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Quality and Nutrient Content of Grapes as Influenced by Foliar Spray of Different Sources of Zinc

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Authors' contributions

This work was carried out in collaboration between both authors. Author SHR designed and conducted the study, performed the statistical analysis and written the manuscript. Author CTS guided author SHR during entire research work and corrected manuscript and helped in improving the quality of paper with valuable suggestions. Both authors read and approved the final manuscript.

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ABSTRACT

Field experiments were conducted in grape orchard (cv Dilkush) of three year old during 2015-16 and 2016-17 to assess the effect of different sources of zinc on quality and nutrients content of grape by using randomised block design with twenty treatments and three replications. The experimental results of the study indicated that among various sources of zinc, zinc metalosate at 0.150 per cent zinc level recorded significantly higher total soluble solids (17.49º Brix), total sugars (18.64%), nitrogen (1.74%), potassium (1.89%), sulphur (0.52%), zinc (47.00 mg kg^{-1}) and reduced titratable acidity (0.19%) in the fruit compared to control (T_3) and other treatments but it was at par with the treatment T_{18} which received zinc @ 0.150 per cent through Zn-EDTA. There was a non-significant difference was observed among the treatments with respect to calcium, magnesium, copper, iron, manganese and boron content of fruit.

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Keywords: Zinc metalosate; Zn-EDTA; ZnSO4; foliar spray; grapes; quality and nutrient content.

1. INTRODUCTION

Zinc plays a profound influence on activation of enzymes like carbonic anhydrase, hydrogenease, stabilization of ribosomal functions and synthesis of cytochrome [1] which in turn helps in starch and carbohydrate metabolism, maintenance of cellular membrane integrity, protein synthesis, regulating the auxin production, pollen formation, chlorophyll synthesis, flower formation and normal fruit development. Gene expressions needed for the environmental stress tolerance in plants is mainly depend on the zinc. Deficiency of zinc leads to chlorosis, smaller leaves and stunted growth [2]. Hence zinc application plays a major attention in crop nutrition.

Grape (*Vitis vinifera* L.) is one of the "important commercial fruit crops" of temperate regions. It is world's 3rd largest cultivated fruit crop after citrus and banana and it contributes 16 per cent of total fruit production. In the world, it grown in an area of 7.50 lakh hectare with a production of 75.8 million tonnes [3]. It is a refreshing fruit, rich source of sugars, acids, minerals, vitamins and tannins. In India, it is cultivated in an area of 1.18 lakh hectares with an annual production of 25.85 lakh tonnes with the productivity of 21.80 t ha^{-1} during 2013-14 [4].Compared to other grape growing countries, its cultivation in India have greater significance due to higher productivity. Major grape cultivating states of India includes Maharashtra, Karnataka, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Haryana and Punjab.

Fruit crop production is governed by several factors like climate, soil, irrigation status, varieties, pests, diseases and nutritional status of soil as well as plant. Deficiency of various nutrients causes drastic reduction in growth, yield and quality of fruits. Though micronutrients required in small quantities their importance in growth, yield and quality of fruit crops is quite essential [5].

Zinc deficiency is widespread compared to other micronutrients. Low levels of plant available zinc were noticed in 30 per cent of the cultivable soils of the world. Zinc deficiency is wide spread and remained a major problem all over the country. It has increased from 44 to 48 per cent and expected to further increase upto 63 per cent by 2025 [6]. In Karnataka, 72 per cent of soils were found deficient in zinc. Zinc deficiency found predominantly in coarse textured calcareous, alkaline and low organic carbon alluvial soils (Entisols and Inceptisols) of Indo- Gangetic alluvial plains of North India and fine textured calcareous black soils (Vertisols) of Deccan Plateau.

Zinc availability to the plant from soil is limited and it depends on factors like dynamic soil properties, organic matter, texture, cultivation, drought and activity of microbes [7]. Hence, plant roots are unable to absorb these micronutrients adequately from the dry top soil therefore foliar application for better results deserves attention [8].

Zinc metalosate is an amino acid chelated zinc fertilizer contains 6.8 per cent of zinc, liquid in nature, 100 per cent water soluble, neutral in charge and brown in colour. It is neither attracted to nor repulsed from negatively charged surfaces of the leaf, hence entire amino acid chelated zinc can easily and quickly pass through the cuticular layer of leaf very rapidly and efficiently without any barriers their by helps in increasing zinc content in the xylem sap without adverse interactions with other materials on the leaf surface [9]. Several studies have been noticed on the use of zinc sulphate as a source of zinc in fruit crop nutrition but the work on the use of amino acid chelated zinc fertilizer (zinc metalosate) and EDTA chelated zinc fertilizer (Zn-EDTA) in fruit crop nutrition is limited. Hence, in order to know the beneficial effect of zinc metalosate, Zn-EDTA and $ZnSO_4$ in varied levels on quality and nutrient content of grape, present investigation were carried out.

2. MATERIALS AND METHODS

Field experiments were conducted in grape orchard (cv. Dilkush) of three year oldduring 2015-2016 and 2016-2017 at Marganahalli village, Chikkaballapur district, which comes under Eastern Dry Zone of Karnataka (Zone 5) at 13º 52' 29'' N latitude and 77º 83' 67'' E longitude at an elevation of 835 m above mean sea level, in order to know the effect of different sources of zinc (Zinc metalosate, Zn-EDTA and $ZnSO_4$) on quality and nutrient content of grapes, by using randomised block design with twenty treatments and three replications. Zinc metalosate is an amino acid chelated liquid zinc fertilizer, contains 6.8 per cent of zinc, neutral in charge, hundred per cent soluble in water and brown in colour whereas Zn-EDTA is EDTA chelated zinc and zinc sulphate is inorganic salt. Treatments consists of $T_{1:}$ NPK, $T_{2:}$ NPK+ soil application of Zn as $ZnSO_{4,}$ $T_{3:}$ NPK + FYM, $T_{4:}$ NPK + Foliar spray of 0.010 % Zn as $ZnSO_{4,}$ $T_{5:}$ NPK + Foliar spray of 0.025 % Zn as $ZnSO_{4,}$ $T_{6:}$ NPK + Foliar spray of 0.050 % Zn as $ZnSO_{4,}$ $T_{7:}$ NPK + Foliar spray of 0.100 % Zn as $ZnSO_{4,}$ $T_{8:}$ NPK + Foliar spray of 0.150 % Zn as $ZnSO_{4,}$ $T_{9:}$ NPK + Foliar spray of 0.010% Zn as zinc metalosate, $T_{10:}$ NPK + Foliar spray of 0.025 % Zn as zinc metalosate, $T_{11:}$ NPK + Foliar spray of 0.050% Zn as zinc metalosate, $T_{12:}$ NPK + Foliar spray of 0.10% Zn as zinc metalosate, $T_{13:}$ NPK + Foliar spray of 0.150% Zn as zinc metalosate, $T_{14:}$ NPK + Foliar spray of 0.010 % Zn as Zn-EDTA, $T_{15:}$ NPK + Foliar spray of 0.025% Zn as Zn-EDTA, $T_{16:}$ NPK + Foliar spray of 0.050% Zn as Zn-EDTA, $T_{17:}$ NPK + Foliar spray of 0.10% Zn as Zn-EDTA, $T_{18:}$ NPK + Foliar spray of 0.150% Zn as Zn-EDTA, $T_{19:}$ T_3 + Soil application of Zn as $ZnSO_4$ and $T_{20:}$ T_3+ Foliar spray of 0.01% Zn as $ZnSO_4$. Before treatments imposition, soil and FYM samples were collected and analysed for various physico-chemical properties using standard procedures (Table 1 and 2). Recommended dose of NPK (500:125: 750 N: P_2O_5: K_2O kg/ha) and FYM (20 kg plant^{-1}) were applied as per the package of practice. About one twenty plants were included in the experiment (Six plant/treatment) and foliar spray was done thrice during vegetative stage (Two months after pruning), before flowering stage (Fifteen days after first spray) and after fruit set stage (Fifteen days after second spray). The total volume of spray used was 500 L ha^{-1}. Foliar spray of zinc was done with help of knapsack sprayer. At one day spray and one week after each spray the index tissue *i.e.* 5th petiole was collected according to the method described by [10] and analysed for zinc content by di-acid digestion and Atomic Absorption Spectrophotometry [11]. At the time of harvest, fruit samples were collected from each treatment and washed with distilled water. Immediately after washing some part of the collected fruit samples were used for estimation of total soluble solids (° Brix), total sugars (%), titratable acidity (%) with standard protocols. Remaining fruit samples were sliced, air dried

Table 1. Initial physico - chemical properties of the soils of the experimental site

Sl. no	Parameters	Values	Method	Reference
1	Sand (%)	68.00	International pipette method	Piper (1966) [11]
2	Silt (%)	12.36		
3	Clay (%)	19.63		
4	Texture class	Sandy loam		
5	pH (1:2.5)	6.45	Potentiometry	Jackson (1973) [12]
6	EC (dS m^{-1})	0.54	Conductometry	Jackson (1973) [12]
7	SOC (%)	0.68	Wet oxidation	Walkley and Black (1934) [13]
8	Available N (kg ha^{-1})	286	Macrokjeldahl distillation	Subbiah and Asija (1956) [14]
9	Available P_2O_5 (kg ha^{-1})	24	Spectrophotometry	Jackson (1973) [12]
10	Available K_2O_5 (kg ha^{-1})	175	Flame photometry	Jackson (1973) [12]
11	Exchangeable Ca (C mol (p$^+$) kg^{-1})	4.50	Versenatetitrimetry	Jackson (1973) [12]
12	Exchangeable Mg (C mol (p$^+$) kg^{-1})	1.90	Versenatetitrimetry	Jackson (1973) [12]
13	Available S (mg kg^{-1})	11.61	Turbidometry	Jackson (1973) [12]
14	Available Zn (mg kg^{-1})	0.55	Atomic Absorption Spectrophotometry	Lindsay and Norwell, (1978) [15]
15	Available Fe (mg kg^{-1})	39.00		
16	Available Mn (mg kg^{-1})	27.00		
17	Available Cu (mg kg^{-1})	0.35		
18	Available B (mg kg^{-1})	0.45	Azomethane –H method	Jones and Case (1990) [16]

and later oven dried at 68°C till a constant weight was obtained. Then the dried fruit samples were grounded in steel Willey mill and then kept in butter paper bags for nutrients like nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, zinc, iron, copper, magnesium and boron estimation. The various parameters estimated in both season fruits and their pooled data were analysed statistically using Fishers method of analysis and variance technique as given by [17]. The level of significance used in 'F' and 't' test was 5 % probability and wherever 'F' test was found significant, the 't' test was performed to estimate critical difference values for comparing various treatments. The results have been interpreted and discussed based on the pooled data of two years (2015-16 and 2016-17). DMRT test was done for pooled data with WASP-Web Agri Stat Package to access the treatments difference easily.

Table 2.Nutrient content of farm yard manure used in the field experiment

Parameters	Composition
pH	7.64
EC (dSm^{-1})	0.11
O.C (%)	28.00
N (%)	1.06
P (%)	0.41
K (%)	0.57
S (%)	0.32
Ca (%)	0.20
Mg (%)	0.12
Fe ($mg\ kg^{-1}$)	4536
Mn ($mg\ kg^{-1}$)	246
Zn ($mg\ kg^{-1}$)	109
Cu ($mg\ kg^{-1}$)	34

3. RESULTS AND DISCUSSION

3.1 Quality Parameters of Grapes as Influenced by Foliar Spray of Different Sources of Zinc

Quality parameters like TSS, total sugarsand titratable acidity contents were variedfrom 12.20 to 17.49 º Brix, 12.82 to 18.64% and 0.19 to 0.68%, respectively. Among different sources, zinc metalosate at 0.150 per cent (T_{13}) significantly increased the total soluble solids (17.49 º Brix), total sugars (18.64%) and decreased the titratable acidity (0.19%), but it was at par with the treatment which received zinc @ 0.150 per cent through Zn-EDTA. The improvement in the quality parameters at 0.10 per cent of zinc throughzinc metalosate and Zn-EDTA, respectively along with recommended dose of NPK is at par with the treatment which received 0.150 per cent of zinc through $ZnSO_4$ (Table 3). Significantly higher total soluble solids andtotal sugars in treatment T_{13} and T_{18} may be due to, zinc metalosate and Zn-EDTA at higherrates *i.e.* 0.150 per cent, significantly increased the zinc concentration in the plant as this zinc metalosate is an amino acid chelated liquid zinc fertilizer, neutral in charge and has higher solubility, hence it is neither attracted to nor repulsed from negatively charged surfaces of the leaf, hence entire amino acid chelated zinc can easily and quickly pass through the cuticular layer of leaf very rapidly and efficiently their by help in increasing zinc content in the xylem sap without adverse interactions with other materials on the leaf surface [9] .Similarly, Zn-EDTA is also ethylene diamine tetra acetic acid chelated zinc fertilizer, during chelation positive charge of the metal ion convert to neutral charge their by it can also easily translocated through the cuticular layer of the leaf and increased the zinc concentration. Also, chelates translocate the nutrients more efficiently within the plant compared to other forms [18]. The increased concentration of zinc through these sources is involved in synthesis of tryptophan that is a precursor of auxin,auxins help in mobilization of carbohydrate from source to sink which inturn increase TSS. Zinc is a component of molecular structure of enzymes carbonic anhydridease which involves in photosynthesis and cause increase in the level of soluble solids and total sugars [1]. This leads to the biochemical conversion of complex food materials into simple sugars. Also zinc definite role in the synthesis of metabolites, hydrolysis of complex polysaccharides into simple sugars and rapid translocation of photosynthetic products and minerals from other parts of the plants to developing fruits [19]. The decrease in titratable acidity may be due to increase in the total soluble solids and total sugars and also zinc influences the activities of dehydrogenase enzyme e.g. glucose-6, phosphate which decrease the acidity. These findings are supported by [20] and [21] in pomegranate with 0.8 per cent and 2000 ppm of zinc, respectively.

Table 3. Quality parameters of grapes as influenced by foliar spray of different sources of zinc

Treatments	TSS (º Brix)			Total Sugars (%)			Titratable Acidity (%)		
	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean
T_1	12.17	12.23	**12.20e**	12.80	12.85	**12.82e**	0.69	0.66	**0.68a**
T_2	12.28	12.42	**12.35e**	12.89	13.01	**12.95e**	0.64	0.62	**0.63cd**
T_3	13.13	13.53	**13.33d**	14.18	14.25	**14.22d**	0.53	0.51	**0.52efg**
T_4	12.20	12.31	**12.26 e**	12.83	12.89	**12.86e**	0.67	0.64	**0.66ab**
T_5	12.29	12.49	**12.39e**	13.04	13.05	**13.05e**	0.63	0.61	**0.62d**
T_6	13.06	13.38	**13.22d**	14.11	14.15	**14.13d**	0.57	0.54	**0.55e**
T_7	13.95	14.53	**14.24c**	15.36	15.52	**15.44c**	0.44	0.40	**0.42i**
T_8	14.88	15.80	**15.34b**	17.03	17.10	**17.07b**	0.31	0.28	**0.30k**
T_9	12.27	12.39	**12.33e**	12.88	12.95	**12.92e**	0.65	0.63	**0.64bcd**
T_{10}	13.13	13.50	**13.32d**	14.19	14.22	**14.21d**	0.53	0.51	**0.52fg**
T_{11}	14.05	14.72	**14.39c**	15.45	15.63	**15.54c**	0.38	0.35	**0.37j**
T_{12}	15.98	16.23	**16.11b**	17.14	17.22	**17.18b**	0.29	0.26	**0.28k**
T_{13}	17.12	17.85	**17.49a**	18.40	18.89	**18.64a**	0.20	0.18	**0.19l**
T_{14}	12.23	12.35	**12.29e**	12.87	12.93	**12.90e**	0.66	0.63	**0.65bc**
T_{15}	13.10	13.42	**13.26d**	14.16	14.19	**14.18d**	0.55	0.52	**0.54ef**
T_{16}	14.02	14.61	**14.32c**	15.41	15.57	**15.49c**	0.41	0.38	**0.40i**
T_{17}	15.93	16.05	**15.99b**	17.10	17.15	**17.13b**	0.30	0.27	**0.29k**
T_{18}	17.05	17.58	**17.32a**	18.33	18.78	**18.56a**	0.21	0.19	**0.20l**
T_{19}	13.15	13.57	**13.36d**	14.21	14.30	**14.26d**	0.52	0.49	**0.51gh**
T_{20}	13.17	13.66	**13.42d**	14.30	14.42	**14.36d**	0.50	0.46	**0.48h**

Treatment values followed by the same letter are not significantly different (P≤0.05)

Table 4. Macronutrient content (%) of grapes as influenced by foliar spray of different sources of zinc

Treatments	Nitrogen			Phosphorus			Potassium		
	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean
T_1	0.98	1.02	**1.00h**	0.22	0.23	**0.23b**	1.10	1.17	**1.14e**
T_2	1.00	1.07	**1.04h**	0.21	0.22	**0.22b**	1.12	1.19	**1.16e**
T_3	1.11	1.18	**1.15ef**	0.25	0.27	**0.26a**	1.23	1.30	**1.27d**
T_4	0.98	1.02	**1.00h**	0.21	0.22	**0.22b**	1.11	1.18	**1.14e**
T_5	1.03	1.09	**1.06gh**	0.19	0.21	**0.20cd**	1.14	1.23	**1.18e**
T_6	1.12	1.20	**1.16ef**	0.18	0.19	**0.19cd**	1.25	1.36	**1.31d**
T_7	1.24	1.37	**1.31d**	0.15	0.17	**0.16f**	1.39	1.51	**1.45c**
T_8	1.39	1.58	**1.48c**	0.12	0.14	**0.13gh**	1.55	1.67	**1.61b**
T_9	1.00	1.06	**1.03h**	0.17	0.20	**0.19cd**	1.12	1.19	**1.16e**
T_{10}	1.11	1.18	**1.15ef**	0.16	0.18	**0.17e**	1.24	1.32	**1.28d**
T_{11}	1.27	1.41	**1.34d**	0.15	0.17	**0.16ef**	1.43	1.49	**1.46c**
T_{12}	1.46	1.65	**1.56b**	0.12	0.14	**0.13g**	1.63	1.72	**1.68b**
T_{13}	1.63	1.84	**1.74a**	0.10	0.11	**0.11i**	1.81	1.97	**1.89a**
T_{14}	0.99	1.05	**1.02h**	0.19	0.21	**0.20c**	1.12	1.18	**1.15e**
T_{15}	1.10	1.16	**1.13fg**	0.18	0.20	**0.19d**	1.23	1.31	**1.27d**
T_{16}	1.25	1.38	**1.32d**	0.16	0.18	**0.17e**	1.40	1.47	**1.44c**
T_{17}	1.42	1.61	**1.52bc**	0.13	0.15	**0.14g**	1.59	1.68	**1.64b**
T_{18}	1.58	1.78	**1.68a**	0.11	0.12	**0.12hi**	1.76	1.91	**1.84a**
T_{19}	1.13	1.20	**1.17ef**	0.24	0.26	**0.25a**	1.24	1.32	**1.28d**
T_{20}	1.16	1.25	**1.21e**	0.22	0.24	**0.23b**	1.27	1.37	**1.32d**

Treatment values followed by the same letter are not significantly different (P≤0.05)

Table 5. Secondary nutrient content (%) of grapes as influenced by foliar spray of different sources of zinc

Treatments	Calcium			Magnesium			Sulphur		
	Season I	SeasonII	Pooled mean	SeasonI	SeasonII	Pooled mean	SeasonI	Season II	Pooled mean
T_1	0.57	0.62	**0.59**	0.42	0.40	**0.41**	0.12	0.14	**0.13e**
T_2	0.59	0.63	**0.61**	0.44	0.45	**0.45**	0.13	0.16	**0.15e**
T_3	0.62	0.66	**0.64**	0.47	0.48	**0.47**	0.16	0.22	**0.19d**
T_4	0.57	0.63	**0.60**	0.43	0.45	**0.44**	0.13	0.15	**0.14e**
T_5	0.59	0.65	**0.62**	0.45	0.47	**0.46**	0.14	0.16	**0.15e**
T_6	0.61	0.67	**0.64**	0.47	0.51	**0.49**	0.18	0.21	**0.20d**
T_7	0.66	0.74	**0.70**	0.53	0.55	**0.54**	0.25	0.29	**0.27c**
T_8	0.73	0.82	**0.78**	0.60	0.61	**0.61**	0.34	0.38	**0.36b**
T_9	0.58	0.63	**0.60**	0.44	0.46	**0.45**	0.13	0.16	**0.15e**
T_{10}	0.61	0.66	**0.64**	0.47	0.49	**0.48**	0.18	0.21	**0.20d**
T_{11}	0.67	0.72	**0.70**	0.52	0.55	**0.54**	0.25	0.30	**0.28c**
T_{12}	0.76	0.81	**0.79**	0.61	0.63	**0.62**	0.36	0.43	**0.40b**
T_{13}	0.87	0.93	**0.90**	0.69	0.72	**0.71**	0.46	0.57	**0.52a**
T_{14}	0.57	0.63	**0.60**	0.43	0.46	**0.45**	0.13	0.15	**0.14e**
T_{15}	0.60	0.65	**0.62**	0.45	0.48	**0.46**	0.17	0.20	**0.19d**
T_{16}	0.65	0.70	**0.68**	0.50	0.53	**0.52**	0.23	0.28	**0.26c**
T_{17}	0.74	0.78	**0.76**	0.58	0.60	**0.59**	0.32	0.39	**0.36b**
T_{18}	0.84	0.89	**0.87**	0.65	0.68	**0.67**	0.42	0.52	**0.47a**
T_{19}	0.63	0.65	**0.64**	0.48	0.49	**0.49**	0.17	0.23	**0.20d**
T_{20}	0.66	0.69	**0.68**	0.51	0.52	**0.52**	0.19	0.25	**0.22cd**
SEm ±	**0.10**	**0.10**	**0.09**	**0.09**	**0.10**	**0.08**			
CD @ 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**			

Treatment values followed by the same letter are not significantly different (P≤0.05)

Table 6. Micronutrient content (mg kg^{-1}) of grapes as influenced by foliar spray of different sources of zinc

Treatments	Zinc			Iron			Copper			Manganese			Boron		
	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean	Season I	Season II	Pooled Mean	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean
T_1	33.61	33.49	**33.55e**	53.21	53.15	**53.18**	5.25	5.17	**5.21**	42.20	42.09	**42.15**	20.75	20.66	**20.71**
T_2	33.89	33.96	**33.93e**	53.55	53.84	**53.70**	5.41	5.63	**5.52**	42.79	42.85	**42.82**	20.79	20.81	**20.80**
T_3	36.52	36.68	**36.60d**	54.62	54.95	**54.79**	5.78	6.02	**5.90**	43.75	44.08	**43.92**	21.06	21.07	**21.07**
T_4	33.69	33.81	**33.75e**	53.35	53.41	**53.38**	5.28	5.37	**5.33**	42.39	42.41	**42.40**	20.77	20.80	**20.79**
T_5	33.94	34.12	**34.03e**	53.60	53.95	**53.78**	5.45	5.70	**5.57**	42.91	43.00	**42.96**	20.81	20.84	**20.83**
T_6	36.55	36.81	**36.68d**	54.18	54.31	**54.25**	5.66	5.89	**5.78**	43.34	43.65	**43.50**	20.84	20.87	**20.86**
T_7	39.46	39.88	**39.67c**	55.29	55.60	**55.45**	5.90	6.35	**6.13**	44.41	44.94	**44.68**	20.89	20.91	**20.90**
T_8	42.59	43.31	**42.95b**	55.81	56.09	**55.95**	6.10	6.60	**6.35**	44.93	45.79	**45.36**	20.92	20.96	**20.94**
T_9	33.85	34.02	**33.94e**	53.49	53.65	**53.57**	5.37	5.55	**5.46**	42.68	42.75	**42.72**	20.79	20.83	**20.81**
T_{10}	36.54	36.83	**36.69d**	54.37	54.51	**54.44**	5.75	6.02	**5.89**	43.59	43.97	**43.78**	20.85	20.88	**20.87**
T_{11}	39.63	40.05	**39.84c**	55.62	55.89	**55.76**	6.00	6.48	**6.24**	44.78	45.39	**45.09**	20.91	20.95	**20.93**
T_{12}	43.00	43.70	**43.35b**	56.17	56.45	**56.31**	6.28	6.83	**6.56**	45.17	46.48	**45.83**	20.96	21.00	**20.98**
T_{13}	46.55	47.45	**47.00a**	56.88	57.07	**56.98**	6.48	6.97	**6.73**	45.53	46.77	**46.15**	21.00	21.05	**21.03**
T_{14}	33.78	33.92	**33.85e**	53.41	53.52	**53.47**	5.31	5.48	**5.39**	42.52	42.59	**42.56**	20.78	20.81	**20.80**
T_{15}	36.40	36.67	**36.54d**	54.29	54.44	**54.37**	5.71	5.97	**5.84**	43.47	43.81	**43.64**	20.84	20.87	**20.86**
T_{16}	39.37	39.78	**39.58c**	55.48	55.74	**55.61**	5.97	6.41	**6.19**	44.60	45.20	**44.90**	20.90	20.93	**20.92**
T_{17}	42.66	43.37	**43.02b**	55.93	56.21	**56.07**	6.19	6.70	**6.45**	45.05	46.00	**45.53**	20.94	20.98	**20.96**
T_{18}	46.07	47.05	**46.56a**	56.70	56.83	**56.77**	6.41	6.90	**6.66**	45.42	46.50	**45.96**	20.97	21.02	**21.00**
T_{19}	36.65	36.79	**36.72d**	54.75	55.10	**54.93**	5.80	6.09	**5.95**	43.93	44.29	**44.11**	21.05	21.06	**21.06**
T_{20}	36.78	36.96	**36.87d**	54.91	55.32	**55.12**	5.85	6.14	**6.00**	44.20	44.41	**44.31**	21.02	21.08	**21.05**
SEm ±				**1.28**	**1.34**	**1.28**	**0.41**	**0.63**	**0.43**	**1.15**	**1.59**	**1.33**	**0.43**	**0.43**	**0.43**
CD @ 5 %				**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Treatment values followed by the same letter are not significantly different (P≤0.05)

3.2 Macronutrient Content of Grapes as Influenced by Foliar Spray of Different Sources of Zinc

About 1.00 to 1.74 per cent N, 0.11 to 0.26 per cent P and 1.14 to1.89 percent K was recorded in the grape. Among the zinc sources both zinc metalosate and Zn-EDTA showed similar effect in increasing the nitrogen and potassium content in fruit compared to zinc sulphate. Significantly higher fruit nitrogen and potassium content was recorded in treatment T_{13} (1.74% and 1.89%) which received zinc @ 0.150 per cent as zinc metalosate compared to other treatments and it was at par with treatment T_{18} (1.68% and 1.84%) which received 0.150 per cent zinc through Zn-EDTA. The least nitrogen and potassium content in grapes was recorded in T_1 (1.00 and 1.14 %, respectively) (Table 4). Foliar application of zinc through these sources, did not show any significant effect in increasing fruit phosphorus content, with increasing zinc levels there was a decrease in phosphorus concentration in grapes. Among the treatments significant improvement in phosphorus content of grapes was observed in treatment T_3(0.26%) which consists of recommended dose of NPK and farm yard manure. Foliar application of zinc through zinc metalosate, Zn-EDTA and $ZnSO_4$along with recommended dose of NPK helped in increasing nitrogen and potassium concentration in index tissue due to synergistic effect between the zinc, nitrogen and potassium, which helped in better uptake, translocation, assimilation and accumulation of nutrients in the economic part of the plant called fruit. Similar supportive results were obtained by [22] and [21]. Due to antagonistic effect between zinc and phosphorus, zinc did not increase the phosphorus content in fruit. But application of FYM along with recommended dose of NPK significantly increased phosphorous content of grapes which may be due to increased availability of phosphorus for plant uptake because organic acids released during decomposition of FYM have leads to release of phosphorus in soil, hence contributed to increase phosphorus content of grapes. These observations conform to those of [22].

3.3 Secondary Nutrient Content of Grapes as Influenced by Foliar Spray of Different Sources of Zinc

Calcium, magnesium and sulphur content in the fruit varied from 0.59 to 0.90, 0.41 to 0.71 and 0.13 to 0.52 per cent, respectively. Zinc application as zinc metalosate, Zn-EDTA and $ZnSO_4$ had no significant effect on calcium and magnesium content of fruit. In contrast to calcium and magnesium, sulphur content in the fruit was increased due to treatment effect. Significantly higher sulphur content of about 0.52 per cent was recorded at 0.150 per cent zinc through zinc metalosate (T_{13}), but it was at par with treatment which received 0.150 per cent zinc through Zn-EDTA (T_{18}) (Table 5). Increased zinc content in the plant tissue with foliar spray of zinc along recommended dose of NPK, enhanced sulphur content in grapes may be due to synergistic effect. These results are in conformation with the findings of [21] and [22].

3.4 Micronutrient Nutrient Content of Grapes as Influenced by Foliar Spray of Different Sources of Zinc

Micronutrients like zinc, iron, copper, manganese and boron content in fruit varied from 33.50 to 47.00, 53.18 to 56.98, 5.21 to 6.73, 42.15 to 46.15 and 20.71 to 21.03 mg kg^{-1}, respectively. Foliar application of zinc through these sources had no significant effect on micronutrient content of fruit except zinc. Compared to control ($T_{3:}$ 36.60 mg kg^{-1}) and other treatments significantly higher zinc content of 47.00 mg kg^{-1} was recorded at 0.150 per cent of zinc through zinc metalosate (T_{13}) and it was at par with 0.150 per cent zinc through Zn-EDTA (T_{18}). Fruit zinc content recorded in the treatments T_{12}(43.35 mg kg^{-1}) and T_{17}(43.02 mg kg^{-1}) is at par with treatment T_8 (42.95 mg kg^{-1}) (Table 6). Foliar application of zinc@ 0.150 per cent through zinc metalosate and Zn-EDTA increased the zinc concentration in the xylem sap through rapid and efficient absorption which in turn increased the translocation of nutrients from source to sink [23]. Higher accumulation of zinc content in the pulp may be due to maintenance of higher concentration of zinc [24]. Similar results were observed by [25] and [21] in pomegranate.

4. CONCLUSION

Both zinc metalosate and Zn-EDTA had greater significant effect on grape nutrition over $ZnSO_4$. Hence farmers need to adopt foliar application of zinc to improve yield, quality and nutrient content etc. of grapes. Foliar application of zinc @ 0.150 per cent through zinc metalosate recorded significantly higher total soluble solids, total sugars, nitrogen, potassium, sulphur, zinc and reduced titratable acidity in the fruit but it was at par with the treatment which received 0.150 per cent zinc through Zn-EDTA.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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