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Effect of soil and foliar application of zinc on quality parameters of sweet orange Var. Nucellar (*Citrus sinensis* L. Osbeck)

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Abstract
An experiment was conducted to study the effect of soil and foliar application of zinc on quality parameters of sweet orange (*Citrus sinensis* L. Osbeck) Cv. Nucellar." was carried out at Sweet Orange Research station, Badnapur, Dist. Jalna during 2017-18.The experiment was laid out in Randomized Block Design (RBD) with 12 treatments and three replication. Observations were recorded on quality characters of sweet orange. The results were revealed that, The quality parameters like reducing sugar, non-reducing sugar, acidity, T.S.S, ascorbic acid, pH, total sugar, are most effective in T_{10} (Soil application of$ZnSO_4$@150gm+ Foliar spray of $ZnSO_4$@0.50%) followed by treatment T_{12} (Soil application of$ZnSO_4$ @150gm+ Foliar spray of $ZnSO_4$@0.75%)and T_{11} (Soil application of $ZnSO_4$**@**100gm+ Foliar spray of $ZnSO_4$@0.75%).

Keywords: TSS, acidity, pH, zinc sulphate

Introduction
Sweet Orange is considered as most important fruit crop of citrus group with their wholesome nature multifold nutrition and medicinal value have made them so important. Sweet Orange (*Citrus sinensis* L.) belongs to family Rutaceae. Sweet Orange is native of Southern China. It is now widely distributed and naturalized in subtropical zone of India. It is cultivated particularly in Brazil, China, Japan, Turkey and India. Andhra Pradesh, Karnataka, Maharashtra, Punjab, Rajasthan and Haryana are main Sweet Orange growing states. Sweet Orange need dry climate and arid weather with distinct summer and winter seasons with low rainfall. It is grown on wide range of soil ranging from clay to light sandy and sensitive to salt. Sweet Orange is well grown on medium black, red, alluvial river bank loamy soil of Maharashtra state and Goradu soil of Gujarat.

Citrus is the third largest fruit crop grown in India after mango and banana. Area and production of citrus in India in the past three decades have increased annually @10.5 percent and 7.8 percent respectively (Srivastava and Singh, 2005) [18]. In the tropics, citrus production is mostly on small scale for local consumption and commercial production is concentrated in the subtropical areas. Free economy, more space for export quality fruits under GATT pact and Horticulture development policy of the Maharashtra State Government further added to the sizable increase in citrus area irrespective of soil-climate complex.

In Sweet Orange 100 g fruit contains 60-80% fruit juice, protein 0.8-1.4 g, fat 0.2-0.4 g, fiber 0.8 g, vitamin-A 198 I.U, 0.113 mg vitamin B_1, 0.046 mg riboflavin, 65.69 mg vitamin C, 0.2-0.8 mg iron, 0.16 mg calcium, potassium 192-201 mg. Sweet Orange tree is medium to large with dense foliage, generally with slender somewhat flexible rather blunt spines in the axils of leaves, leaves oval or ovate oblong, smooth, shiny, lighter below, margin entire, petioles smaller than those of *Citrus aurantium*, calyx cupped, sepals four or five thick greenish, persistent, petals usually five thick, fleshy recurved, stamens 20-25 hypogenous, filaments flattened, inverted in group shorter than petals distinctly divide into stigma, style and ovary, stigma knob like, style long and slender, ovary rounded.10-14 loculed fruit globose or oblate, light orange to reddish, rind smooth, pulp juicy, sub-acid. Yellow to orange or redish, core solid. Peel tight juice sacs spindle shaped, seeds few or many, white inside highly poly embryonic.

In India citrus grown in area 846 thousand ha and the production 7464 thousand MT with the productivity 8.80 MT/ha (Anonymous 2011) [2]. Maharashtra is the largest producer of sweet orange in the country and contributes to about 49 percent of the total production. Maharashtra state produces 0.65 m MT sweet orange from an area of 0.11 m ha with the productivity of 6.1 MT/ha. The major sweet orange producing belts in the state are Aurangabad, Jalna, Jalgaon,

Ahmednagar, Amravati and Pune. Sweet orange is grown widely in the different districts of Maharashtra but Jalna, Aurangabad, Nanded and Parbhani are the major area in production, among them Jalna is dominant in area and production (Karegonkar *et al.* 2011) [9]. In Jalna district of Maharashtra area under sweet orange is 18028 ha with the production 191145 MT and productivity is 10600 kg ha^{-1}. The long warm to hot dry summers and medium cool winters prevailing in this district suited for best quality sweet orange production. Nucellar cultivar has been under cultivation in this region, but now a day's area under sathgudi mosambi is increasing day by day due to more market demand. Sathgudi fruits are good acid sugar ratio, more juice percentage i.e., thin peel thickness. Moreover sathgudi fruits are produced in less grades i.e. two or three grades. Nucellar mosambi is an established cultivar of the region having good yield potential and excellent taste of juice. Hence it was become necessary to test performance of both the cultivars in Marathwada region to know their growing and overall performance.

Deficiency of zinc is globally considered as the most crunch nutritional problem in citrus growing belts for sustainable citrus production (Srivastava and Singh, 2005) [18]. Exogenous application of soluble zinc sources similar to fertilizer application has been advocated to various crops. This causes transformation of about 96-99 percent of applied available zinc to various unavailable forms

For instant, Zinc deficiency often occurred due to heavy phosphate application. Manganese deficiency occurs especially due to over liming, heavy phosphate application and excess of iron, copper and zinc in the soil. Copper deficiency is induced by heavy liming and excessive application of nitrogen and phosphate on the yield of crop could be improved with little quantities of micronutrients applied either singly or in mixtures through soil or foliar application (Malewar, 2005) [12].

The total area under Zn deficiency is about 10 M ha in India. Approximately 85 percent of rice-wheat cropping system is present in the Indo-Gangetic plain region and Zn is limiting factor in crop production due to alkaline and calcareous soil. Improving production from this cereal belt is therefore, vital for sustaining nutritional security and grain production in country (Singh *et al*., 2005) [16].

Sub-optimum nutrition of Zinc is one of the prime concerns of citrus nutrition. Worldwide occurrence of Zn deficiency known by various names like, rosette, little leaf, wrenching, mottle leaf etc. is basically characterized by interveinal chlorosis mayor may not be coupled with resetting of leaves. Metabolically, zinc deficiency induces many morphological, cytological as well as anatomical changes.

Even under Indian conditions, less systematic work was carried on role of zinc solubilizing bacteria in sweet orange and their effects on qualitative as well as quantitative production besides overcoming citrus decline and nutritional disorders. Such important aspect has not reviewed adequate attention so far. In order to fill this gap on this important area of plant nutrition and for widening our understanding on crop response to Zinc Sulphate, an attempt was made of carrying out a research work on this aspect. Hence, the present investigations was proposed to generate sufficient data base for balanced fertilization arriving at ideal nutrient management practices and effect of Zinc Sulphate application for optimum and good quality production of sweet orange.

Material and Methods

The experiment was conducted during 2017-18, on uniform 8 years old plants of cv. Nucellar mosambi planted at the spacing of 6x6m at the Sweet Orange Research Station, Badnapur, district Jalna of Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. Station is situated at 409 m above mean sea level at 19.87°N latitude and 75.72°E longitudes with an altitude of 523 meters. The average rainfall of the station is about 650 mm received mostly during June to September. The mean minimum and maximum temperature during the last five years were 15.25 ^{0}C and 43.85 ^{0}C and the mean relative humidity ranges from 30 to 90 percent and rainfall in the year 2017 is 662 mm. Experiment was laid out in a Randomized Block Design (RBD) with three replication and twelve treatments these are control i.e.(T_1), Soil application of $ZnSO_4$@100gm+RDF(T_2), Soil application of $ZnSO_4$@150gm+RDF (T_3), Soil application of $ZnSO_4$@200gm+RDF (T_4), Soil application of$ZnSO_4$@250gm+RDF(T_5), Foliar spray of $ZnSO_4$@0.50%+RDF (T_6), Foliar spray of $ZnSO_4$@0.75%+RDF(T_7), Foliar spray of $ZnSO_4$ @1%+RDF(T_8), Soil application of $ZnSO_4$@100gm+ Foliar spray of $ZnSO_4$@ 0.50%(T_9), Soil application of $ZnSO_4$@150gm+Foliar spray of $ZnSO_4$@0.50% (T_{10}), Soil application of $ZnSO_4$@100gm+ Foliar spray of $ZnSO_4$@0.75%(T_{11}), Soil application of $ZnSO_4$ @150gm+ Foliar spray of $ZnSO_4$@0.75% (T_{12}). Juice was extracted by a fruit juice extractor and filtered through a muslin cloth and weighed. The percentage was calculated as per the following formula:

$$\text{Juice (\%)} = \frac{\text{Weight of Juice}}{\text{Weight of fruit}} \text{X } 100$$

The percentage of total soluble solids of each sample was determined with the help of a Hand Refractometer. The freshly extracted juice of a composite sample of single fruit was taken into a beaker and its pH was recorded with the help of electrically operated "pH meter" The pH meter was calibrated before recording the pH values with the help of Buffer tables. For determination of acidity, 10 ml of juice was diluted to 250 ml with the help of distilled water. The known volume of the juice was then titrated against (0.1 N) NaOH solution using phenolphthalein as an indicator. This was measured by using Burette. A know quantity of juice was taken. After clarification with lead acetate and deleading with potassium oxalate, reducing sugars were estimated by Fehling's solution with methylene blue as an indicator (Lane and Eynon 1923 [11] method given by The percentage of non reducing sugars was estimated by subtracting the reducing sugars from total sugars. Determination of ascorbic acid was done by 2, 6 – Di chloro phenol Indophenol dye method of Johnson (1948) [8] as described by A known quantity of sample was blended with (3 percent) Metaphosphoric acid (HPO_3) to make the final volume of (100 ml) and then filtered. A known quantity of aliquot was titrated against (0.025 percent) 2, 6 - Dichlorophenol Indophenol dye to a pink colour end point. The ascorbic acid content of the sample was calculated taking into consideration the dye factor and expressed as mg Ascorbic acid per 100 g fruit pulp.

$$\text{Mg of Ascorbic Acid/100 g juice} = \frac{(\text{Titrate value} \times \text{Dye factor} \times \text{volume made up})}{\text{Aliquot taken for estimation} \times \text{Wt. or volume of sample taken for estimation.}} \times 100$$

Results and Discussion

It is clear from the data given in table that, the maximum TSS (9.64) was recorded in the treatment T_{10} i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$@0.50%, followed by treatment T_{11} (9.52) i.e. Soil application of ZnSO4 **@**100gm+ Foliar spray of $ZnSO_4$@0.75% and T_{12} (9.16) i.e.Soil application of ZnSO4 **@**150gm+ Foliar spray of $ZnSO_4$@ 0.75%, which were statistically at par with T_9 (8.12) i.e. Soil application of $ZnSO_4$ **@**100gm+ Foliar spray of $ZnSO_4$@0.50%, The minimum TSS was recorded in T_1 (7.27) i.e. control, And T_{10} (9.64) was statistically superior over the control.The maximum juice percent (53.51%) was recorded in the treatment T_{10} i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$@0.50%, followed by the treatment T_{11} (51.80%) i.e. Soil application of $ZnSO_4$ **@**100gm+ Foliar spray of $ZnSO_4$@0.75%, and T_{12} (51.73%) i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$@0.75%, which were statistically at par with T_7 (49.35%), i.e. Foliar spray of $ZnSO_4$ @ 0.75%.The minimum juice percent content was recorded in control T_1 (38.18%). The maximum ascorbic acid (53.53%) was recorded in treatment T_{10} i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$@0.50%, followed by the treatments T_{11} (53.00%) i.e. Soil application of $ZnSO_4$ **@**100gm+ Foliar spray of $ZnSO_4$@ 0.75% and T_{12} (52.50%) i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$@0.75%, which were statistically at par with treatment T_9 (48.96%) i.e. Soil application of $ZnSO_4$ **@**100gm+ Foliar spray of $ZnSO_4$@0.50%.

The minimum Vitamin C content was recorded in control in T_1 (40.46%) Thus, from Table-9.3 it is obvious that all the treatments of Soil application of $ZnSO_4$ 150gm+ Foliar spray of $ZnSO_4$@ 0.50%,(T_{10}), Soil application of $ZnSO_4$ **@**100gm+ Foliar spray of $ZnSO_4$@ 0.75% (T_{11}) and i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$@0.75%, (T_{12}) proved beneficial for ascorbic acid over control (T_1). Present investigation clearly indicated that the Zinc Soil application of ZnSO4 **@** 150gm+ foliar spray of $ZnSO_4$@0.50% treatment had significant effect on chemical characteristics of Sweet Orange fruit. Sajid *et al.,* (2012) [15] also reported that foliar application of Zinc and boron significantly enhanced fruit juice content, total soluble solids (TSS), ascorbic acid and of sweet orange fruit. However, fruit juice content, TSS and ascorbic acid were observed significantly higher, when the fruit was treated with high Zinc (1%) and low boron (0.02%).Similar result were observed, concluded that in sweet orange maximum T.S.S, juice and ascorbic acid with the application of multimicronutrients and NPK either applied through soil or fertigation, where as ascorbic acid of the fruit juice was found highest in balanced nutrient application.The increase in T.S.S was due to increase in photosynthesis activity (kulkarni, 2002) [10]. Similar observations were recorded by and highest TSS in sweet orange with foliar application of $ZnSO_4$ + Borax was noted.

Application of multimicronutrients along with NPK might have improved tree health and this could be the main reason for increase in juice content. It has been reported by various researchers that balanced nutrition considerably increased the juice content in the fruits of healthy trees. Devi *et al*., (1997) [6] who found that juice content of sweet orange fruits was significantly increased when the plants were supplied with soil application of $ZnSO_4$, $FeSO_4$ and $MnSO_4$ at 50g/tree and combined foliar spray of the micronutrient at 0.5% concentration.

The maximum reducing sugar was recorded in the treatment T_{10} (3.09%) i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$@0.50%, followed by the treatment T_{11} (3.01%) i.e. Soil application of $ZnSO_4$ **@** 100gm+ Foliar spray of $ZnSO_4$@0.75% and which were statistically at par with T_{12} (2.96%) i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$ @ 0.75%, and which are statistically at par with T_9 (2.99%) i.e. Soil application of $ZnSO_4$ **@**100 gm+ Foliar spray of $ZnSO_4$ @ 0.50%, The maximum non- reducing sugar in T_{10} i.e. Soil application of $ZnSO_4$ **@**150gm+ Foliar spray of $ZnSO_4$@ 0.50% (4.84%), and followed by the treatment T_{12} i.e. Soil application of $ZnSO_4$ 150gm+ Foliar spray of $ZnSO_4$ @ 0.75% (4.80%),T_{11} i.e. Soil application of $ZnSO_4$ 100gm+ Foliar spray of $ZnSO_4$@0.75% (4.54%) and which were statistically at par with T_9 i.e. Soil application of $ZnSO_4$ **@**100gm+ Foliar spray of $ZnSO_4$@0.50% (4.47%). The data presented in Table-10.3 and depicted in Fig.10.Revealed that maximum total sugar was recorded in the treatment T_{10} (7.93%), followed by treatment T_{12} and T_{11} (7.80 and 7.55%) respectively and were statistically at par by the treatment T_9 (7.46%). Present investigation clearly indicated that the Zinc Soil application of $ZnSO_4$ **@** 150gm+ foliar spray of $ZnSO_4$@0.50% treatment had show significant effect on chemical characteristics of Sweet Orange fruit.

Concluded that the significant effect of multi-micronutrients application resulted in a significant increase in reducing, non-reducing and total sugars in sweet orange fruits. These multi-micronutrients treatments comprised of boron and Zinc along with other micronutrients, which have an important role in sugar metabolism. these results are supported by the findings of Dixit *et.al.,* (1977) [7], who found increase in sugar content of juice in kinnow mandarin fruits due to foliar sprays of $ZnSO_4$+FeSO4 similar results were recorded by Anees *et al*., (2011) [3] reported that the maximum total soluble solids (27.9 $Brix^0$), ascorbic acid / vitamin C contents (153.3%), total sugars (50.08), reducing (19.92%) and non reducing sugars (8.83%) were found in 0.4% $FeSO_4$ + 0.8% H_3BO_3 + 0.8% $ZnSO_4$ in mango. The maximum pH was recorded in treatment T_{10} (4.82) i.e. Soil application of $ZnSO_4$ **@** 150gm+ Foliar spray of $ZnSO_4$@0.50%. Titrable acidity was maximum recorded in treatment T_{10} (0.63%) i.e. Soil application of $ZnSO_4$ **@** 150gm+ Foliar spray of $ZnSO_4$@0.50%.Present investigation clearly indicated that the Zinc Soil application of $ZnSO_4$ **@** 150gm+ foliar spray of $ZnSO_4$@0.50% treatment had show significant effect on chemical characteristics of Sweet Orange fruit. Concluded the decreased acidity in micronutrient treated fruit juice might be due to their utilization in respiration and rapid metabolic transformation of organic acids into sugars (Brahmahachari *et al*., 1997) [4] The results obtained in this present investigation were in agreement with those of Devi *et al*.,(1997) [6] in sweet orange. Similar results were also reported by Deolankar and Firke (2001) [5] in banana and by Singh *et al*., (2003) [17] in pomegranate and patil and Hiwarale (2004) [13] in acid lime.

Table 1: Effect of soil and foliar application of zinc on Different chemical attributes of Sweet Orange fruits.

Tr. No.	Treatment details	T.S.S	Juice %	Ascorbic acid (mg/100ml juice)	Reducing sugar (%)	Non-Reducing sugar (%)	Total sugar (%)	pH	Titrable acidity (%)
T_1	Control	7.27	38.18	40.46	1.97	3.70	5.67	3.52	0.38
T_2	Soil application of $ZnSO_4$ @ 100 gm+RDF	7.50	41.75	42.13	2.28	4.11	6..39	4.13	0.41
T_3	Soil application of $ZnSO_4$@ 150gm+RDF	7.42	41.10	42.43	2.14	3.83	5.97	4.2	0.47
T_4	Soil application of $ZnSO_4$@ 200gm+RDF	7.44	39.88	45.44	2.16	4.46	6.62	4.12	0.51
T_5	Soil application of $ZnSO_4$ @ 250gm+RDF	7.48	41.75	44.76	2.56	3.74	6.3	4.24	0.53
T_6	Foliar spray of $ZnSO_4$@0.50%+RDF	7.74	49.35	44.8	2.70	4.46	7.16	4.29	0.54
T_7	Foliar spray of $ZnSO_4$@0.75%+RDF	7.86	40.93	46.23	2.48	4.32	6.8	4.32	0.54
T_8	Foliar spray of $ZnSO_4$ @1%+RDF	8.02	44.77	46.3	2.85	4.47	7.32	4.47	0.54
T_9	Soil application of $ZnSO_4$ @ 100gm+ Foliar spray of $ZnSO_4$ @ 0.50%	8.12	44.79	48.96	2.99	4.47	7.46	4.48	0.55
T_{10}	Soil application of $ZnSO_4$ @ 150gm+ Foliar spray of $ZnSO_4$@0.50%	9.64	53.51	53.23	3.09	4.84	7.93	4.82	0.63
T_{11}	Soil application of $ZnSO_4$ @ 100gm+ Foliar spray of $ZnSO_4$@0.75%	9.52	51.80	53.00	3.01	4.54	7.55	4.49	0.60
T_{12}	Soil application of $ZnSO_4$ @ 150gm+ Foliar spray of $ZnSO_4$@0.75%	9.16	51.73	52.5	2.96	4.80	7.80	4.48	0.58
SE ±		0.26	1.20	1.44	0.088	0.17	0.16	0.14	0.014
C.D.at 5%		0.76	3.54	4.23	0.95	0.52	0.49	0.43	0.04

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