Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 298-302
Received: 24-05-2018
Accepted: 29-06-2018

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Effect of soil application of zinc on growth and quality of Tomato (*Solanum lycopersicon* L.) in different zinc fertility soils of eastern dry zone (Zone V) of Karnataka

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Abstract
Micronutrient deficiencies are not only hampering crop productivity but also deteriorating fruit quality. The present investigation was undertaken with the main objective to study the effect of soil application of zinc in tomato (*Solanum lycopersicum* L.) @ 0, 5, 10, 15 and 20 kg $ZnSO_4$ ha^{-1}) on the growth and quality parameters in greenhouse conditions at UAS (B), Bangalore, Karnataka. The experiment was conducted in Factorial completely randomized design (FCRD) with three replication and 15 locations with varied zinc fertility levels. Zinc application increased the plant growth and quality parameters. Among the all treatments maximum plant growth and quality parameters were achieved by the Zn application at 20 kg $ZnSO_4$ ha^{-1} along with RDF and the lowest performance was recorded in the control treatment. The results of this study suggest that soil application of zinc at 20 kg $ZnSO_4$ ha^{-1} along with RDF in all the zinc fertility levels of the soils significantly increased plant height, chlorophyll, TSS, Vitamin C, lycopene and Titra table acidity.

Keywords: tomato, zinc sulphate, growth, quality, chlorophyll, lycopene and fertility levels

Introduction
Intensive cultivation made Indian agriculture to show multiple nutrient deficiencies. This is true especially in the case of micronutrients. Among the micronutrients, the occurrence of zinc deficiency is widespread. Analysis of soil samples from all over India showed that 48.5 per cent of the soils and 44 per cent of the plant samples were potentially zinc deficient and in Karnataka it is 56 - 60 per cent soilsare deficient and affecting crop yields and likely to be increased from 49 per cent to 63 per cent by 2025. Zinc deficiency not only causes yield losses but also affects human health. Deficiency of zinc has increased in southern statesdue to extensive use of NPK without micronutrients (Singh, 2006) [11]. Micronutrients are just as important in plant nutrition as that of the major nutrients. Plants grown on micronutrient deficient soils can exhibit similar reductions in plant growth and yield as that of major nutrients.
Zinc is one of the 17 essential elements necessary for the normal growth and development of plants. Zinc plays a key role in plants with enzymes and proteins involved in carbohydrate metabolism, protein synthesis, gene expression, auxin (growth regulator) metabolism, pollen formation, maintenance of biological membranes, protection against photo-oxidative damage and heat stress and resistance to infection by certain pathogens (Alloway, 2008) [1]. Zinc deficiency in plants retards photosynthesis and nitrogen metabolism, reduces flowering and fruit development, prolongs growth periods (resulting in delayed maturity), decreases yield, quality and results in sub-optimal nutrient-use efficiency. Zinc deficiency is found to be one of the major constraint in obtaining high yield and quality of tomato. Keeping in view the present study was undertaken to know the effect of varied levels of zinc on different zinc fertility level soils (low, medium and high).

Materials and Methods
Fifteen surface soils belonging to low, medium and high zinc status were collected from eastern dry zone (Zone 5) of Karnataka and analyzed for available zinc status. Soil samples from the surface layer (0-15 cm) were collected at different locations of tomato growing areas and analyzed for pH, EC, organic carbon, available major, secondary and micronutrients using standard procedures (Jackson, 1973) [6]. Green house experiment was conducted with tomato as test crop by applying graded levels of zinc along with a standard check (RDF). The.

Experiment was layout in Factorial completely randomized design (FCRD) with three replication and 15=Locations of varied zinc fertility levels. Plant protection measures and irrigations to the crop is given as per requirement of the crop. Crop was harvested after 100 days after transplanting. The details of the experiment are presented in Table.1.

Table 1: Details of the pot experiment

Experimental details	
Test crop	Tomato (Hybrid US-440)
Number of replications	3
No. of Treatments	5
Number of locations	15
Number of pots	225
RDF (kg ha^{-1})	250:250:250 kg N, P_2O_5, K_2O ha^{-1} – UAS (B)
Design of experiment	FCRD
Treatment details	
T_1	Control (RDF)
T_2	Rec. NPK + $ZnSO_4$ @ 5 kg ha^{-1}
T_3	Rec. NPK + $ZnSO_4$ @ 10 kg ha^{-1}
T_4	Rec. NPK + $ZnSO_4$ @ 15 kg ha^{-1}
T_5	Rec. NPK + $ZnSO_4$ @ 20 kg ha^{-1}

The Titratable acidity and Vitamin C (Ascorbic acid) was determined in fresh samples of uniformly matured fruits by 2, 6- dichlorophenol method of AOAC (1970). Total soluble solids were estimated by using Hand Refractometer and lycopene by using standard procedure by Ranganna, 1977.

Results and Discussion

Physico chemical properties

The pH was slightly acidic to slightly alkaline (5.98 to 7.76) in nature. The EC ranges from 0.13 to 1.13 dS m^{-1}which are non saline in nature. The organic carbon ranges from low to high in content (0.42 to 1.81 %). The texture of the experimental soils was comprised of sandy loam and sandy clay loam in texture. The details regarding available major, secondary and micronutrient status of the experimental soils are presented in Table.2.

Growth parameters

The results of the investigation showed that with increasing zinc content in soils the plant height increased significantly irrespective of all the locations. Highest plant height is recorded in the treatments receiving 20 kg $ZnSO_4$ ha^{-1} and the lowest was recorded in the control. The mean plant height in the control treatment is 75.61 cm, whereas in the treatments receiving 5, 10, 15, 20 kg $ZnSO_4$ ha^{-1} the plant height is 94.48, 100.28, 109.82 and 115.29 cm respectively. The results are presented in the Table 3. The above results clearly showed there is a significant improvement in plant height with the application of zinc. These results are in conformity with the findings of Muhammad *et al*. (2014) [7]. Increase in plant height may be attributed to the role of zinc in auxin synthesis and also helps in cell differentiation that helps in root and shoot growth of plants. Similar reports were made by Basavarajeswari *et al*. (2008). Nitrogen encourages vegetative growth while phosphorus and zinc encourages reproductive growth. These findings could give further support to the observations made by Wajid *et al*. (2010) [12] and Nawaz *et al*. (2012) [8].

There was a significant variations were observed among the treatments in respect of the chlorophyll content of the tomato. The lowest chlorophyll was recorded in all the control pots, where as highest was recorded in the pots treated with 15 kg $ZnSO_4$ ha^{-1} with RDF. The mean chlorophyll content was varied from 9.63 to 12.31 SPAD reading. The results are presented in Table 4. The SPAD readings for T_1, T_2, T_3, T_4 and T_5 are 9.63, 10.27, 10.70, 12.31 and 11.93 respectively. The highest mean chlorophyll content was observed in low zinc fertility soils followed by high and medium soils and are statistically significant between the treatments. This showed that the zinc application increased the chlorophyll content. Salman *et al*. (2010) opined that zinc application increased the chlorophyll content. Similar reports were also made by Gurmani *et al*. (2010) [5].

Table 2: Available major, secondary and micronutrients of the experimental soils

S. No	Place	Av. N	Av. P_2O_5	Av.K_2O	Av. S	Ex. Ca	Ex. Mg	Av. Zn	Av. Fe	Av. Cu	Av. Mn	Av. B
		kg ha^{-1}				m.eq 100 g^{-1} soil		mg kg^{-1}				
1	Kanjanahalli-1	263.46	65.12	320.86	39.61	6.10	1.90	0.17	5.96	1.72	4.62	1.12
2	Kanjanahalli-2	274.50	84.76	443.77	56.00	5.90	2.10	0.26	11.66	3.01	15.35	0.59
3	Sadanahalli-1	250.50	76.50	420.12	80.59	5.10	3.20	0.26	7.77	1.64	8.98	0.48
4	Sadanahalli-2	279.50	74.30	380.90	73.76	4.90	2.10	0.19	3.65	1.54	5.16	1.19
5	Kethanahalli	227.50	65.30	324.60	58.73	4.60	1.90	0.24	14.06	1.83	9.66	0.78
6	Milapanahalli	239.90	89.10	110.50	66.93	2.60	1.60	0.70	3.84	1.92	2.00	1.15
7	Addegoppa	234.00	69.80	480.56	28.68	4.50	2.20	0.62	2.96	0.98	4.21	0.53
8	Yerranagenahalli	220.12	124.50	297.60	61.46	3.90	2.10	1.01	10.14	1.09	8.50	0.79
9	Madivala-1	326.14	50.12	525.50	57.37	4.50	2.40	1.17	3.48	1.22	2.15	0.42
10	Guddanahalli-2	285.38	43.72	267.46	98.34	8.40	4.70	1.16	2.38	0.83	4.86	0.68
11	Madivala-1	257.15	84.25	775.49	43.71	10.30	2.90	3.53	3.73	1.04	3.11	0.43
12	Garudanahalli-2	254.02	89.58	512.06	65.56	8.40	3.20	4.74	3.27	1.12	3.27	0.52
13	Vagari	225.79	61.85	400.51	94.24	9.60	4.50	2.82	1.90	1.47	3.57	1.01
14	Haripura-1	216.38	66.12	193.54	36.88	6.10	2.20	3.29	4.50	1.86	6.16	0.92
15	Haripura-2	238.34	67.19	391.10	56.00	4.90	4.00	4.89	6.62	1.70	6.78	0.98
	Minimum	216.38	43.72	110.50	28.68	2.60	1.60	0.17	1.90	0.83	2.00	0.42
	Maximum	326.14	124.50	775.49	98.34	10.30	4.70	4.89	14.06	3.01	15.35	1.19
	Mean	252.85	74.15	389.64	61.19	5.99	2.73	1.67	5.73	1.53	5.89	0.77

Table 3: Effect of zinc application on plant height (cm) of tomato in different soils

Soils	T_1	T_2	T_3	T_4	T_5	Mean
A_1	59.80	95.00	113.62	121.00	123.59	102.60
A_2	68.77	79.00	86.71	104.00	120.60	91.82
A_3	71.76	111.00	96.68	99.00	113.62	98.41

A_4	68.77	82.00	98.67	114.00	120.60	96.81
A_5	61.79	87.00	97.67	106.00	118.60	94.21
A_6	77.74	98.00	99.67	110.00	122.59	101.60
A_7	83.72	98.00	108.64	104.00	113.62	101.60
A_8	68.77	81.00	95.38	107.00	112.80	92.99
A_9	83.72	99.00	96.95	105.00	109.73	98.88
A_{10}	80.73	94.00	98.67	113.07	115.61	100.42
A_{11}	77.74	94.00	100.66	110.00	115.61	99.60
A_{12}	81.73	89.00	88.70	116.00	122.59	99.60
A_{13}	86.71	99.00	109.63	117.00	115.61	105.59
A_{14}	77.74	92.00	96.15	113.79	109.21	97.78
A_{15}	84.72	119.15	116.33	107.48	95.00	104.54
Mean	75.61	94.48	100.28	109.82	115.29	
	SEm±	CD at 1%				
A	2.630	9.703				
T	1.518	5.602				
A X T	5.880	21.697				

T1 Control
T2 Rec. NPK + ZnSO4 @ 5 kg ha-1
T3 Rec. NPK + ZnSO4 @ 10 kg ha-1
T4 Rec. NPK + ZnSO4 @ 15 kg ha-1
T5 Rec. NPK + ZnSO4 @ 20 kg ha-1 A-Soils
A_1 –A_5 - Low Zinc Soils
A_6 –A_{10} - Medium Zinc Soils
A_{11} –A_{15}-High Zinc Soils

Table 4: Effect of zinc application on Chlorophyll (SPAD reading) of tomato in different soils

Soils	T_1	T_2	T_3	T_4	T_5	Mean
A_1	12.20	13.29	15.85	18.10	20.03	15.89
A_2	9.11	12.36	16.05	16.10	14.05	13.53
A_3	12.10	13.36	12.06	11.90	10.07	11.90
A_4	10.10	9.17	10.07	12.10	11.06	10.50
A_5	9.10	9.37	10.07	12.10	13.06	10.74
A_6	7.10	8.87	9.07	12.10	10.07	9.44
A_7	12.10	12.36	12.46	12.60	12.66	12.43
A_8	9.10	8.07	7.87	8.10	9.07	8.44
A_9	8.60	9.47	8.57	7.90	6.08	8.12
A_{10}	7.10	9.57	8.87	11.10	12.06	9.74
A_{11}	6.90	8.87	6.68	14.10	11.86	9.68
A_{12}	9.50	10.17	11.26	12.10	11.86	10.98
A_{13}	9.20	8.87	12.26	11.90	12.06	10.86
A_{14}	10.10	11.16	11.36	12.30	13.06	11.60
A_{15}	12.10	9.17	8.07	12.10	11.86	10.66
Mean	9.63	10.27	10.70	12.31	11.93	
	SEm±	CD at 1%				
A	0.319	1.176				
T	0.184	0.679				
A X T	0.713	2.630				

T1 Control
T2 Rec. NPK + ZnSO4 @ 5 kg ha-1
T3 Rec. NPK + ZnSO4 @ 10 kg ha-1
T4 Rec. NPK + ZnSO4 @ 15 kg ha-1
T5 Rec. NPK + ZnSO4 @ 20 kg ha-1
A-Soils
A1 –A5 -Low Zinc Soils
A6 –A10 - Medium Zinc Soils
A11 –A15-High Zinc Soi**ls**

Quality parameters

The application of Zn through zinc sulphate improved quality parameters and the results are depicted in Figure. 1. Total soluble solid content of the fruits varied due to different zinc levels. The mean values ranged from 4.90 to 5.90 ^{0}Brix. The mean TSS for T_1, T_2, T_3, T_4 and $T_5$are 4.90, 5.42, 5.30, 5.42 and 5.90 ^{0}Brix respectively. The highest TSS content was recorded in the fruits which are grown with 20 kg $ZnSO_4$ ha^{-1}along wither commended dose of NPK, where it was recorded lowest in control. There is a slight variation of TSS in different locations of experimental soils, and they are statistically significant. The results are in conformity with the findings of Salam *et al*. (2010) [10]. The mean TSS was almost same in all the fertility levels of the soils irrespective of low, medium and high zinc status. As TSS is significant, it clearly shows that zinc application improved the total soluble solids content of the tomato.

Vitamin C is an important vitamin to human health. Marked differences were observed in vitamin C content of the fruit due to the varied zinc levels. The mean vitamin C for studied soils ranges from 29.11 to 47.19 mg 100 g^{-1}. With varied zinc level application the mean vitamin C content is 29.11, 35.01, 38.09, 40.60 and 47.19 @ T_1, T_2, T_3, T_4 and T_5respectively. The highest mean was recorded in the treatment receiving 20 kg $ZnSO_4$ ha^{-1}along with recommended dose of NPK and lowest was recorded in control. Highest mean was recorded in high zinc soils followed by medium and low zinc fertility soils. Dube *et al*. (2004) [4] pined that vitamin C content of the fruits improved with zinc sulphate @ 20 kg ha^{-1} respectively. These results are also similar to that of the findings made by Salam *et al*., 2010.

The lycopene content of the fruits increased with the increasing zinc levels. The mean lycopene content ranges from 8.36 to 17.26 mg 100 g^{-1}. With varied levels of zinc application, the lycopene content is 8.36, 9.65, 11.76, 14.84 and 17.26 mg 100 g^{-1} for T_1, T_2, T_3, T_4 and T_5respectively. The highest mean lycopene was recorded in treatment T_5 with 20 kg $ZnSO_4$with RDF. On the other hand the lowest was recorded in control where no zinc application. This clearly shows that zinc plays an important role in increasing the lycopene content in the fruit. These results are also in conformity with the findings made by Salam *et al*. (2010) [10].

Titratable acidity is an important factor for canning of fruits. High acidity is better for canning purpose. Considering the main effect of zinc, acidity was significantly influenced. Acidity content of the fruits increased with the increasing zinc levels. The mean titratable acidity ranged from 0.22 – 0.40 %. With varied zinc levels such as T_1, T_2, T_3, T_4 and T_5 the titratable acidity is 0.22, 0.28, 0.32, 0.34 and 0.40 percent. The results of the investigation reflected that the mean titratable acidity for high zinc fertility soils is more followed by medium and low fertility soils. The highest acidity (0.45 %) was recorded in fruits which were produced with 20 kg $ZnSO_4$ ha^{-1}+ RDF and lowest (0.14%) was recorded in control. These results are similar to that of the findings made by Salam *et al*. (2010) [10].

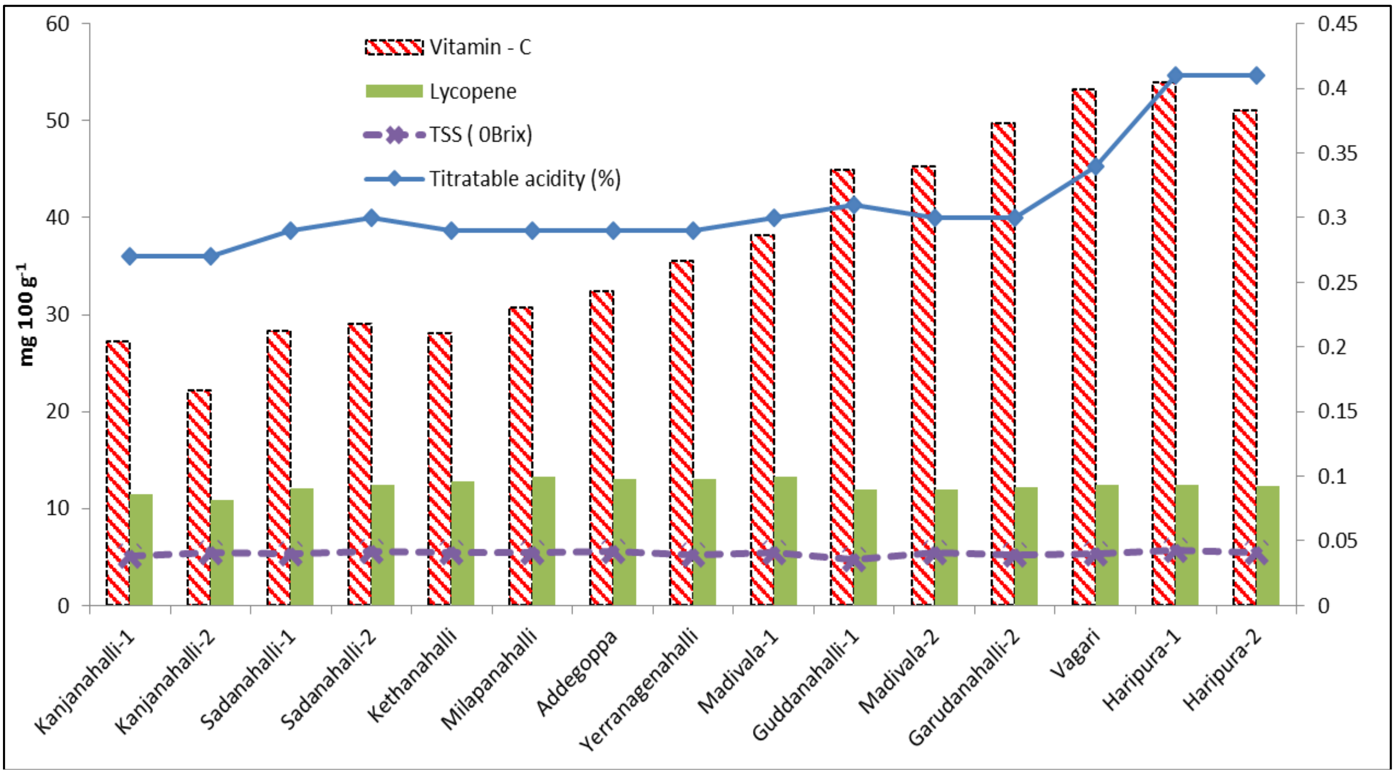

Fig 1: Mean quality parameters of tomato among different locations of soils

Conclusion

The need for micronutrients in crop production has long been recognized in the field of agriculture. Thus, it can be concluded that the treatments which have received the soil application of zinc through Zinc Sulphate @ 20 kg ha^{-1} along with RDF was found to be the best treatment to improve growth, and fruit quality of tomato.

Acknowledgement

The first author (IF 160021) is highly grateful to the DSTINSPIRE, New Delhi for the financial assistance given in the form of fellowship during the period of study and also to Department of Soil Science and Agricultural Chemistry, GKVK, UAS (B), Bangalore.

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