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EFFECT OF MICRONUTRIENTS SPRAY ON GROWTH AND YIELD OF TOMATO (*SOLANUM LYCOPERSICON* L.)

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Abstract

A field experiment was conducted to find out the effect of micronutrients spray on growth and yield of Tomato **(***Solanum lycopersicon L.*) during 2012-13 and 2013-14 on tomato variety Pusa Rohini (DT – 39) at the vegetable research farm of the Department of Horticulture, Allahabad School of Agriculture, Sam Higgin Bottom University of Agriculture, Technology and Sciences, Allahabad. The results based on two years mean revealed that out of twenty seven different treatments, the combined application of Boron (100 ppm) x Zn (100 ppm) x copper 100 ppm resulted in maximum Plant height per plant (37.07 and 36.16 cm @ 100 ppm Boron x Zn @ 0 ppm Copper @ 100 ppm), (47.43 cm and 46.42 cm), (51.67 cm and 49.98 cm), Plant spread per plant (45.17 cm and 44.55 cm), (55.30 cm and 54.22 cm), (62.58 cm and 61.24 cm), Number of branches per plant (4.90 cm and 4.56 cm), (5.50 cm and 5.19 cm), (6.7 cm and 6.49 cm), Number of leaves per plant (18.77 cm and 18.35 cm), (32.67 cm and 32.05 cm), (34.00 cm and 33.68 cm), Length of longest leaf (16.20 cm and 15.95 cm), (22.20 cm and 22.05 cm), (27.67 cm and 27.57 cm), Width of longest leaf per plant (10.35 cm and 10.22 cm), (20.67 cm and 20.25 cm), (25.00 cm and 24.77 cm) at 30, 60, 90 DA, Leaf area index (2.87 cm and 2.95 m^2/m^2) at flowering stage with application of Boron @ 250 ppm, Zn @ 100 ppm and Copper @ 100 ppm whereas minimum under control as well as other treatments. Days taken to fruits initiation per plant (81.53 days and 79.47 days), Number of fruits per plant (42.39 with application of Boron @100 ppm) x Zn @100 ppm x copper @ 100 ppm and 40.11 with application of Boron @ 250 ppm x Zn @ 0 ppm x copper @ 100 ppm), Weight of one fruit (0.085 g and 0.082 g), Weight of fruits per plant (3.04 kg and 2.98 kg), Weight fruits per plot (8.21 kg and 8.64 kg), with application of Boron @ 100 ppm x Zn @ 100 ppm x copper @ 100 ppm) , Weight of fruits per ha (263.60 q and 261.73 q) with application of Boron @ 250 ppm x Zn @ 250 ppm x copper @ 250 ppm) recording fruit yield differed significantly from the control as well as other treatments.

Key words : Tomato, boron, zinc & Cu, spray, growth parameters, yield parameters.

Introduction

Tomato is one of the important vegetable crops grown all over the world. Average fruit and quality in crop plants greatly influence by both macro and micronutrients. Not only major nutrients, micronutrients also play a crucial role in seed production of tomato (Sivaiah *et al*., 2013). Some micronutrients like Zinc, Iron, Manganese, Copper, Boron and Magnesium have an important role in the physiology of tomato crop and are required for plant activities such as aspiration, meristamatic development, chlorophyll formation, photosynthesis, hormone synthesis, gossypol, tannin and phenolic compounds development (Saravaiya *et al*., 2014). Tomato yield can be pushed up by the judicious use of recommended dose of major nutrients along with micronutrients. Boron, copper and zinc also play an important role in enhancing the production of tomato crop by providing resistance against certain diseases becomes imperative in cultivation of tomato crops for increasing the production. Applications of micronutrients using boron, zinc and copper have been reported in increasing seed yield in tomato. Sivaiah *et al*., 2013). Total soluble solids contents (TSS) are important for the industrialization process as product yield is directly related to ºBrix, especially when the objective is dehydration, concentration of the pulp, or both the vitamins A & C play an important role in human health and it is found in fruits and vegetables in the form of ascorbic acid. Its main functions are in the prevention of scurvy and maintenance of skin and blood vessels (Saravaiya *et al.*, 2014; Lee and Kader, 2000). The main objective of the paper is to study the effect of micronutrients *viz*., zinc, boron and copper application on

tomato fruit yield and quality of tomato.

Materials and Methods

The present investigations were carried out at the Horticulture research farm of the Department of Horticulture, Allahabad School of Agriculture, Sam Higgin Bottom University of Agriculture, Technology and Sciences, Allahabad-211007 in winter seasons of the year 2012-13 and 2013-14 on tomato variety Pusa Rohini (DT – 39). Twenty seven micronutrient treatments consisting of i) Zinc ii) Boron iii) Copper each 0, 100 and 250 ppm and there in combination applied through foliar spray at two growth stages that is 10 and 20 days after transplanting. Boron as boric acid, zinc as zinc sulphate, copper as copper sulphate was applied. The pH of the solution was adjusted to neutral before application. The trial was laid out in R.B.D. (factorial) with three replications. Nitrogen, phosphorus and potassium were applied at the rate of 100, 75 and 55 kg/ha to all treatments. Half dose of nitrogen and full dose of phosphorus and potassium were applied after first and second earthing up. Twenty five days old seedlings of tomato Pusa Rohini (D T–39) were transplanted in both the years. Observations were taken on ten randomly selected plants. Fully mature fruits were harvested. The data on growth parameters and fruit yield parameters characters were recorded. Growth parameters at 30, 60 and 90 DAT like plant height per plant (cm), plant spread per plant (cm), number of branches per plant, number of leaves per plant, length of longest leaf (cm), width of longest leaf per plant (cm) and leaf area index (m^2/m^2) at 50% flowering stage were recorded and were subjected to statistical analysis following the principles and procedures outlined by Kumari (2012), Sarawaiya (2014).

Results and Discussion

The observations on various vegetative growth parameters were recorded per plant per hectare at 30, 60, 90 days after transplanting revealed significant differences among the treatments in both the years. The application of boron, zinc and copper significantly increased growth of tomato plant. Table 1 indicated the maximum plant height per plant at (90 days after transplanting) final growth stage (51.67 cm and 49.98 cm) with application of boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm followed by (45.53 cm and 44.78 cm) with application of boron @ 100 ppm + Zn @ 250 ppm + Cu @ 100 ppm while smallest plant height recorded in control condition of the treatments (Suhathiya and Singaravel, 2010; Naga *et al*., 2015). Plant spread per plant at different growth stages application of micronutrients mixture showed from table 2 maximum response of micronutrients in tomato at 90 days after transplanting. The maximum plant spread per plant (62.58 cm and 61.24 cm) with application of boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm followed by (56.25 cm and 55.41 cm) with application of boron @ 100 ppm + Zn @ 100 ppm + Cu @ 250 ppm and minimum size of plant under unsprayed plant. Number of primary branch per plant at different growth stages application of micronutrients mixture. The more number of primary branches per plant showed from Table No-3 at 90 days after transplanting (6.70 and 6.49) with application of Boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm followed by (5.60 and 5.55) with application of Boron @ 100 ppm + Zn @ 250 ppm + Cu @ 100 ppm as compare all other treatment (Naga *et al*., 2013; Haris and Mathuma, 2015). The rate increase in number of leaves per plant at different stages of growth after application of micronutrients table 4 showed the similar effect in both the years. Application of micronutrients mixture resulted in maximum increase in the number of leaves at final growth stage (34.00 and 33.68) with application of Boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm followed by with application of Boron @ 0 ppm + Zn @ 100 ppm + Cu @ 100 ppm (26.33 and 26.32) whereas minimum noted in unsprayed plant (Suhathiya and Singaravel, 2010; Naga *et al*., 2013; Haris and Mathuma, 2015). Length of longest leaf per plant is given in table 5. The highest length of longest leaf was observed at 90 days after transplanting in both the years (27.67 cm and 27.57 cm) with application of boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm followed by the application of boron @ 100 ppm + Zn @ 0 ppm + Cu @ 100 ppm (26.00 cm and 25.96 cm) while minimum were recorded under unsprayed plant in both the years. The analysis of variance for width of longest leaf per plant measured at 90 days after transplanting revealed significant differences among the treatments in both years. The maximum width of longest leaf showed in table 6 (25.00 and 24.77 cm) with application of boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm followed by the application of Boron @ 100 ppm + Zn @ 0 ppm + Cu @ 100 ppm (22.33 cm and 22.25 cm) whereas lowest length of leaf under control treatments. Leaf area index at 50% flowering was obtained in both the years with the combined application of boron, Zn and copper. Table 7 showed the maximum leaf area index (2.87 m^2/m^2 at spray of boron @ 250 ppm + Zn @ 100 ppm + Cu @ 100 ppm and 2.95 m^2/m^2 at spray of boron @ 250 ppm + Zn @ 100 ppm + Cu @ 250 ppm followed (2.63 m^2/m^2 boron

Table 1 : Plant height (cm).

Treatments	2012-13												2013-14											
↓	30 DAT				60 DAT				90 DAT				30 DAT				60 DAT				90 DAT			
Cu ppm →	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean
B0 x Zn 0	23.53	34.17	28.53	28.74	26.33	37.30	30.33	31.32	28.63	42.17	33.27	34.69	22.92	33.58	28.15	28.22	26.25	36.15	29.78	30.73	28.82	41.24	33.18	34.41
B0 x Zn 100	25.50	36.13	32.90	31.51	28.33	38.53	33.47	33.44	32.23	41.97	35.44	36.55	25.44	35.14	32.54	31.04	28.21	38.17	33.13	33.17	32.08	41.42	34.58	36.02
B0 x Zn 250	24.50	34.50	32.67	30.56	30.97	35.97	32.73	33.22	33.50	40.17	36.27	36.65	23.38	34.54	31.83	29.92	30.57	34.60	32.23	32.47	33.08	39.45	36.07	36.20
Mean	24.51	34.93	31.36	30.27	28.54	37.27	32.18	32.66	31.46	41.43	34.99	35.96	23.913	34.420	30.841	29.72	28.34	36.31	31.71	32.12	31.33	40.70	34.61	35.55
B 100 x Zn 0	27.87	36.60	33.60	32.69	33.63	42.63	34.53	36.93	37.37	45.40	36.50	39.76	27.59	**36.16**	32.68	32.14	33.38	40.58	32.81	35.59	37.04	43.57	35.82	38.81
B 100 x Zn 100	29.73	**37.07**	35.40	34.07	37.17	**47.43**	40.20	41.60	38.53	**51.67**	44.10	44.77	27.95	36.07	34.85	32.96	36.36	**46.42**	39.69	40.82	38.37	**49.98**	42.48	43.61
B100 x Zn 250	27.13	35.20	31.27	31.20	34.93	42.30	32.53	36.59	36.67	45.53	34.60	38.93	25.48	34.76	30.44	30.22	33.91	41.05	32.11	35.69	36.05	44.78	34.11	38.31
Mean	28.24	36.29	33.42	32.65	35.24	44.12	35.76	38.37	37.52	47.53	38.40	41.15	27.008	35.662	32.656	31.78	34.55	42.68	34.87	37.37	37.15	46.11	37.47	40.24
B 250 x Zn 0	26.73	31.60	32.27	30.20	29.73	33.93	33.50	32.39	31.90	36.17	33.70	33.92	26.44	30.09	32.01	29.51	29.68	33.42	33.22	32.11	31.83	36.19	33.68	33.90
B 250 x Zn 100	27.67	35.23	34.07	32.32	31.67	35.93	33.37	33.66	34.73	37.03	34.67	35.48	27.25	34.58	33.78	31.87	31.18	35.48	33.11	33.26	34.40	36.22	33.98	34.86
B 250 x Zn 250	24.93	33.27	31.80	30.00	28.83	33.47	33.23	31.84	30.63	40.47	35.30	35.47	24.80	33.07	31.73	29.87	28.92	33.19	32.88	31.67	30.81	38.75	35.21	34.92
Mean	26.44	33.37	32.71	30.84	30.08	34.44	33.37	32.63	32.42	37.89	34.56	34.96	26.165	32.580	32.508	30.42	29.93	34.03	33.07	32.34	32.34	37.05	34.29	34.56
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	30.27	32.65	30.84		32.66	38.37	32.63		35.96	41.15	34.96		29.72	31.78	30.42		32.12	37.37	32.34		35.55	40.24	34.56	
Zn	30.54	32.63	30.59		33.55	36.23	33.89		36.12	38.93	37.02		29.96	31.96	30.00		32.81	35.75	33.27		35.71	38.16	36.48	
Cu	26.40	34.86	32.50		31.29	38.61	33.77		33.80	42.29	35.98		25.70	34.22	32.00		30.94	37.68	33.22		33.61	41.29	35.46	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.404	0.571	1.145	9.50	0.333	0.471	0.946	98.46	0.295	0.417	0.837	127.10	0.223	0.316	0.634	21.79	0.221	0.312	0.627	180.72	0.235	0.332	0.666	167.41
Zinc	0.404	0.571	1.145	8.76	0.333	0.471	0.946	19.26	0.295	0.417	0.837	23.67	0.223	0.316	0.634	26.09	0.221	0.312	0.627	51.27	0.235	0.332	0.666	28.61
B x Zn	0.699	0.988	NS	1.44	0.577	0.816	1.639	5.46	0.511	0.723	1.450	11.12	0.387	0.547	1.099	5.68	0.382	0.541	1.085	12.70	0.407	0.575	1.154	15.45
Copper	0.404	0.571	1.145	117.10	0.333	0.471	0.946	124.87	0.295	0.417	0.837	223.11	0.223	0.316	0.634	391.74	0.221	0.312	0.627	240.85	0.235	0.332	0.666	291.77
B x Cu	0.699	0.988	NS	2.13	0.577	0.816	1.639	11.41	0.511	0.723	1.450	10.87	0.387	0.547	1.099	9.07	0.382	0.541	1.085	22.60	0.407	0.575	1.154	17.71
Zn x Cu	0.699	0.988	NS	0.20	0.577	0.816	NS	1.69	0.511	0.723	NS	0.57	0.387	0.547	NS	2.37	0.382	0.541	1.085	4.13	0.407	0.575	NS	0.14
B x Zn x Cu	1.211	1.712	NS	0.71	1.000	1.414	NS	1.82	0.885	1.252	2.512	7.13	0.670	0.948	1.903	2.41	0.662	0.937	1.880	4.09	0.704	0.996	1.999	8.72

Table 2 : Plant spread (cm).

Treatments	2012-13												2013-14											
Bo & Zn ppm ↓																								
Cu ppm →	30 DAT				60 DAT				90 DAT				30 DAT				60 DAT				90 DAT			
Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	
B0 x Zn 0	25.69	33.60	26.67	28.65	31.04	40.70	37.60	31.04	40.63	47.83	43.36	43.94	25.04	33.87	26.53	28.48	30.87	40.21	36.86	35.98	40.13	46.65	42.78	43.18
B0 x Zn 100	34.56	40.40	35.88	36.95	37.97	45.04	40.18	37.97	50.20	59.03	56.65	55.29	34.36	39.11	35.61	36.36	38.17	44.15	40.01	40.78	49.24	57.35	55.53	54.04
B0 x Zn 250	35.88	38.30	34.09	36.09	37.12	42.15	36.61	37.12	46.75	52.90	49.85	49.83	35.16	37.71	33.60	35.49	36.25	41.62	36.25	38.04	45.85	51.48	48.33	48.55
Mean	32.043	37.434	32.215	33.90	35.375	42.630	38.130	35.375	45.86	53.25	49.95	49.69	31.52	36.90	31.91	33.44	35.09	42.00	37.71	38.27	45.07	51.82	48.88	48.59
B 100 x Zn 0	28.78	39.03	35.87	34.56	40.32	47.51	46.90	40.32	42.44	52.77	45.87	47.02	28.69	37.95	35.63	34.09	40.01	46.84	46.22	44.35	42.33	51.74	45.88	46.65
B 100 x Zn 100	37.70	**45.17**	38.43	40.43	48.10	**55.30**	44.97	48.10	53.70	**62.58**	56.25	57.51	37.63	**44.55**	37.92	40.03	46.78	**54.22**	43.53	48.18	52.80	**61.24**	55.41	56.49
B100 x Zn 250	33.17	42.60	34.47	36.74	40.42	45.23	40.65	40.42	45.46	52.40	46.09	47.98	33.13	41.74	34.31	36.39	40.31	44.22	39.49	41.34	45.32	52.34	44.79	47.48
Mean	33.217	42.267	36.256	37.25	42.946	49.348	44.175	42.946	47.20	55.91	49.40	50.84	33.15	41.41	35.95	36.84	42.37	48.42	43.08	44.62	46.82	55.11	48.69	50.21
B 250 x Zn 0	27.10	36.68	28.52	30.77	36.30	42.95	40.98	36.30	41.30	50.13	44.88	45.44	27.02	34.74	28.45	30.07	35.86	42.11	40.53	39.50	40.29	49.70	43.92	44.63
B 250 x Zn 100	34.94	40.29	33.25	36.16	40.63	45.51	42.76	40.63	45.68	52.35	45.45	47.83	34.72	38.97	32.42	35.37	40.31	44.27	41.92	42.16	45.15	51.26	45.13	47.18
B 250 x Zn 250	28.00	34.15	33.33	31.83	34.88	42.66	38.70	34.88	40.10	45.42	42.18	42.57	27.98	34.24	32.95	31.72	34.79	42.12	38.52	38.48	40.11	44.79	42.04	42.31
Mean	30.013	37.041	31.701	32.92	37.270	43.706	40.813	37.270	42.36	49.30	44.17	45.28	29.90	35.98	31.28	32.39	36.99	42.83	40.32	40.05	41.85	48.58	43.69	44.71
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	0 ppm	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	33.90	37.25	32.92		38.71	45.49	40.60	38.71	49.69	50.84	45.28		33.44	36.84	32.39		38.27	44.62	40.05		48.59	50.21	44.71	
Zn	31.33	37.85	34.89		40.48	44.50	39.82	40.48	45.47	53.54	46.79		30.88	37.25	34.54		39.94	43.71	39.29		44.82	52.57	46.12	
Cu	31.76	38.91	33.39		38.53	45.23	41.04	38.53	45.14	52.82	47.84		31.53	38.10	33.05		38.15	44.42	40.37		44.58	51.84	47.09	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**SE(m)**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.475	0.671	1.348	22.85	0.460	0.650	1.305	0.460	0.440	0.623	1.250	44.43	0.748	1.057	2.122	9.68	0.759	1.073	2.153	18.69	0.784	1.109	2.227	12.97
Zinc	0.475	0.671	1.348	47.25	0.460	0.650	1.305	0.460	0.440	0.623	1.250	96.69	0.748	1.057	2.122	18.32	0.759	1.073	2.153	9.88	0.784	1.109	2.227	27.97
B x Zn	0.822	1.163	2.334	4.30	0.796	1.126	2.260	0.796	0.763	1.079	2.165	14.20	1.295	1.831	NS	1.29	1.314	1.858	NS	1.19	1.359	1.921	3.856	3.65
Copper	0.475	0.671	1.348	62.39	0.460	0.650	1.305	0.460	0.440	0.623	1.250	78.31	0.748	1.057	2.122	21.18	0.759	1.073	2.153	17.55	0.784	1.109	2.227	22.09
B x Cu	0.822	1.163	NS	1.38	0.796	1.126	NS	0.796	0.763	1.079	NS	1.42	1.295	1.831	NS	0.39	1.314	1.858	NS	0.41	1.359	1.921	NS	0.46
Zn x Cu	0.822	1.163	NS	1.62	0.796	1.126	2.260	0.796	0.763	1.079	NS	0.82	1.295	1.831	NS	0.67	1.314	1.858	NS	1.35	1.359	1.921	NS	0.28
B x Zn x Cu	1.424	2.014	NS	1.94	1.379	1.950	NS	1.379	1.321	1.868	NS	0.66	2.243	3.172	NS	0.73	2.276	3.219	NS	0.53	2.353	3.328	NS	0.26

Table 3 : Number of branch per plant.

Treatments	2012-13												2013-14											
Bo & Zn ppm ↓																								
Cu ppm →	30 DAT				60 DAT				90 DAT				30 DAT				60 DAT				90 DAT			
	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean
B0 x Zn 0	2.12	3.00	2.73	2.62	3.10	4.27	3.60	3.66	3.80	4.97	4.73	4.50	1.98	2.93	2.68	2.53	3.08	4.23	3.58	3.63	3.78	4.89	4.67	4.45
B0 x Zn 100	3.33	4.00	3.00	3.44	3.83	5.00	4.17	4.33	4.63	5.63	5.03	5.10	3.29	3.65	2.86	3.27	3.83	4.91	4.14	4.30	4.61	5.56	4.98	5.05
B0 x Zn 250	2.80	3.50	2.93	3.08	3.63	4.67	4.07	4.12	4.67	5.50	4.90	5.02	2.78	3.49	2.88	3.05	3.61	4.62	4.04	4.09	4.63	5.48	4.88	4.99
Mean	2.75	3.50	2.89	3.05	3.52	4.64	3.94	4.04	4.37	5.37	4.89	4.87	2.69	3.35	2.81	2.95	3.51	4.58	3.92	4.00	4.34	5.31	4.84	4.83
B 100 x Zn 0	2.43	3.67	3.33	3.14	3.70	4.83	4.07	4.20	4.30	5.63	4.90	4.94	2.42	3.62	3.28	3.11	3.64	4.78	4.05	4.16	4.25	5.53	4.88	4.89
B 100 x Zn 100	3.67	**4.90**	4.17	4.24	4.70	5.50	4.53	4.91	5.30	6.70	5.10	5.70	3.32	**4.56**	4.04	3.97	4.63	5.19	4.44	4.75	5.26	6.49	5.07	5.61
B100 x Zn 250	2.53	3.70	3.13	3.12	4.17	4.67	4.37	4.40	4.53	5.60	5.17	5.10	2.49	3.71	3.11	3.10	4.16	4.62	4.35	4.38	4.45	5.55	4.86	4.95
Mean	2.88	4.09	3.54	3.50	4.19	5.00	4.32	4.50	4.71	5.98	5.06	5.25	2.74	3.96	3.48	3.39	4.15	4.86	4.28	4.43	4.65	5.86	4.94	5.15
B 250 x Zn 0	2.40	3.13	2.73	2.76	3.43	4.37	3.87	3.89	4.17	4.97	4.60	4.58	2.41	3.07	2.71	2.73	3.41	4.30	3.84	3.85	3.72	4.74	4.58	4.34
B 250 x Zn 100	3.20	4.00	3.67	3.62	4.17	4.93	3.90	4.33	5.13	5.50	4.83	5.16	3.10	3.75	3.61	3.48	4.15	4.91	3.89	4.32	5.01	5.54	4.75	5.10
B 250 x Zn 250	2.63	3.00	2.80	2.81	3.87	4.17	3.93	3.99	4.33	5.20	4.80	4.78	2.54	2.96	2.81	2.77	3.85	4.05	3.92	3.94	4.33	5.14	4.45	4.64
Mean	2.74	3.38	3.07	3.06	3.82	4.49	3.90	4.07	4.54	5.22	4.74	4.84	2.68	3.26	3.04	3.00	3.81	4.42	3.88	4.03	4.35	5.14	4.59	4.69
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	3.05	3.50	3.06		4.04	4.50	4.07		4.87	5.25	4.84		2.95	3.39	3.00		4.00	4.43	4.03		4.83	5.15	4.69	
Zn	2.84	3.77	3.00		3.91	4.53	4.17		4.67	5.32	4.97		2.79	3.58	2.97		3.88	4.45	4.13		4.56	5.25	4.86	
Cu	2.79	3.66	3.17		3.84	4.71	4.06		4.54	5.52	4.90		2.70	3.53	3.11		3.82	4.62	4.03		4.45	5.44	4.79	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.072	0.102	0.205	12.90	0.072	0.101	0.204	13.17	0.098	0.138	0.277	5.44	0.094	0.133	0.266	6.77	0.090	0.128	0.256	6.91	0.103	0.145	0.292	5.15
Zinc	0.072	0.102	0.205	47.35	0.072	0.101	0.204	18.30	0.098	0.138	0.277	10.94	0.094	0.133	0.266	19.19	0.090	0.128	0.256	10.24	0.103	0.145	0.292	11.42
B x Zn	0.125	0.177	NS	2.48	0.124	0.176	NS	0.86	0.169	0.239	NS	0.69	0.162	0.230	NS	1.31	0.156	0.221	NS	0.38	0.178	0.252	NS	0.83
Copper	0.072	0.102	0.205	36.03	0.072	0.101	0.204	39.68	0.098	0.138	0.277	25.95	0.094	0.133	0.266	19.23	0.090	0.128	0.256	21.26	0.103	0.145	0.292	23.82
B x Cu	0.125	0.177	NS	2.02	0.124	0.176	NS	0.99	0.169	0.239	NS	1.04	0.162	0.230	NS	1.56	0.156	0.221	NS	0.66	0.178	0.252	NS	0.64
Zn x Cu	0.125	0.177	NS	0.96	0.124	0.176	NS	2.06	0.169	0.239	NS	1.27	0.162	0.230	NS	0.34	0.156	0.221	NS	1.31	0.178	0.252	NS	1.44
B x Zn x Cu	0.217	0.306	NS	0.49	0.215	0.304	NS	0.26	0.293	0.414	NS	0.45	0.281	0.398	NS	0.43	0.271	0.383	NS	0.23	0.308	0.436	NS	0.20

Table 4 : Number of leaves per plant.

Treatments	2012-13												2013-14											
Bo & Zn ppm ↓																								
Cu ppm →	30 DAT				60 DAT				90 DAT				30 DAT				60 DAT				90 DAT			
	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean
B0 x Zn 0	10.70	13.77	11.43	11.97	16.50	21.42	19.23	19.05	19.03	24.00	19.33	20.79	10.61	13.59	11.29	11.83	16.35	21.29	19.17	18.94	18.88	23.92	19.23	20.68
B0 x Zn 100	14.13	17.03	13.80	14.99	19.40	23.00	19.33	20.58	22.67	26.33	22.33	23.78	13.88	16.94	13.77	14.86	19.33	22.78	19.30	20.47	22.55	26.32	22.21	23.69
B0 x Zn 250	12.97	14.79	12.67	13.47	19.00	21.67	20.67	20.44	20.00	22.33	22.00	21.44	12.95	14.78	12.59	13.44	18.89	21.65	20.13	20.22	19.92	22.29	21.92	21.38
Mean	12.60	15.20	12.63	13.48	18.30	22.03	19.74	20.02	20.57	24.22	21.22	22.00	12.48	15.10	12.55	13.38	18.19	21.91	19.53	19.88	20.45	24.17	21.12	21.92
B 100 x Zn 0	13.30	15.85	14.57	14.57	22.00	24.67	19.67	22.11	23.67	25.67	22.33	23.89	13.22	15.78	14.52	14.51	21.79	24.25	19.63	21.89	23.70	25.60	22.29	23.86
B 100 x Zn 100	14.93	18.77	14.10	15.93	23.67	32.67	24.67	27.00	24.67	34.00	23.33	27.33	14.74	18.35	13.98	15.69	23.64	32.05	24.22	26.64	24.57	33.68	23.29	27.18
B100 x Zn 250	14.20	15.87	13.37	14.48	20.33	25.00	21.00	22.11	23.00	25.00	22.67	23.56	14.17	15.59	13.25	14.34	20.07	24.94	20.84	21.95	22.94	24.96	22.61	23.50
Mean	14.14	16.83	14.01	14.99	22.00	27.44	21.78	23.74	23.78	28.22	22.78	24.93	14.04	16.57	13.92	14.84	21.83	27.08	21.56	23.49	23.74	28.08	22.73	24.85
B 250 x Zn 0	12.47	14.40	13.03	13.30	17.13	20.47	17.33	18.31	18.67	23.00	20.67	20.78	12.12	14.34	12.99	13.15	16.91	20.19	17.25	18.12	18.65	22.88	20.50	20.68
B 250 x Zn 100	14.33	16.60	15.10	15.34	19.00	23.33	18.67	20.33	19.33	24.33	18.67	20.78	14.13	16.38	14.43	14.98	18.89	23.02	18.57	20.16	19.25	24.21	18.54	20.67
B 250 x Zn 250	11.73	12.67	10.53	11.64	17.67	20.00	15.00	17.56	19.67	22.33	18.33	20.11	11.73	12.33	10.34	11.47	17.64	19.79	14.94	17.46	19.41	22.22	18.30	19.98
Mean	12.84	14.56	12.89	13.43	17.93	21.27	17.00	18.73	19.22	23.22	19.22	20.56	12.66	14.35	12.59	13.20	17.81	21.00	16.92	18.58	19.10	23.10	19.12	20.44
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	13.48	14.99	13.43		20.02	23.74	18.73		22.00	24.93	20.56		13.38	14.84	13.20		19.88	23.49	18.58		21.92	24.85	20.44	
Zn	13.28	15.42	13.20		19.82	22.64	20.04		21.82	23.96	21.70		13.16	15.18	13.08		19.65	22.42	19.88		21.74	23.85	21.62	
Cu	13.20	15.53	13.18		19.41	23.58	19.51		21.19	25.22	21.07		13.06	15.34	13.02		19.28	23.33	19.34		21.10	25.12	20.99	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.202	0.286	0.573	19.42	0.330	0.467	0.937	61.96	0.354	0.500	1.004	39.64	0.318	0.450	0.903	8.06	0.551	0.780	1.565	21.34	0.501	0.709	1.423	20.02
Zinc	0.202	0.286	0.573	39.00	0.330	0.467	0.937	22.49	0.354	0.500	1.004	12.95	0.318	0.450	0.903	13.96	0.551	0.780	1.565	7.80	0.501	0.709	1.423	6.24
B x Zn	0.350	0.495	0.993	6.58	0.572	0.809	1.624	5.18	0.612	0.866	1.739	2.84	0.551	0.779	1.563	2.81	0.955	1.351	NS	1.62	0.869	1.228	NS	1.36
Copper	0.202	0.286	0.573	44.71	0.330	0.467	0.937	51.91	0.354	0.500	1.004	44.64	0.318	0.450	0.903	17.49	0.551	0.780	1.565	17.73	0.501	0.709	1.423	22.01
B x Cu	0.350	0.495	NS	0.90	0.572	0.809	1.624	2.87	0.612	0.866	NS	1.05	0.551	0.779	NS	0.28	0.955	1.351	NS	0.90	0.869	1.228	NS	0.47
Zn x Cu	0.350	0.495	NS	2.50	0.572	0.809	NS	1.59	0.612	0.866	1.739	4.14	0.551	0.779	NS	1.24	0.955	1.351	NS	0.47	0.869	1.228	NS	1.98
B x Zn x Cu	0.606	0.857	NS	0.70	0.991	1.401	NS	1.55	1.061	1.500	NS	2.00	0.954	1.349	NS	0.18	1.654	2.339	NS	0.52	1.504	2.128	NS	0.92

Table 5 : Length of longest leaf per plant (cm).

Treatments	2012-13												2013-14											
Bo & Zn ppm ↓																								
Cu ppm →	30 DAT				60 DAT				90 DAT				30 DAT				60 DAT				90 DAT			
	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean
B0 x Zn 0	10.00	12.33	12.20	11.51	14.67	18.00	15.17	15.94	19.67	21.67	20.33	20.56	9.88	12.26	12.08	11.41	14.53	17.83	15.08	15.81	19.45	21.51	20.24	20.40
B0 x Zn 100	11.40	14.22	13.03	12.88	17.00	22.33	20.00	19.78	21.33	25.00	22.33	22.89	11.38	14.19	12.98	12.85	17.02	22.24	19.96	19.74	21.21	24.93	22.13	22.76
B0 x Zn 250	11.73	13.10	12.00	12.28	17.00	20.33	18.00	18.44	20.67	23.33	21.00	21.67	11.68	13.06	11.99	12.24	16.98	20.29	17.97	18.41	20.58	23.17	20.97	21.57
Mean	11.04	13.22	12.41	12.22	16.22	20.22	17.72	18.06	20.56	23.33	21.22	21.70	10.98	13.17	12.35	12.17	16.17	20.12	17.67	17.99	20.41	23.21	21.11	21.58
B 100 x Zn 0	13.07	15.60	13.20	13.96	17.17	20.33	19.00	18.83	22.33	26.00	23.67	24.00	13.05	15.60	13.21	13.95	17.12	20.25	18.95	18.78	22.25	25.96	23.48	23.89
B 100 x Zn 100	14.07	16.20	13.23	14.50	18.83	22.20	17.33	19.46	22.00	27.67	23.33	24.33	13.96	15.95	13.11	14.34	18.79	22.05	17.18	19.34	21.88	27.57	22.92	24.12
B100 x Zn 250	13.37	15.00	13.70	14.02	16.33	18.67	16.33	17.11	22.00	25.00	23.00	23.33	13.34	14.89	13.66	13.97	16.25	18.52	16.28	17.02	21.86	24.88	22.92	23.22
Mean	13.50	15.60	13.38	14.16	17.44	20.40	17.56	18.47	22.11	26.22	23.33	23.89	13.45	15.48	13.33	14.09	17.39	20.27	17.47	18.38	22.00	26.14	23.11	23.75
B 250 x Zn 0	11.07	14.63	12.23	12.64	16.33	19.67	17.00	17.67	20.00	24.00	23.00	22.33	11.00	14.55	12.20	12.58	16.27	19.60	16.97	17.61	19.66	23.90	22.93	22.16
B 250 x Zn 100	12.37	15.50	12.80	13.56	17.33	20.33	18.00	18.56	22.33	26.33	23.00	23.89	12.28	15.39	12.38	13.35	17.12	20.23	17.98	18.44	22.09	26.02	22.92	23.68
B 250 x Zn 250	12.43	14.07	12.07	12.86	16.33	19.00	17.33	17.56	21.67	24.33	23.00	23.00	12.49	13.91	12.01	12.80	16.31	18.90	17.31	17.51	21.58	24.26	22.90	22.91
Mean	11.96	14.73	12.37	13.02	16.67	19.67	17.44	17.93	21.33	24.89	23.00	23.07	11.92	14.62	12.20	12.91	16.57	19.58	17.42	17.85	21.11	24.73	22.92	22.92
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	12.22	14.16	13.02		18.06	18.47	17.93		21.70	23.89	23.07		12.17	14.09	12.91		17.99	18.38	17.85		21.58	23.75	22.92	
Zn	12.70	13.65	13.05		17.48	19.26	17.70		22.30	23.70	22.67		12.65	13.51	13.00		17.40	19.17	17.65		22.15	23.52	22.57	
Cu	12.17	14.52	12.72		16.78	20.10	17.57		21.33	24.81	22.52		12.12	14.42	12.62		16.71	19.99	17.52		21.17	24.69	22.38	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.188	0.266	0.534	26.72	0.248	0.351	NS	1.30	0.215	0.304	0.611	26.33	0.239	0.339	0.680	16.34	0.297	0.420	NS	0.84	0.294	0.416	0.835	13.86
Zinc	0.188	0.266	0.534	6.42	0.248	0.351	0.704	15.33	0.215	0.304	0.611	11.49	0.239	0.339	0.680	3.31	0.297	0.420	0.842	10.49	0.294	0.416	0.835	5.68
B x Zn	0.326	0.461	NS	0.50	0.430	0.607	1.219	7.41	0.373	0.527	NS	2.28	0.415	0.587	NS	0.47	0.514	0.727	1.458	5.59	0.509	0.720	NS	1.37
Copper	0.188	0.266	0.534	42.64	0.248	0.351	0.704	48.81	0.215	0.304	0.611	67.64	0.239	0.339	0.680	25.58	0.297	0.420	0.842	33.18	0.294	0.416	0.835	36.95
B x Cu	0.326	0.461	NS	2.28	0.430	0.607	NS	0.84	0.373	0.527	NS	1.17	0.415	0.587	NS	1.40	0.514	0.727	NS	0.60	0.509	0.720	NS	0.76
Zn x Cu	0.326	0.461	NS	1.55	0.430	0.607	NS	0.61	0.373	0.527	NS	2.33	0.415	0.587	NS	1.13	0.514	0.727	NS	0.44	0.509	0.720	NS	1.34
B x Zn x Cu	0.565	0.798	NS	0.52	0.744	1.052	NS	1.20	0.646	0.913	NS	0.53	0.718	1.016	NS	0.32	0.890	1.259	NS	0.84	0.882	1.248	NS	0.30

Table 6 : Width of longest leaf per plant (cm).

Treatments	2012-13												2013-14											
Bo & Zn ppm ↓																								
Cu ppm →	30 DAT				60 DAT				90 DAT				30 DAT				60 DAT				90 DAT			
	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean
B0 x Zn 0	6.47	8.20	7.27	7.31	10.50	12.67	11.00	11.39	16.87	19.67	17.67	18.07	6.41	8.15	7.23	7.27	10.47	12.62	10.97	11.35	16.71	19.63	17.58	17.97
B0 x Zn 100	8.20	9.93	8.40	8.84	14.00	15.33	13.00	14.11	18.00	20.33	18.00	18.78	8.15	9.84	8.33	8.77	13.69	15.12	12.97	13.93	17.58	20.24	17.87	18.56
B0 x Zn 250	7.13	9.60	7.37	8.03	11.50	14.00	12.00	12.50	16.67	19.50	17.17	17.78	6.97	9.53	7.34	7.95	11.39	13.99	11.94	12.44	16.70	19.46	17.11	17.76
Mean	7.27	9.24	7.68	8.06	12.00	14.00	12.00	12.67	17.18	19.83	17.61	18.21	7.18	9.18	7.63	8.00	11.85	13.91	11.96	12.57	17.00	19.78	17.52	18.10
B 100 x Zn 0	8.03	9.40	8.23	8.56	14.67	18.33	15.67	16.22	20.00	22.33	21.00	21.11	7.97	9.35	8.19	8.50	14.72	18.30	15.62	16.21	19.95	22.25	20.91	21.04
B 100 x Zn 100	8.50	10.35	9.40	9.42	16.67	20.67	17.00	18.11	22.00	25.00	21.33	22.78	8.49	10.22	9.40	9.37	16.61	20.25	17.01	17.96	21.85	24.77	21.38	22.67
B100 x Zn 250	8.40	9.93	8.73	9.02	14.00	17.00	14.67	15.22	20.33	22.00	19.33	20.56	8.33	9.94	8.62	8.97	14.04	16.52	14.61	15.06	20.02	21.76	19.19	20.32
Mean	8.31	9.90	8.79	9.00	15.11	18.67	15.78	16.52	20.78	23.11	20.56	21.48	8.26	9.84	8.74	8.95	15.12	18.36	15.75	16.41	20.61	22.92	20.50	21.34
B 250 x Zn 0	7.47	9.20	8.30	8.32	13.67	17.00	14.00	14.89	18.00	20.67	18.57	19.08	7.41	9.11	8.27	8.26	13.68	16.79	13.97	14.81	17.81	20.67	18.54	19.01
B 250 x Zn 100	8.43	10.07	7.93	8.81	15.00	17.67	15.67	16.11	19.00	22.67	20.00	20.56	8.41	10.02	7.88	8.77	14.95	17.62	15.61	16.06	18.88	22.54	19.92	20.45
B 250 x Zn 250	7.90	8.60	8.13	8.21	14.00	15.67	14.33	14.67	18.00	20.67	18.67	19.11	7.59	8.55	8.04	8.06	13.88	15.52	14.24	14.55	17.69	20.31	18.41	18.80
Mean	7.93	9.29	8.12	8.45	14.22	16.78	14.67	15.22	18.33	21.33	19.08	19.58	7.80	9.23	8.06	8.36	14.17	16.65	14.61	15.14	18.13	21.17	18.96	19.42
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	8.06	9.00	8.45		12.67	16.52	15.22		18.21	21.48	19.58		8.00	8.95	8.36		12.57	16.41	15.14		18.10	21.34	19.42	
Zn	8.06	9.02	8.42		14.17	16.11	14.13		19.42	20.70	19.15		8.01	8.97	8.32		14.13	15.98	14.02		19.34	20.56	18.96	
Cu	7.84	9.48	8.20		13.78	16.48	14.15		18.76	21.43	19.08		7.75	9.41	8.14		13.71	16.30	14.10		18.58	21.29	18.99	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.145	0.205	0.411	10.56	0.217	0.306	0.615	81.91	0.206	0.291	0.585	63.71	0.193	0.272	0.546	6.19	0.179	0.253	0.507	119.57	0.229	0.324	0.650	50.68
Zinc	0.145	0.205	0.411	11.27	0.217	0.306	0.615	27.39	0.206	0.291	0.585	16.28	0.193	0.272	0.546	6.44	0.179	0.253	0.507	38.19	0.229	0.324	0.650	13.28
B x Zn	0.251	0.354	NS	1.34	0.375	0.530	1.065	2.76	0.357	0.505	NS	0.95	0.333	0.472	NS	0.77	0.310	0.438	0.879	4.13	0.397	0.561	NS	1.04
Copper	0.145	0.205	0.411	35.46	0.217	0.306	0.615	45.81	0.206	0.291	0.585	49.85	0.193	0.272	0.546	20.44	0.179	0.253	0.507	61.08	0.229	0.324	0.650	40.73
B x Cu	0.251	0.354	NS	0.49	0.375	0.530	NS	1.15	0.357	0.505	NS	0.51	0.333	0.472	NS	0.24	0.310	0.438	NS	0.96	0.397	0.561	NS	0.41
Zn x Cu	0.251	0.354	NS	0.35	0.375	0.530	NS	0.45	0.357	0.505	NS	0.72	0.333	0.472	NS	0.19	0.310	0.438	NS	0.59	0.397	0.561	NS	0.54
B x Zn x Cu	0.434	0.614	NS	0.91	0.650	0.919	NS	0.47	0.618	0.874	NS	0.46	0.578	0.817	NS	0.51	0.536	0.758	NS	0.60	0.687	0.972	NS	0.24

Table 7 : Leaf area index at 50 % flowering stage.

Treatments	2012-13				2013-14			
Bo & Zn ppm ↓ / Cu ppm →	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean
B0 × Zn 0	1.98	2.16	2.06	2.07	1.48	1.50	1.56	1.51
B0 × Zn 100	2.00	2.37	2.14	2.17	1.50	1.87	1.95	1.77
B0 × Zn 250	2.15	2.34	2.16	2.22	1.65	1.67	1.66	1.66
Mean	2.04	2.29	2.12	2.15	1.54	1.68	1.72	1.65
B 100 × Zn 0	2.05	2.46	2.25	2.26	1.55	1.76	1.96	1.76
B 100 × Zn 100	2.38	2.55	2.27	2.40	1.88	2.05	2.11	2.02
B100 × Zn 250	2.16	2.75	2.48	2.46	1.66	2.25	2.31	2.07
Mean	2.20	2.59	2.33	2.37	1.70	2.02	2.13	1.95
B 250 × Zn 0	2.28	2.40	2.30	2.33	1.78	1.90	1.87	1.85
B 250 × Zn 100	2.45	2.87	2.41	2.58	1.95	2.37	2.95	2.42
B 250 × Zn 250	2.38	2.63	2.41	2.47	1.88	2.85	2.91	2.55
Mean	2.37	2.64	2.37	2.46	1.87	2.38	2.57	2.27
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	2.15	2.37	2.46		1.65	1.95	2.27	
Zn	2.22	2.38	2.38		1.71	2.07	2.09	
Cu	2.20	2.50	2.28		1.70	2.02	2.14	
Factor	SE(m)	SE(d)	C.D. at 5%	F test	SE(m)	SE(d)	C.D. at 5%	F test
Boron	0.010	0.014	0.027	273.91	0.007	0.009	0.019	2295.12
Zinc	0.010	0.014	0.027	99.45	0.007	0.009	0.019	1092.90
B × Zn	0.017	0.024	0.047	8.98	0.011	0.016	0.032	166.23
Copper	0.010	0.014	0.027	266.38	0.007	0.009	0.019	1210.97
B × Cu	0.017	0.024	0.047	8.00	0.011	0.016	0.032	139.92
Zn × Cu	0.017	0.024	0.047	9.77	0.011	0.016	0.032	128.19
B × Zn × Cu	0.029	0.041	0.082	12.31	0.020	0.028	0.056	106.26

@ 250 ppm + Zn @ 250 ppm + Cu @ 100 ppm and 2.91 m^2/m^2 at spray of boron @ 250 ppm + Zn @ 250 ppm + Cu @ 250 ppm, while unsprayed plants recorded minimum leaf area index m^2/m^2 during 2012-13 and 2013-14, respectively.

The application boron, zinc and copper significantly increased the number of days for fruit formation per plant in days in both the year. Results presented in table 8 indicated that maximum number of days for fruit initiation recorded (81.53 days and 79.47 days) with spray of boron @ 250 ppm + Zn @ 250 ppm + Cu @ 250 ppm followed by the application of spray of boron @ 250 ppm + Zn @ 250 ppm + Cu @ 100 ppm (81.20 days and 79.20 days) while minimum were recorded under unsprayed plant in both the years. The total number of mature fruits differed significantly among the treatments table 9 presented in both the years. The maximum number of mature fruits (42.39 spray of Boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm and 40.11 with spray of boron @ 250 ppm + Zn @ 0 ppm + Cu @ 100 ppm) followed (42.02 with spray of Boron @ 250 ppm + Zn @ 100 ppm + Cu @ 100 ppm and 39.13 boron @ 0 ppm + Zn @ 0 ppm + Cu @ 100 ppm)) while minimum were recorded under unsprayed plant in both the years. The weight of one fruit per plant in kg was calculated significantly higher yield of tomato. The data table 9 indicated highest one weight (0.085 kg and 0.82 kg) with spray of Boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm followed by the application of Boron @ 250 ppm + Zn @ 0 ppm + Cu @ 100 ppm (0.074 kg and 0.073 kg) whereas minimum calculated under unsprayed plant. The application boron, zinc and copper significantly increased fruit yield per plant as well as yield per hectare in both the year. Results presented in table 9 indicated that maximum fruit yield (3.04 and 2.98 kg) per plant was obtained with the combined application of Boron @ 100 ppm + Zn @ 100 ppm + copper @ 100 ppm followed by the spray of Boron @ 100ppm + Zn @ 0 ppm + copper @ 100 ppm (2.69 and 2.70 kg) while unsprayed plants recorded minimum fruit yield per plant (1.52 and 1.50 kg) during 2012-13

Table 8 :

Treatments	Days taken to fruits initiation per plant (days)								Number of fruits per plant							
Bo & Zn ppm ↓	**2012-13**				**2013-14**				**2012-13**				**2013-14**			
Cu ppm →	**Cu 0**	**Cu 100**	**Cu 250**	**Mean**	**Cu 0**	**Cu 100**	**Cu 250**	**Mean**	**Cu 0**	**Cu 100**	**Cu 250**	**Mean**	**Cu 0**	**Cu 100**	**Cu 250**	**Mean**
B0 × Zn 0	65.13	69.00	72.93	69.02	63.77	66.83	71.00	67.20	23.55	38.99	28.50	30.35	27.37	39.13	31.41	32.64
B0 × Zn 100	70.80	68.10	72.07	70.32	68.83	66.10	70.00	68.31	29.22	37.21	34.34	33.59	27.28	35.18	32.41	31.63
B0 × Zn 250	68.27	73.37	71.17	70.93	66.23	71.27	69.07	68.86	27.23	37.13	28.27	30.88	25.05	29.18	26.18	26.80
Mean	68.07	70.16	72.06	70.09	66.28	68.07	70.02	68.12	26.67	37.78	30.37	31.61	26.57	34.50	30.00	30.36
B 100 × Zn 0	71.60	70.97	71.13	71.23	69.37	68.80	68.90	69.02	29.87	41.54	32.08	34.50	27.12	39.38	32.28	32.93
B 100 × Zn 100	72.67	70.33	69.17	70.72	74.20	68.47	70.50	71.06	37.28	42.39	40.86	40.18	28.83	36.17	33.38	32.79
B100 × Zn 250	70.33	66.97	64.70	67.33	68.37	64.73	62.13	65.08	35.57	38.03	36.77	36.79	25.81	29.98	26.56	27.45
Mean	71.53	69.42	68.33	69.76	70.64	67.33	67.18	68.39	34.24	40.65	36.57	37.15	27.25	35.18	30.74	31.06
B 250 × Zn 0	64.07	68.20	67.00	66.42	64.30	61.93	65.70	63.98	25.59	40.00	30.42	32.00	28.19	40.11	32.62	33.64
B 250 × Zn 100	65.53	68.40	79.77	71.23	59.07	71.10	77.70	69.29	35.38	42.02	39.77	39.06	28.77	36.37	37.08	34.08
B 250 × Zn 250	80.33	81.20	81.53	81.02	78.27	79.20	79.47	78.98	28.51	33.74	31.01	31.09	26.55	30.92	28.89	28.78
Mean	69.98	72.60	76.10	72.89	67.21	70.74	74.29	70.75	29.83	38.59	33.74	34.05	27.84	35.80	32.86	32.17
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	70.09	69.76	72.89		68.12	68.39	70.75		31.61	37.15	34.05		30.36	31.06	32.17	
Zn	68.89	70.76	73.10		66.73	69.55	70.97		32.28	37.61	32.92		33.07	32.83	27.68	
Cu	69.86	70.73	72.16		68.04	68.71	70.50		30.24	39.00	33.56		27.22	35.16	31.20	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.857	1.212	2.433	4.029	0.802	1.135	2.277	3.248	0.126	0.178	0.358	486.627	0.107	0.151	0.303	72.908
Zinc	0.857	1.212	2.433	6.043	0.802	1.135	2.277	7.225	0.126	0.178	0.358	532.904	0.107	0.151	0.303	812.474
B × Zn	1.484	2.099	4.213	10.775	1.390	1.965	3.944	13.942	0.218	0.309	0.620	50.640	0.185	0.262	0.525	4.225
Copper	0.857	1.212	NS	1.846	0.802	1.135	NS	2.493	0.126	0.178	0.358	1231.515	0.107	0.151	0.303	1381.499
B × Cu	1.484	2.099	4.213	2.722	1.390	1.965	3.944	3.897	0.218	0.309	0.620	32.453	0.185	0.262	0.525	7.822
Zn × Cu	1.484	2.099	NS	1.362	1.390	1.965	NS	1.588	0.218	0.309	0.620	130.382	0.185	0.262	0.525	146.417
B × Zn × Cu	2.571	3.636	NS	1.232	2.407	3.404	6.832	2.468	0.378	0.535	1.073	7.482	0.320	0.453	0.910	4.167

Table 9 :

Treatments	Weight of one fruit (g)								Yield of fruits per plant (kg)							
Bo & Zn ppm ↓	2012-13				2013-14				2012-13				2013-14			
Cu ppm →	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean
B0 × Zn 0	0.043	0.071	0.049	0.054	0.042	0.067	0.050	0.053	1.52	2.52	1.70	1.91	1.50	2.43	1.77	1.90
B0 × Zn 100	0.058	0.072	0.064	0.065	0.057	0.073	0.061	0.064	2.11	2.75	2.35	2.40	2.10	2.60	2.22	2.31
B0 × Zn 250	0.049	0.065	0.058	0.057	0.047	0.065	0.056	0.056	1.77	2.31	2.11	2.06	1.74	2.31	2.05	2.04
Mean	0.050	0.069	0.057	0.059	0.049	0.068	0.056	0.058	1.80	2.53	2.06	2.13	1.78	2.44	2.01	2.08
B 100 × Zn 0	0.055	0.073	0.060	0.063	0.051	0.071	0.055	0.059	1.98	2.69	2.08	2.25	1.89	2.70	2.07	2.22
B 100 × Zn 100	0.074	0.085	0.071	0.077	0.074	0.082	0.067	0.074	2.66	3.04	2.56	2.75	2.65	2.98	2.44	2.69
B100 × Zn 250	0.065	0.070	0.060	0.065	0.059	0.072	0.061	0.064	2.26	2.54	2.28	2.36	2.17	2.51	2.18	2.29
Mean	0.065	0.076	0.064	0.068	0.061	0.075	0.061	0.066	2.30	2.76	2.31	2.45	2.24	2.73	2.23	2.40
B 250 × Zn 0	0.046	0.074	0.056	0.059	0.043	0.073	0.053	0.056	1.63	2.63	1.98	2.08	1.57	2.45	1.92	1.98
B 250 × Zn 100	0.061	0.072	0.062	0.065	0.056	0.067	0.060	0.061	2.16	2.63	2.19	2.33	2.05	2.44	2.02	2.17
B 250 × Zn 250	0.054	0.071	0.062	0.062	0.051	0.063	0.059	0.058	1.95	2.45	2.18	2.19	1.91	2.34	2.12	2.12
Mean	0.054	0.072	0.060	0.062	0.050	0.068	0.057	0.058	1.91	2.57	2.12	2.20	1.84	2.41	2.02	2.09
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	0.059	0.068	0.062		0.058	0.066	0.058		2.13	2.45	2.20		2.08	2.40	2.09	
Zn	0.059	0.069	0.062		0.056	0.066	0.059		2.08	2.49	2.21		2.03	2.39	2.15	
Cu	0.056	0.073	0.060		0.053	0.070	0.058		2.00	2.62	2.16		1.95	2.53	2.09	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.001	0.002	0.003	17.288	0.001	0.002	0.003	15.234	0.026	0.036	0.073	44.721	0.021	0.030	0.060	72.274
Zinc	0.001	0.002	0.003	21.421	0.001	0.002	0.003	20.924	0.026	0.036	0.073	67.725	0.021	0.030	0.060	73.425
B × Zn	0.002	0.003	NS	1.310	0.002	0.003	NS	1.846	0.044	0.063	0.126	3.399	0.037	0.052	0.104	6.637
Copper	0.001	0.002	0.003	56.917	0.001	0.002	0.003	57.130	0.026	0.036	0.073	154.204	0.021	0.030	0.060	199.995
B × Cu	0.002	0.003	NS	1.678	0.002	0.003	NS	1.332	0.044	0.063	0.126	3.210	0.037	0.052	0.104	3.144
Zn × Cu	0.002	0.003	0.006	3.406	0.002	0.003	0.006	3.789	0.044	0.063	0.126	10.326	0.037	0.052	0.104	14.974
B × Zn × Cu	0.003	0.005	NS	0.591	0.003	0.005	NS	0.338	0.077	0.109	NS	0.620	0.064	0.090	NS	0.350

Table 10 :

Treatments	Yield of fruits per plot (kg)								Yield of fruits per hectare (q)							
Bo & Zn ppm ↓	2012-13				2013-14				2012-13				2013-14			
Cu ppm →	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean	Cu 0	Cu 100	Cu 250	Mean
B0 × Zn 0	4.71	6.84	5.77	5.77	4.57	7.52	5.46	5.85	143.63	236.07	172.10	183.93	141.20	232.00	169.37	180.86
B0 × Zn 100	6.45	7.75	6.53	6.91	6.22	7.89	6.30	6.80	198.60	250.67	201.60	216.96	193.83	247.77	198.73	213.44
B0 × Zn 250	5.34	7.07	6.34	6.25	5.44	7.18	6.49	6.37	171.67	221.30	197.40	196.79	169.57	218.93	196.00	194.83
Mean	5.50	7.22	6.21	6.31	5.409	7.530	6.083	6.34	171.30	236.01	190.37	199.23	168.20	232.90	188.03	196.38
B 100 × Zn 0	6.08	7.76	6.01	6.62	5.75	7.85	5.96	6.52	182.73	247.33	185.03	205.03	179.67	243.27	181.63	201.52
B 100 × Zn 100	7.71	8.21	7.95	7.96	7.62	8.64	7.89	8.05	235.43	263.60	244.30	247.78	233.67	261.73	241.70	245.70
B100 × Zn 250	6.78	7.53	6.93	7.08	6.66	7.44	6.61	6.91	211.10	232.13	213.07	218.77	207.63	230.50	210.70	216.28
Mean	6.85	7.83	6.96	7.22	6.677	7.976	6.820	7.16	209.76	247.69	214.13	223.86	206.99	245.17	211.34	221.17
B 250 × Zn 0	4.75	7.76	5.93	6.15	5.03	7.87	5.78	6.23	153.87	243.40	181.97	193.08	151.30	241.13	177.10	189.84
B 250 × Zn 100	6.60	8.12	5.62	6.78	6.72	8.27	5.71	6.90	212.07	263.17	236.00	237.08	208.83	258.30	233.67	233.60
B 250 × Zn 250	5.81	7.33	6.48	6.54	5.68	7.46	6.61	6.58	178.97	231.30	206.97	205.74	176.50	228.23	203.87	202.87
Mean	5.72	7.74	6.01	6.49	5.808	7.866	6.032	6.57	181.63	245.96	208.31	211.97	178.88	242.56	204.88	208.77
Over all mean	0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm		0 ppm	100 ppm	250 ppm	
B	6.31	7.22	6.49		6.341	7.158	6.568		199.23	223.86	211.97		196.38	221.17	208.77	
Zn	6.18	7.22	6.62		6.198	7.250	6.619		194.01	233.94	207.10		190.74	230.91	204.66	
Cu	6.02	7.60	6.39		5.965	7.791	6.312		187.56	243.22	204.27		184.69	240.21	201.42	
Factor	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**	**SE(m)**	**SE(d)**	**C.D. at 5%**	**F test**
Boron	0.092	0.130	0.262	27.201	0.063	0.089	0.179	44.792	0.627	0.887	1.779	386.165	0.733	1.037	2.080	285.940
Zinc	0.092	0.130	0.262	31.902	0.063	0.089	0.179	70.600	0.627	0.887	1.779	1053.977	0.733	1.037	2.080	774.672
B × Zn	0.160	0.226	NS	1.551	0.109	0.154	0.310	5.560	1.086	1.536	3.082	10.057	1.269	1.795	3.603	9.136
Copper	0.092	0.130	0.262	79.703	0.063	0.089	0.179	236.747	0.627	0.887	1.779	2075.363	0.733	1.037	2.080	1509.891
B × Cu	0.160	0.226	0.453	3.903	0.109	0.154	0.310	5.696	1.086	1.536	3.082	56.819	1.269	1.795	3.603	39.474
Zn × Cu	0.160	0.226	0.453	5.375	0.109	0.154	0.310	15.682	1.086	1.536	3.082	139.648	1.269	1.795	3.603	100.138
B × Zn × Cu	0.276	0.391	NS	1.944	0.189	0.267	0.537	2.890	1.881	2.660	5.338	7.303	2.199	3.110	6.241	5.263

and 2013-14, respectively. It is also observed that the application of 100 ppm boron gave highest fruit yield per plant followed by boron 250 ppm while it was minimum under unsprayed plants in both the years. Similarly 100 ppm copper and 100 ppm zinc also gave best performance regarding fruit yield in present investigation. The data table 10 showed that the yield per plot in kg maximum obtained (8.21 kg and 8.64 kg) with spray of boron @ 100 ppm + Zn @ 100 ppm) + copper @ 100 ppm followed by (8.12 kg and 8.27 kg) followed by the spray of boron @ 250 ppm + Zn @ 100 ppm + copper @ 100 ppm whereas the minimum under control treatment (4.71 kg and 4.57 kg) during 2012-13 to2013-14. A significant increase in fruit yield per hectored was observed with the foliar application of micronutrients (table 10). Results showed that maximum fruit yield was produced with spray of born, Zn and Cu.

Micronutrients application may be attributed to enhanced photosynthesis activity and increased production and accumulation of carbohydrates and favorable effect on vegetative growth and retention of flowers and fruits, which increased number of fruits per plant besides increasing the size. Similarly, Singh and Tiwari (2013), Mishra *et al*. (2012), Patil *et al*. (2009), Sivaiah *et al*. (2013) and Sathya *et al*. (2013) obtained higher yield and yield attributes with the application of micronutrient.

Conclusion

From the above discussion under Allahabad Agro-climatic condition in the eastern U.P., it may be concluded that combination of Boron @ 100 ppm × Copper sulphate @ 100 ppm × Zinc sulphate @ 100 ppm with recommended dose of NPK. Growth parameters like plant height per plant (cm), plant spread per plant (cm), number of branches per plant, number of leaves per plant, length of longest leaf (cm), width of longest leaf per plant (cm) with spray of boron @ 100 ppm + Zn @ 100 ppm + Cu @ 100 ppm and leaf area index (m^2/m^2) at 50% flowering stag with spray of boron @ 250 ppm + Zn @ 100 ppm + Cu @ 100 ppm may be suggested for better growth of tomato plant.

Yields parameters recommended with application of like, days taken to fruit formation with spray of boron @ 250 ppm + Zn @ 250 ppm + Cu @ 250 ppm. Number of fruits per plant, yield per plant (kg), weight of one fruit (kg), yield per plot (kg) and yield (q/ha with spray of boron, @ 100 ppm + zinc sulphate @ 100 ppm + copper sulphate @ 100 ppm may be suggested for better yield and quality of tomato.

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