45
LSD _(0.05)	10.22	0.061	0.87	1.85	5.45

Means in a column followed by the same letter do not differ significantly at 5% level;
Here, T₀ = Zn_{0 kg}B_{0 kg/ha}, T₁ = Zn_{2 kg}B_{1.5 kg/ha}, T₂ = Zn_{4.0 kg}B_{2.0kg/ha} and T₃ = Zn_{6kg} B_{2.5kg/ha}.
and P₀ = without fruit thinning per plant, P₁ = 10 fruits were retained/plant, P₂=20 fruits were retained/plant and P₃ = 30 fruits were retained per plant

T₃P₂ (151.33) treatments respectively, while the minimum seeds (97.67) per fruit was observed from T₀P₀ treatment.

3.12 Weight of Seeds per Fruit

The effects of micronutrients on the weight of seeds per fruit of tomato were found to be statistically significant (Table 13). The maximum weight of seeds per fruit (0.557g) was found from T₃ (Zn₆ B_{2.5} kg /ha) treatment and followed by (0.533g) T₂ (Zn₄ B₂ kg/ ha) treatment. On the other hand, the lowest (0.496g) was recorded from T₀ (control) treatment. The treatments of fruit thinning per plant differed significantly in respect of weight of seeds per fruit (Table 14). The treatment P₃ (30 fruits were retained/plant) produced the highest weight of seeds (0.604g) per fruit of tomato . The minimum weight of seeds (0.395g) per fruit was recorded from P₀ (without fruit thinning) treatment.

The combined effect of zinc and boron application with fruit thinning was found significant variation on weight of seeds per fruit of tomato (Table 15). The maximum weight of seeds per fruit (0.654g) was observed from T₃P₃ treatment, which was statistically similar to T₃P₂, T₂P₂ and T₂P₃ treatments respectively, while the minimum weight of seeds (0.397g) per fruit was observed from T₀P₀ treatment.

3.13 Seed Yield per Plant

Significant influence was also found as to the tomato seed yield per plant due to the application of different levels of micronutrients (Table 13). It ranged from 6.41g to 5.54g. Distinct variation was observed as to the varied levels of zinc and boron regarding this trait. The maximum seeds yield per plot (6.41g) was found from T₃ (Zn₆ kg B_{2.5} kg /ha) treatment which was statistically similar to (6.30g) T₂ (Zn_{4kg} B₂ kg /ha) treatment. On the other hand, the lowest (5.54 g) was recorded from T₀ (control) treatment. Seed yield per plant differed significantly due to the fruit thinning per plant (Table 14). The highest tomato seed yield (8.17g) per plant was found with P₃ (30 fruits were retained per plant) treatment and followed by (7.31g) P₀ (without fruit thinning per plant) treatment. Besides the lowest seed yield (3.02 g) per plant was recorded from P₁ (10 fruits were retained per plant) treatment.

The combined effect of different levels of micronutrient application with fruit thinning was found statistically significant variation on seed yield per plant of tomato (Table 15). The

maximum seed yield per plant (8.68g) was observed from T₃P₃ treatment, which was statistically similar to T₃P₂ (8.44 g) treatment, while the minimum yield (2.68 g) per plant was observed from T₀P₁ treatment which was statistically identical with T₁P₁, T₂P₁ and T₃P₁ treatments respectively.

3.14 Seed Yield per Plot

Significant influence was found as to the seed yield per plot of tomato due to the application of different levels of micronutrients (Table 13). The maximum seed yield per plot (89.35g) was found from T₃ (Zn₆ kg B_{2.5} kg /ha) treatment and followed by (86.23g) T₂ (Zn_{4kg} B₂ kg /ha) treatment. On the other hand, the lowest (78.21 g) was recorded from T₀ (control) treatment. Seed yield of tomato per plot differed significantly due to the fruit thinning per plant (Table 14). The highest seed yield (101.22 g) per plot was found with P₃ (30 fruits were retained per plant) treatment and followed by (98.14g) P₀ (without fruit thinning per plant) treatment. Besides the lowest seed yield (57.21 g) per plot was recorded from P₁ (10 fruits were retained per plant) treatment. The combined effect of different levels of micronutrient application with fruit thinning was found statistically significant variation on seed yield of tomato per plot (Table 15). The maximum seed yield per plot (108.12 g) was observed from T₃P₃ treatment, while the minimum yield (54.12g) per plot was observed from T₀P₁ treatment which was statistically identical with T₁P₁, T₂P₁ and T₃P₁ treatments respectively.

3.15 Seed Yield per Hectare

Seed yield per hectare of tomato was found to be significantly influenced by the application of different levels of micronutrients (Fig. 1). The maximum seed yield per hectare (297.82 kg) was found from T₃ (Zn₆ kg B_{2.5} kg /ha) treatment and followed by (287.44 kg) T₂ (Zn_{4kg} B₂ kg /ha) treatment. On the other hand, the lowest (260.69kg) was recorded from T₀ (control) treatment.

Seed yield of tomato per hectare significantly varied due to the fruit thinning per plant (Fig. 2). The highest seed yield (337.41 kg) per hectare was found from P₃ (30 fruits were retained per plant) treatment and followed by (327.15 kg) P₀ (without fruit thinning per plant) treatment. Besides the lowest seed yield (190.69 kg) per hectare was recorded from P₁ (10 fruits were retained per plant) treatment.

The combined effect of different levels of micronutrient application with fruit thinning was found statistically significant variation on seed yield of tomato per hectare (Table 15). The maximum seed yield per hectare (360.39 kg) was observed from T₃P₃ treatment, while the minimum yield (180.39 kg) per hectare was observed from T₀P₁ treatment.

3.16 Seed Germination Percentage

Application of different levels of zinc boron combinations showed non-significant effect on the percent seed germination of tomato (Table 16). The germination percentage varied from 97.83% to 96.66%. The effect of different levels of fruit thinning was found to be non-significant on the seed germination percentage (Table 17). The combined effect of both was also found to be statistically non-significant in this respect (Table 18). Singh and Kanwar, 1995 [15] reported that fruit thinning had no effect on

germination percentage of seeds. Similar results were also reported by [29].

3.17 Seed Vigor Index

The variation in the vigor of produced seed was found significant in tomato due to the application of different levels of zinc and boron combinations (Table 16). It was observed that the highest seed vigor index (1234.2) was found in T₂ (Zn 4.0 kg B_{2.0} kg/ha) treatment and T₀ (Zn 0.0 kg B₀ kg/ha) treatment gave the lowest seed vigor index (848.9). Seed vigor index significantly varied due to the fruit thinning per plant (Table 17). The highest seed vigor index (1163.3) was found from P₂ (20 fruits were retained per plant) treatment which was statistically identical to (1145.0) P₃ (30 fruits were retained per plant) treatment. Besides the lowest seed vigor index (897.9) was recorded from P₀ (without fruit thinning per plant) treatment. The combined effect of zinc boron combinations with fruit

Table 16. Effect of zinc and boron on germination percentage and vigor index of tomato Seeds

Treatments	Seed germination %	Vigor index
T ₀	96.66	848.9 d
T ₁	97.41	1043.7 c
T ₂	97.83	1234.2 a
T ₃	97.16	1132.8 b
CV (%)	10.34	12.56
LSD _(0.05)	---	66.58

Means in a column followed by the same letter do not differ significantly at 5% level,
Here, T₀ = Zn₀ kg B₀ kg/ha, T₁ = Zn 2 kg B_{1.5} kg/ha, T₂ = Zn 4.0 kg B_{2.0} kg/ha and T₃ = Zn 6 kg B_{2.5} kg/ha

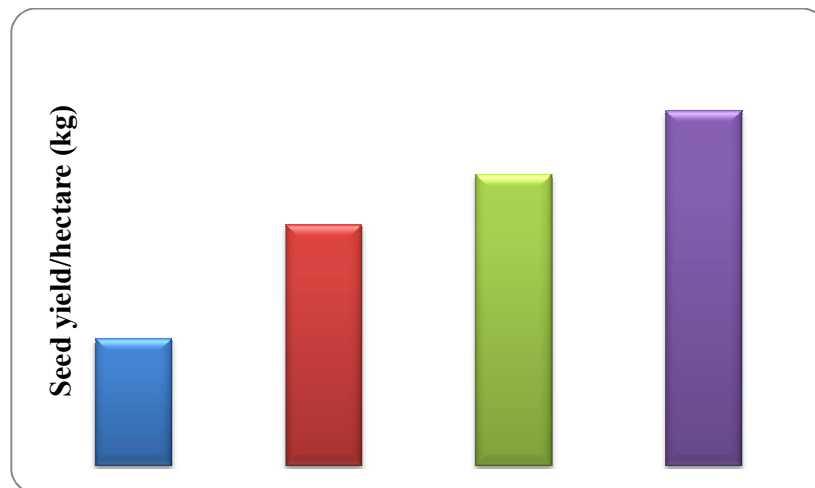


Fig. 1. Effect of zinc and boron on seed yield per hectare of tomato
Here, T₀ = Zn₀ kg B₀ kg/ha, T₁ = Zn 2 kg B_{1.5} kg/ha, T₂ = Zn 4.0 kg B_{2.0} kg/ha and T₃ = Zn 6 kg B_{2.5} kg/ha.

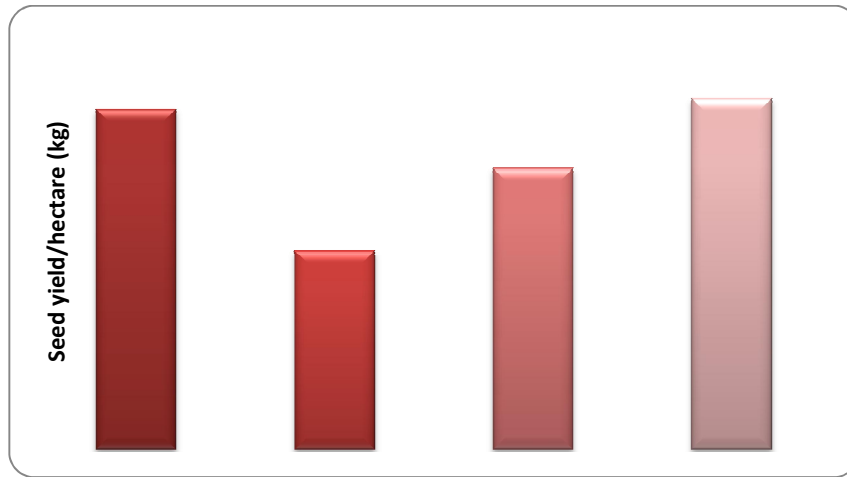


Fig. 2. Effect of fruit thinning on seed yield per hectare of tomato

Here, P₀ = without fruit thinning per plant, P₁ = 10 fruits were retained/plant, P₂=20 fruits were retained/plant and P₃ = 30 fruits were retained per plant

Table 17. Effect of fruit thinning on germination percentage and vigor index of tomato seeds

Treatments	Seed germination %	Vigor index
P ₀	96.83	897.9 c
P ₁	97.75	1053.4 b
P ₂	97.58	1163.3 a
P ₃	96.91	1145.0 a
CV (%)	10.34	12.56
LSD _(0.05)	---	71.43

Means in a column followed by the same letter do not differ significantly at 5% level; and P₀ = without fruit thinning/plant, P₁ = 10 fruits were retained/plant, P₂=20 fruits were retained/plant and P₃ = 30 fruits were retained/plant

Table 18. Combined effect of zinc and boron with fruit thinning on germination percentage and vigor index of tomato seeds

Treatments	Seed germination %	Vigor index
T ₀ P ₀	95.33	642.5 i
T ₀ P ₁	96.33	747.1 hi
T ₀ P ₂	97.66	1048.5efg
T ₀ P ₃	97.33	957.5fg
T ₁ P ₀	97.66	692.8 i
T ₁ P ₁	99.00	1227.9 bcd
T ₁ P ₂	96.66	1241.8 bcd
T ₁ P ₃	96.33	1012.5 efg
T ₂ P ₀	97.00	1292.8bc
T ₂ P ₁	99.66	1156.1 cde
T ₂ P ₂	97.00	1129.5 def
T ₂ P ₃	97.66	1317.0 ab
T ₃ P ₀	97.33	898.1 gh
T ₃ P ₁	96.00	1082.4 def
T ₃ P ₂	99.00	1233.6 bcd
T ₃ P ₃	96.33	1358.3 a
CV (%)	10.34	12.56
LSD _(0.05)	----	61.16

Means in a column followed by the same letter do not differ significantly at 5% level; Here, T₀ = Zn_{0 kg}B_{0 kg/ha}, T₁ = Zn_{2 kg}B_{1.5 kg/ha}, T₂ = Zn_{4.0 kg}B_{2.0kg/ha} and T₃ = Zn_{6kg} B_{2.5kg/ha} and P₀ = without fruit thinning per plant, P₁ = 10 fruits were retained/plant, P₂=20 fruits were retained/plant and P₃ = 30 fruits were retained per plant

thinning on the vigor of seed was found to be statistically significant (table 18). Maximum seed vigor index (1358.3) was found in the treatment combination of T_3P_3 which was statistically similar with (1317.0) T_2P_3 . On The Other Hand, The Minimum Seed Vigor Index (642.5) Was Obtained From The Treatment Combination OF T_0P_0 .

4. CONCLUSION AND RECOMMENDATION

Growth features, fruit yield components and seed yield in tomato were significantly influenced after micronutrients application along with fruit thinning practice. On the basis of the findings of the present study, the following conclusions could be drawn:

- A combination of 6 kg zinc and 2.5 kg boron per hectare demonstrated was better result in respect of plant growth and fruit and seed of tomato.
- Considering the yield attributes and seed yield of tomato exhibited better performance in case of P_3 (30 fruits were retained per plant) treatment.
- The results of the investigation suggested that, high seed yield and good quality seed of tomato can be obtained with the application of 6 kg zinc and 2.5 kg boron per hectare in combination with 30 fruits were retained per plant.
- Based on the findings of the study, trial may be given at different tomato growing regions of Bangladesh with the selected dose of Zn and B before more conformation of the results.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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