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Effect of zinc and boron on growth, yield and quality of tomato (*Lycopersicon esculentum.*Mill) cv. *Heem Sohna*, under protected cultivation

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Abstract:

The experiment was carried out at vegetable Research Farm in Department of Horticulture, Sam Higginbottom Institute of Agriculture Technology, Allahabad, during mid-November to 8- may the year 2012 – 2013. The experiment was laid out in R.B.D. with three replications and nine treatments with following combination of which was T_1 (control),T_2(Zn 1.25 g/L), T_3 (Zn 2.0 g/L), T_4 (B 1.25g/L),T_5 (B 1.25g/L + Zn 1.25 g/L),T_6 (B 1.25 g/L),T_7 (B 2.0g/L),T_8 (B 2.0g/L + Zn 1.25g/L) and T_9 (B 2.0 g/L + Zn 2.0 g/L). The cultivar of tomato was "heem shona" Syngenta Company. The highest fruit weight (72.67 g) was recorded in T_6 and the highest plant height (2.93) m, No. leaves per plant (39.33) leaves, No. clusters per plant (12.33), No. fruits per cluster (7.17), No. fruit per plant (88.33), yield per plant (6.33 kg), total yield (113.628 t /ha) shelf life (26.33 days) Total soluble solid (^{0}Brix) (5.67) Vitamin C (32.57 mg / 100 g) and benefit: cost ratio (4.05 was obtained in T_5 treatment under Allahabad agro climatic conditions.

Key words: zinc, boron, tomato, protected cultivation

1. Introduction

Tomato *(Lycopersicon esculentum.* Mill) belongs to family solanaceae having chromosome number (2n=24); it is a self-pollinated crop. Tomato is one of most popular and nutritious fruit vegetable, widely grown around the world and second ranked after potato.

Tomato has its origin in Peru, Ecuador and Bolivia on the basis of availability of numerous wild and cultivated relatives of the tomato in this area. From its centre of origin, the tomato first moved to Mexico for domestication and cultivation. From Mexico it arrived in Europe by 1554.

The major tomato growing countries are China, India, USA, Turkey, Egypt and Italy. In the world the total area under tomato cultivation is 4,582,438 thousand ha with a production of 150,513,813 thousand t and with productivity of 32.8 t/ha in 2010 - 11. (Indian Horticulture Database, 2012-13).

Total area under tomato crop in India is assessed to be 0.865 million ha with the productivity of (16,826,000 t) with productivity of 19.5 t/ha (Indian Horticulture Database, 2011).

Tomato is consumed fresh and also in processed form of which one-third is used as processed products and two-third of tomato fruit is consumed fresh. The area under tomato is constantly increasing to produce more quality yield because it is a major vegetable in the menu of human diet. The fruits are eaten raw or cooked, large quantities of tomato are used to produce soup, juice, ketchup, puree, paste and powder. Tomato is a rich source of vitamins, minerals, organic acids, sugars, ascorbic acids, acidity and lycopene. Nutritive value varies in different cultivars depending upon the agro-climatic condition. It is also rich in nutrients and calories. It is a good source of Fe and vitamin A, B, and C. Edible portion of tomato contains energy 18 kcal, protein 0.95 g, fat 0.11g, carbohydrate 4.01 g, sugars total 2.49 g, Ca 11mg, Fe 0.68 mg, Mg 9 mg, P 28 mg, K 218 mg, Na 11 mg, Zn 0. 14 mg, Vitamin C 22.8 mg, Thiamin 0.036 mg, Riboflavin 0.022 mg, Vitamin B-6 0.079 mg, Vitamin E 0.56 mg, Fatty acids, total saturated 0.015 g, Fatty acids, total polyunsaturated 0.044 g per 100 g (USDA, 2013). Consumption of tomato and its products can significantly reduce the risk of developing of colon, rectal, and stomach cancer. Recent studies suggest that tomatoes contain the antioxidant lycopene, which markedly reduces the risk of prostate cancer (Kucuk, 2001).

To improve the yield and quality of the product, it is necessary to pay attention on the optimum 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 trace elements or minor elements such as boron and zinc etc.

Boron (B) 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, 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. The leaves become wrinkled and curled with light green colour. Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins.

Zinc (Zn), as one of the essential micronutrients in plants is necessary for plant growth and development and involved in many enzymatic activities and IAA formation to increase flower number and fruit set. However, excessive Zn in plants can profoundly affect normal ionic homeostatic systems by interfering with the uptake, transport, osmotic and regulation of essential ions and results in the disruption of metabolic processes such as transpiration, photosynthesis and enzyme activities related to metabolism (Sainju *et al.* , 2003).

Tomato is a warm season crop and requires relatively long season to produce a profitable crop. It is highly susceptible to frost. Environment factors such as temperature and moisture etc. markedly influence the process of fruit set of tomato and subsequent in fruit development and yield (Calvert, 1959). Despite its economic importance, growers are not in a position to produce good quality tomato with high productivity due to various biotic (pest and diseases), abiotic (rainfall, temperature, relative humidity and light intensity) and crop factors (flower and fruit drop). Due to erratic behavior of weather, the crops grown in open field are often exposed to fluctuating levels of temperature, humidity, wind flow etc. which ultimately affect the crop productivity adversely (Ochigbu and Harris, 1989). Besides this, limited availability of land for cultivation hampers the vegetable production. Hence, to obtain a good quality produce and production during off season, there is a need to cultivate tomato under protected conditions such as green house, poly house and net house etc. Growth, development, productivity and post-harvest quality parameters of tomato crop largely depend on the interaction between the genetic constitution of the plants and environmental conditions under which they are grown. Basically tomato is a warm season crop and lacks adaptability to varied environmental conditions. Hence tomato is one such crop which responds very well to the favorable environmental conditions.

Growing environment can be modified to suit to crops by use of protected structure for cultivation. Protected cultivation involves protection of crop at various production stages from adverse environmental conditions such as extreme temperature, hail storm, scorching sun and heavy rain. The optimum temperature for most varieties between 18 to 24 °C. The plant tissues are damaged below 10 °C and above 38 °C. Keeping all the fact in view, a field experiment entitled "To

Study effect of FYM, NPK and Micronutrients on Growth, Yield and Fruit Quality of Tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna* under protected cultivation" was designed.

2. Objectives

1. To find out the most suitable treatment for growth, yield and fruit quality of tomato under protected cultivation.
2. To work out the economics of various treatments.

3. Materials and Methods

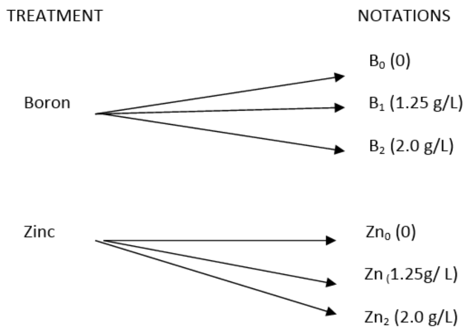
The experiment entitled **"Effect of Boron and Zinc on growth, yield and quality of tomato (*Lycopersicon esculentum.* Mill) cv. *Heem Sohna,* under protected cultivation"** was carried out separately during the year 2012-2013 under the agro-climatic conditions of Allahabad, at the research farm of horticulture department, Sam Higginbottom Institute of Agriculture, Technology & Sciences (Deemed-to-be-University) Allahabad.

Experimental Design:

The experiment was laid out in Randomized Block Design comprising of 9 treatments with three replications. Treatments were randomly arranged in each replication, divided into nine plots. Applied as foliar sprays two times, the particulars of the treatments are presented below.

Treatment details

The following treatments were applied:



Treatment Combinations:

T_1	control	
T_2	B_0Zn_1	(Zn 1.25 g/L)
T_3	B_0Zn_2	(Zn 2.0 g/L)
T_4	B_1Zn_0	(B 1.25 g/L)
T_5	B_1Zn_1	(B 1.25 g/L +Zn 1.25 g/L)
T_6	B_1Zn_2	(B 1.25 g/L +Zn 2.0 g/L)
T_7	B_2Zn_0	(B 2.0 g/L)
T_8	B_2Zn_1	(B 2.0 g/L +Zn 1.25 g/L)
T_9	B_2Zn_2	(B 2.0 g/L +Zn 2.0 g/L)

Observational details:

Five plants from each net plot were randomly selected and they were labeled. These plants were used for recording all morphological observations in respect of growth, yield and fruit quality of the crop. The details of the observations recorded are given below.

Growth parameters:

Plant height (m)

Number of leaves per plant

Yield parameters:

Number of cluster per plant

Number of fruits per cluster

Number of fruits per plant
Fruit weight (g)
Yield per plant (kg)
Total yield per poly house (tones per poly house 220 m$^{2)}$
Total yield in hectare (tones per poly house in hectare)

Quality characters:
Shelf life
T.S.S. (Total soluble solids) ^{0}Brix
Ascorbic acid (mg/100 gm fruit pulp)

Economics of treatments

Results and Discussion

4. Growth parameters

4.1. Plant height

The data presented in table 4.1 clearly showed that the boron and zinc played significant role in directly affecting plant height. The maximum of plant height was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5, which was recorded (2.93) m, followed by T_6 @ (1.25 g/L B+ 2.0 g/L Zn) (2.90) m. The minimum of plant height (1.94) m was noticed with control. These result are in close conformity with the finding of control.

Table 4.1 Effect of zinc and boron on plant height of tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna under* protected cultivation.

S.O.N	Treatments	Treatments Combinations	Plant height (m)
1	T_1	CONTROAL	1.94
2	T_2	B_0Zn_1	2.57
3	T_3	B_0Zn_2	2.80
4	T_4	B_1Zn_0	2.42
5	T_5	B_1Zn_1	2.93
6	T_6	B_1Zn_2	2.90
7	T_7	B_2Zn_0	2.73

8	T_8	B_2Zn_1	2.83
9	T_9	B_2Zn_2	2.78
		F- test	**S**
		S. Ed. (±)	**0.038**
		C. D. (P = 0.05)	**0.080**

4.2 Number of leaves per plant

The data presented in table 4.2 clearly showed that the boron and zinc played significant role in directly affecting the number of leaves per plant. The maximum number of leaves per plant was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5, which was recorded (39.33) leaves , followed by T_6 @ (1.25 g/L B+ 2.0 g/L Zn) (38.67) leaves. The minimum number of leaves per plant (29.00) leaves was noticed with control.

Table 4.2 Effect of zinc and boron on number of leaves per plant of tomato (*Lycopersicon esculentum.* Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	**Treatments**	**Treatments Combinations**	**No. of leaves**
1	T_1	CONTROL	29.00
2	T_2	B_0Zn_1	31.33
3	T_3	B_0Zn_2	34.33
4	T_4	B_1Zn_0	31.33
5	T_5	B_1Zn_1	39.33
6	T_6	B_1Zn_2	38.67
7	T_7	B_2Zn_0	33.33
8	T_8	B_2Zn_1	35.00
9	T_9	B_2Zn_2	34.00
		F- test	**S**
		S. Ed. (±)	**1.268**
		C. D. (P = 0.05)	**2.688**

5. Yield parameters

5.1 Number of Clusters per plant

The data presented in table 5.1 clearly showed that the boron and zinc played significant role in directly affecting number of cluster per plant. The maximum number of cluster per plant was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5, which was recorded (12.33) cluster , followed byT_6 @(1.25 g/LB+ 2.0 g/L Zn) (12.00) cluster. The minimum number of flower cluster per plant (9.33) cluster was noticed with control.

Table 5.1 Effect of zinc and boron on number of cluster per plant of tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	Treatments	Treatments Combinations	no. clusters per plant
1	T_1	CONTROL	9.33
2	T_2	B_0Zn_1	11.40
3	T_3	B_0Zn_2	11.67
4	T_4	B_1Zn_0	11.00
5	T_5	B_1Zn_1	12.33
6	T_6	B_1Zn_2	12.00
7	T_7	B_2Zn_0	11.33
8	T_8	B_2Zn_1	11.77
9	T_9	B_2Zn_2	11.47
		F- test	**S**
		S. Ed. (±)	**0.347**
		C. D. (P = 0.05)	**0.735**

5.2 Number of fruits per cluster

The data presented in table 5.2 clearly showed that the boron and zinc played significant role in directly affecting number of fruits per cluster. The maximum number of fruits per cluster was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5, which was recorded (7.17)fruits per cluster, followed by T_6 @ (1.25 g/L B+ 2.0 g/L Zn) (6.97) fruits per cluster .The minimum number of fruit per cluster (5.83) was noticed with control **.**

Table. 5.2 Effect of zinc and boron on number of fruits per cluster of tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	Treatments	Treatments Combinations	No. of Fruits per Cluster
1	T_1	CONTROL	5.83
2	T_2	B_0Zn_1	**6.27**
3	T_3	B_0Zn_2	**6.60**
4	T_4	B_1Zn_0	**6.07**
5	T_5	B_1Zn_1	7.17

6	T_6	B_1Zn_2	6.97
7	T_7	B_2Zn_0	6.17
8	T_8	B_2Zn_1	6.67
9	T_9	B_2Zn_2	6.50
		F- test	**S**
		S. Ed. (±)	**0.260**
		C. D. (P = 0.05)	**0.550**

5.3 Fruit Weight (g).

The data presented in table 5.3 clearly showed that the boron and zinc played significant role in directly affecting of fruit weight. The maximum weight of fruit was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 2.0 g/L Zn) that is T_6, which was recorded (72.67) g, followed by T_5 @ (1.25 g/L B+ 1.25 g/L Zn) (71.67) g. The minimum weight of fruit (57.67) g was noticed with control.

Table. 5.3 Effect of zinc and boron on fruit weight (g) of tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	Treatments	Treatments Combinations	Fruit Weight (g)
1	T_1	CONTROL	57.67
2	T_2	B_0Zn_1	63.00
3	T_3	B_0Zn_2	71.67
4	T_4	B_1Zn_0	62.00
5	T_5	B_1Zn_1	71.67
6	T_6	B_1Zn_2	72.67
7	T_7	B_2Zn_0	65.00
8	T_8	B_2Zn_1	71.00
9	T_9	B_2Zn_2	70.33
		F- test	**S**
		S. Ed. (±)	**1.213**
		C. D. (P = 0.05)	**2.572**

5.4 Number of Fruit per plant

The data presented in table 5.4 clearly showed that the boron and zinc played significant role in directly affecting number of fruits per plant. The maximum number of fruits per plant was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5, which was recorded (88.33) fruit , followed by T_6 @ (1.25g/L B+ 2.0 g/L Zn) (83.60) fruit. The minimum number of fruit per plant (54.50) was noticed with control.

Table. 5.4 Effect of zinc and boron on number of fruits per plant of tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	Treatments	Treatments Combinations	No. fruits per plant
1	T_1	CONTROL	54.50
2	T_2	B_0Zn_1	71.58
3	T_3	B_0Zn_2	77.20
4	T_4	B_1Zn_0	66.73
5	T_5	B_1Zn_1	88.33
6	T_6	B_1Zn_2	83.60
7	T_7	B_2Zn_0	69.83
8	T_8	B_2Zn_1	78.37
9	T_9	B_2Zn_2	74.64
		F- test	**S**
		S. Ed. (±)	**3.293**
		C. D. (P = 0.05)	**6.980**

5.5 Fruit yield per plant (kg).

The data presented in table 5.5 clearly showed that the boron and zinc played significant role in directly affecting the fruit yield per plant. The maximum fruit yield per plant was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5, which was recorded (6.33) kg, followed by T_6 @ (1.25 g/L B+ 2.0 g/L Zn) (6.07) kg. The minimum fruit yield per plant (3.14) kg was noticed with control.

Table 5.5 Effect of zinc and boron on fruit yield per plant (kg) of tomato (*Lycopersicon esculentu.*Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	Treatments	Treatments Combinations	yield per plant (kg)
1	T_1	CONTROL	3.14
2	T_2	B_0Zn_1	4.50
3	T_3	B_0Zn_2	5.52
4	T_4	B_1Zn_0	4.13
5	T_5	B_1Zn_1	6.33

6	T_6	B_1Zn_2	6.07
7	T_7	B_2Zn_0	4.54
8	T_8	B_2Zn_1	5.56
9	T_9	B_2Zn_2	5.25
		F- test	**S**
		S. Ed. (±)	**0.215**
		C. D. (P = 0.05)	**0.455**

5.6 Fruit yield per poly house (tons per poly house 220m^2)

The data presented in table 5.6 clearly showed that the boron and zinc played significant role in directly affecting the fruit yield per poly house. The maximum fruit yield per poly house was recorded statistically significant in applying boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5, which was recorded (3.342 tons per poly house 220m^2), followed by T_6 @ (1.25 g/L B+ 2.0 g/L Zn) (3.207 tons per poly house 220m^2). The minimum fruit yield per poly house (1.659 tons per poly house 220m^2) was noticed with control.

Table 5.6 Effect of zinc and boron on fruit yield (ton) of tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna*under protected cultivation.

S.O.N	**Treatments**	**Treatments Combinations**	**Mean yield per poly house (tones per poly house 220m^2)**
1	T_1	CONTROL	1.659
2	T_2	B_0Zn_1	2.376
3	T_3	B_0Zn_2	2.917
4	T_4	B_1Zn_0	2.183
5	T_5	B_1Zn_1	3.342
6	T_6	B_1Zn_2	3.207
7	T_7	B_2Zn_0	2.398
8	T_8	B_2Zn_1	2.935
9	T_9	B_2Zn_2	2.773
		F- test	**S**
		S. Ed. (±)	**0.113**
		C. D. (P = 0.05)	**0.240**

6. Quality parameters

6.1 Ascorbic acid content (mg/100g fruit pulp).

The data presented in table 6.1 clearly showed that the boron and zinc played significant role in directly affecting the ascorbic acid (vitamin c) content (mg/100g fruit pulp) of tomato . The maximum ascorbic acid (vitamin c) content was recorded statistically significant in boron and zinc application @ (1.25 g/LB+ 1.25 g/L Zn) that is T_5, which was recorded (32.57) mg/100 fruit pulp, followed by T_6 @ (1.25 g/L B+ 2.0 g/L Zn) (31.90) mg/100 fruit pulp. The minimum ascorbic acid (vitamin c) content (28.67) mg/100 fruit pulp was noticed with control.

Table 6.1 Effect of zinc and boron on ascorbic acid content (mg/100g) of tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	Treatments	Treatments Combinations	Meanascorbic acid (mg/100g)
1	T_1	CONTROL	28.67
2	T_2	B_0Zn_1	29.30
3	T_3	B_0Zn_2	30.23
4	T_4	B_1Zn_0	29.10
5	T_5	B_1Zn_1	32.57
6	T_6	B_1Zn_2	31.90
7	T_7	B_2Zn_0	29.33
8	T_8	B_2Zn_1	31.67
9	T_9	B_2Zn_2	29.67
		F- test	**S**
		S. Ed. (±)	**0.21**
		C. D. (P = 0.05)	**0.44**

6.2 Total Soluble Solids (^{0}Brix)

The data presented in table 6.2 clearly showed that the boron and zinc played significant role in directly affecting the Total soluble solids (^{0}brix).The maximum of total soluble solids (mg/100 fruit pulp). was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5,which was recorded (5.80) ^{0}brix, followed by T_6 @ (1.25 g/L B+ 2.0 g/L Zn) (5.73) ^{0}brix . The minimum of total soluble solids ^{0}brix. (5.00) was noticed with control

Table 6.2 Effect of zinc and boron on total soluble solids (^{0}Brix) of tomato (*Lycopersicon esculentum* .Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	Treatments	Treatments Combinations	TSS (^{0}Brix)
1	T_1	CONTROL	5.00
2	T_2	B_0Zn_1	5.40
3	T_3	B_0Zn_2	5.67
4	T_4	B_1Zn_0	5.37
5	T_5	B_1Zn_1	5.80
6	T_6	B_1Zn_2	5.73
7	T_7	B_2Zn_0	5.57
8	T_8	B_2Zn_1	5.70
9	T_9	B_2Zn_2	5.67
		F- test	**S**
		S. Ed. (±)	**0.052**
		C. D. (P = 0.05)	**0.110**

6.3 Shelf life of fruit.

The data presented in table 6. 3 clearly showed that the boron and zinc played significant role in directly affecting shelf life of fruit. The maximum shelf life of fruit was recorded statistically significant in boron and zinc application @ (1.25 g/L B+ 1.25 g/L Zn) that is T_5, which was recorded (26.33) days, followed by T_6 @ (1.25 g/L % B+ 2.0 g/L Zn) (24.33) days. The minimum shelf life of fruit (15.33) days was noticed with control.

Table 6.3 Effect of zinc and boron on shelf life of tomato (*Lycopersicon esculentum.*Mill) cv. *Heem Sohna* under protected cultivation.

S.O.N	Treatments	Treatments Combinations	Days
1	T_1	CONTROL	15.33
2	T_2	B_0Zn_1	17.00
3	T_3	B_0Zn_2	21.27
4	T_4	B_1Zn_0	16.67
5	T_5	B_1Zn_1	26.33
6	T_6	B_1Zn_2	24.33
7	T_7	B_2Zn_0	18.33
8	T_8	B_2Zn_1	23.00
9	T_9	B_2Zn_2	20.33
		F- test	**S**
		S. Ed. (±)	**0.636**

7. Economics of the treatments

The data presented in table 7.3: the maximum benefit: cost ratio (4.05) was observed in T_5 (B_1Zn_1), followed by (3.87) with T_6 (B_1Zn_2). The minimum benefit cost ratio was observed in control (2.04).

Note: one hectare equal 10 000 m², since 25% area will be utilized in path, bunds and fixing up the structure of poly house, so the rest 7500 m². 7500 m²/220m²=34 poly house.

Table7.3: Treatment wise cost of cultivation of tomato per hectare and benefit cost ratio.

Treatment	Total cost perha	total yield t /ha	Price selling rate Rs/t	gross return	net return Rs/ha	benefit cost ratio
T_1	**552464.98**	56.406	20 000	1128120	575655.02	2.04
T_2	**556714.98**	80.784	20 000	1615680	1058965.02	2.90
T_3	**560964.98**	99.178	20 000	1983560	1422595.02	3.53
T_4	**555864.98**	74.222	20 000	1484440	928275.02	2.67
T_5	**560114.98**	113.628	20 000	2272560	1712445.02	4.05
T_6	**562664.98**	109.038	20 000	2180760	1618095.02	3.87
T_7	**559264.98**	81.532	20 000	1630640	1071375.02	2.91
T_8	**563514.98**	99.790	20 000	1995800	1432285.02	3.54
T_9	**567764.98**	94.282	20 000	1885640	1317875.02	3.32

8. Discussion

Tomato (*Lycopersicon esculentum.*Mill), is one of the highly remunerative vegetables cultivated in most parts of the World. It has attained a status of high value crop in the world in recent years and occupies a pride of place among vegetables in the world. The high market price it fetches is attributed to heavy demand from the urban consumers. There is a good demand for export too. The export market needs fruits with longer shelf life, medium sized fruits with good taste. However, the supply is inadequate due to the low productivity of the crop (El-Dissoky R.A. and A.E.S. Abdel-Kadar. 2013).

Growing environment can be modified to suit to crops by use of protected structure for cultivation. Protected cultivation involves protection of crop at various production stages from adverse environmental conditions such as extreme temperature, humidity, hail storm, scorching sun and heavy rain and control of pest and diseases. Hence, to obtain a good quality produce and production during off seasons, there is a need to cultivate tomato under protected conditions such as green house, poly house and net house etc (Raja *et al.* , 2012).

Plants require to essential for the normal life processes of plants and are needed in very small amounts are called trace elements or minor elements such as boron, zinc and magnesium etc. Boron play an essential role in the development and growth of new cell in the plant meristem, improve of fruit quality and fruit set. Zinc is involved in many enzymatic activities and IAA formation to increase flower number and fruit set. Mg is primary constituent of chlorophyll and ATP require Mg.Fe is a constituent of many enzyme in the nutritional metabolasim (Sainju *et al.* , 2003) which in turn might have increased the rate of growth and positive development in yield and quality characters which is Resulted in high yield of tomato Further, application of B and Zn which might have accelerated the vigorous growth , increase of yield and improve quality of tomato plant. It is also relevant to mention that tomato plants nourished with interaction between B and Zn gave maximum values in growth, yield and quality parameters.

9. Summary and Conclusion

The present investigation entitled "Effect of zinc and boron on growth, yield and quality of tomato (*Lycopersicon esculentum*.Mill) cv. *Heem Sohna*, under protected cultivation" was carried out at the vegetable research farm at Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences (Deemed- to-be University) Allahabad during the year 2012 – 2013 to study the effect of boron and zinc on growth, yield and quality of tomato.

The treatment was laid out in randomized block design (3 x 3) comprising 3 levels of boron (0, 1.25and 2.0 g/L) and 3 levels of zinc (0,1.25 and 2.0g/L) making 9 treatment combinations each replicated two times.

The results of the investigation, regarding the influence of boron, zinc and their interaction applied as foliar sprays on growth, yield and quality of tomato have been presented, interpreted in the light of impact of different treatments during the experimentation, and discussed in the preceding chapters.

Results of the experiment are summarized below:

1. Boron @1.25g/L (B_1) recorded maximum plant height (2.93) m, number of leaves per plant (39.33) leaves inT_5, followed by B_2 (2.0g/L boron) inT_6, which was recorded (2.90) m plant height, number of leaves per plant (38.67) and the minimum was with (control) in T, which was recorded (1.94) m plant height, number of leaves per plant (29.00) leaves.
2. Zinc @1.25 (Zn_1) recorded maximum plant height (2.93) m, number of leaves per plant (39.33) leaves in T_5, followed by Zn_2 (2.0g/L Zn) in (T_6), which was recorded (2.90) m plant height, number of leaves per plant (38.67) leaves and the minimum was recorded (1.94) m plant height with (control) inT_1, number of leaves per plant (29.00) leaves.
3. Treatment combination B_1Zn_1 (1.25 g/L boron +1.25g/L zinc) in T_5 recorded maximum plant height, number of leaves per plant, followed by B_1Zn_2 (1.25g/L boron + 2.0g/L zinc) in T_6 and the minimum was with (control) in T_1.
4. 1.25 g/L boron (B_1) and 1.25 g/L zinc (Zn_1) were found as appropriate levels of boron and zinc and their combination B_1Zn_1 (1.25 g/L boron + 1.25 g/L zinc) in T_5 emerged as superior over all other treatment combinations tried in this experiment, in relation to vegetative growth of tomato.

5. Boron @1.25 g/L (B_1) inT_5 recorded maximum number of clusters per plant (12.33) cluster , number of fruits per cluster (7.17) fruits per cluster followed by B_2 (2.0 g/L boron) inT_6 which was recorded (12.00) cluster, number of fruits per cluster (6.97) fruits per cluster and the minimum was with (control) in T_1 which was recorded (9.33) cluster , number of fruits per cluster (5.83) fruits per cluster .
6. Zinc @1.25 g/L (Zn_1) in T_5 recorded maximum number of clusters per plant, number of fruits per cluster , followed by Zn_2 (2.0 g/L zinc) in T_6 and the minimum was with (control) in T_1 .
7. Treatment combination B_1Zn_1(1.25 g/L boron + 1.25 g/L zinc) in T_5 recorded maximum number of clusters per plant, number of fruits per cluster, followed by (B_1Zn_2 1.25 g/L boron 2.0 g/L zinc) in T_6 and the minimum recorded was with (control) inT_1.
8. Maximum weight of fruit was recorded (72.67) g with Boron @1.25 g/L (B_1) in $T_{6,}$ followed by B2 (2.0 g/L boron) in T_5 which was recorded (71.67) g and the minimum was recorded (57.67) g with (control) in T_1.
9. Maximum weight of fruit was recorded with zinc @zinc 2.0 g/L (Zn_2) in T_6 followed by Zn_1 (1.25 g/L zinc) inT_5 and the minimum was recorded with (control) in T_1.
10. Treatment combination B_1Zn_2 (1.25 g/L boron + 2.0 g/L zinc) in T_6 recorded maximum weight of fruit followed by B_1Zn_1 (1.25 g/L boron + 2.0 g/L zinc) in T_5 The minimum was recorded with (control) in T_1.
11. Boron @1.25 g/L (B_1) in T_5 recorded maximum yield per poly house (6.33) kg, followed by B_2 (2.0 g/L boron) in T_6 (6.07) kg and the minimum was recorded (3.14) kg with (control) in $T_{1.}$
12. Zinc @1.25 (Zn_1) in T_5 recorded maximum yield per poly house (6.33) kg, followed by Zn_2 (2.0 g/L zinc) in T_6 (6.07) kg

and the minimum was recorded (3.14) kg with (control) in T_1.

13. Treatment combination B_1Zn_1 (1.25 g/L boron + 1.25 g/L zinc) in T_5 recorded maximum yield per poly house followed by B_1Zn_2 (1.25 g/L boron + 2.0 g/L zinc) in T_6The minimum was recorded with (control) in T_1.
14. For yielding attributes and yield of tomato, 1.25 g/L boron (B_1) and 1.25 g/L zinc (Zn_1) were found as appropriate levels of boron and zinc and their combination B_1Zn_1 (1.25 g/L boron + 1.25 g/L zinc) in T_5 emerged as superior over all other treatment combinations tried in this experiment.
15. Maximum total soluble solids and vitamin C content and shelf life of fruit was recorded with Boron @1.25 g/L (B_1) in T_5 followed by B_2 (2.0 g/L boron) in T_6 and the minimum was recorded with (control) in T_1.
16. Maximum total soluble solids and vitamin C content and shelf life of fruit was recorded with zinc @1.25 g/L (Zn_1) inT_5 followed by Zn_2 (2.0 g/L zinc) in T_6 and the minimum was with (control) in T_1.
17. Treatment combination B_1Zn_1 (1.25 g/L boron + 1.25 g/L zinc) in T_5 recorded maximum total soluble solids and vitamin C content and shelf life of fruit followed by B_1Zn_2 (1.25 g/L boron + 2.0 g/L zinc) in T_6 and the minimum was recorded with (control) in T_1.
18. For obtaining best quality of tomato, 1.25g/L boron (B_1) and 1.25 g/L zinc (Zn_1) were found as appropriate levels of boron and zinc and their combination B_1Zn_1 (1.25 g/L boron + 1.25 g/L zinc) in T_5 emerged as superior over all other treatment combinations tried in the experiment.
19. Maximum gross return, net return and benefit: cost ratio was obtained with treatment combination B_1Zn_1 (1.25 g/L boron + 1.25 g/L zinc) inT_5 (4.05) followed by B_1Zn_2 (1.25 g/L boron + 2.0 g/L zinc) in T_6 (3.87) and the minimum was recorded (2.04) with (control) in T_1.

20. Out of the 9 interacting treatment combinations tried in this experiment, B_1Zn_1 (1.25 g/L boron + 1.25 g/L zinc) in T_5 emerged as superior over all other treatment combinations in relation to growth, yielding attributes, yield, quality and economic returns for cultivation of tomato under the agro-climatic conditions of Allahabad.

10. Conclusion

Based on the result of experiment it is concluded that the treatment T_5 (1.25g/L boron + 1.25 g/L zinc) was recorded the best among all the treatment combinations on growth, yield and quality of tomato. The treatment T_5 (1.25g/L boron + 1.25 g/L zinc) was obtained the highest total yield (113.628 tone in hectare) under protected cultivation with highest benefit: cost ratio (4.05).

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