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

MA Thorat, MB Patil, SG Patil and DP Deshpande

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. It 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 replications. 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 T₀ (Soil application of ZnSO₄ 150 gm+ Foliar spray of ZnSO₄ @0.5%) followed by treatment T₁ (Soil application of ZnSO₄ 150 gm+ Foliar spray of ZnSO₄ @0.75%) and T₁₁ (Soil application of ZnSO₄ @100 gm+ Foliar spray of ZnSO₄ @0.75%).

Keywords: T.S.S, 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 IU, 0.113 mg vitamin B₁, 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 oblomg, 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 oblote, 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 satghudi mosambi is increasing day by day due to more market demand. Satghudi fruits are good acid sugar ratio, more juice percentage i.e., thin peel thickness. Moreover satghudi 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 and 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 °C and 43.85 °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. (T1), Soil application of ZnSO₄@100gm+RDF (T2), Soil application of ZnSO₄@150gm+RDF (T3), Soil application of ZnSO₄@200gm+RDF (T4), Soil application of ZnSO₄@250gm + RDF(T5), Foliar spray of ZnSO₄@0.50%+RDF (T6), Foliar spray of ZnSO₄@0.75%+RDF (T7), Foliar spray of ZnSO₄@1%+RDF(T8), Soil application of ZnSO₄@100gm+ Foliar spray of ZnSO₄@0.50% (T9), Soil application of ZnSO₄@150gm+Foliar spray of ZnSO₄@0.50% (T10), Soil application of ZnSO₄@100gm+ Foliar spray of ZnSO₄@0.75% (T11), Soil application of ZnSO₄@150gm+ Foliar spray of ZnSO₄@0.75% (T12). 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:

\[
\text{Weight of Juice} \times 100
\]

\[
\text{Juice (%) = } \frac{\text{Weight of fruit}}{\text{Weight of Juice}}\times 100
\]

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 (HPO₃) 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.
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} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.50%, followed by treatment T_{11} (9.52) i.e. Soil application of ZnSO_{4} \cdot 100gm+ Foliar spray of ZnSO_{4}@0.50% and T_{12} (9.16) i.e. Soil application of ZnSO_{4} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.75%, which were statistically at par with T_{13} (8.12) i.e. Soil application of ZnSO_{4} \cdot 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} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.50%, followed by the treatment T_{11} (51.80%) i.e. Soil application of ZnSO_{4} \cdot 100gm+ Foliar spray of ZnSO_{4}@0.75%, and T_{12} (51.73%) i.e. Soil application of ZnSO_{4} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.75%, which were statistically at par with T_{17} (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} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.50%, followed by the treatments T_{11} (53.00%) i.e. Soil application of ZnSO_{4} \cdot 100gm+ Foliar spray of ZnSO_{4}@0.75% and T_{12} (52.50%) i.e. Soil application of ZnSO_{4} \cdot 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} \cdot 100gm+ Foliar spray of ZnSO_{4}@0.50%.

The minimum Vitamin C content was recorded in control T_{1} (40.46%) Thus, from Table-9.3 it is obvious that all the treatments of Soil application of ZnSO_{4} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.50%,, T_{10}), Soil application of ZnSO_{4} \cdot 100gm+ Foliar spray of ZnSO_{4}@0.75% , T_{11} and i.e. Soil application of ZnSO_{4} \cdot 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 ZnSO_{4} \cdot 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) [16]. 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) [9] 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} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.50%, followed by the treatment T_{11} (3.01%) i.e. Soil application of ZnSO_{4} \cdot 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} \cdot 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} \cdot 100 gm+ Foliar spray of ZnSO_{4}@0.50%. The maximum non-reducing sugar in T_{10} i.e. Soil application of ZnSO_{4} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.50% (4.84%), and followed by the treatment T_{12} i.e. Soil application of ZnSO_{4} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.75% (4.80%), T_{11} i.e. Soil application of ZnSO_{4} \cdot 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} \cdot 100gm+ Foliar spray of ZnSO_{4}@0.50% which were statistically at par with T_{9}.

The results obtained in this present investigation clearly indicated that the Zinc Soil application of ZnSO_{4} \cdot 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}+FeSO_{4} similar results were recorded by Anees et al., (2011) [15] reported that the maximum total soluble solids (27.9 Brix\textsuperscript{a}), 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_{2}BO_{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} \cdot 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} \cdot 150gm+ Foliar spray of ZnSO_{4}@0.50%. Present investigation clearly indicated that the Zinc Soil application of ZnSO_{4} \cdot 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) [15] The results obtained in this present investigation were in agreement with those of Devi et al.,(1997) [8] in sweet orange. Similar results were also reported by Deolankar and Firke (2001) [15] in banana and by Singh et al., (2003) [17] in pomegranate and patil and Hiwarale (2004) [18] in acid lime.

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\[ \text{Mg of Ascorbic Acid/100 g juice} = \frac{(\text{Titrate value} \times \text{Dye factor} \times \text{volume made up})}{\text{X 100}} \]

Aliquot taken for estimation × Wt. or volume of sample taken for estimation.

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\[ \text{Results and Discussion} \]

(Titratable acidity was expressed as % Brix)
Table 1: Effect of soil and foliar application of zinc on Different chemical attributes of Sweet Orange fruits.

<table>
<thead>
<tr>
<th>Tr. No.</th>
<th>Treatment details</th>
<th>T.S.S</th>
<th>Juice %</th>
<th>Ascorbic acid (mg/100ml juice)</th>
<th>Reducing sugar (%)</th>
<th>Non-Reducing sugar (%)</th>
<th>Total sugar (%)</th>
<th>pH</th>
<th>Titrable acidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Control</td>
<td>7.27</td>
<td>38.18</td>
<td>40.46</td>
<td>1.97</td>
<td>3.70</td>
<td>5.67</td>
<td>3.52</td>
<td>0.38</td>
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<td>T2</td>
<td>Soil application of ZnSO₄ @ 100 gm+RDF</td>
<td>7.50</td>
<td>41.75</td>
<td>42.13</td>
<td>2.28</td>
<td>4.11</td>
<td>6.39</td>
<td>4.13</td>
<td>0.41</td>
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<tr>
<td>T3</td>
<td>Soil application of ZnSO₄ @ 150gm+RDF</td>
<td>7.42</td>
<td>41.40</td>
<td>42.43</td>
<td>2.14</td>
<td>3.83</td>
<td>5.97</td>
<td>4.2</td>
<td>0.47</td>
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<td>T4</td>
<td>Soil application of ZnSO₄ @ 200gm+RDF</td>
<td>7.44</td>
<td>39.88</td>
<td>45.44</td>
<td>2.16</td>
<td>4.46</td>
<td>6.62</td>
<td>4.12</td>
<td>0.51</td>
</tr>
<tr>
<td>T5</td>
<td>Soil application of ZnSO₄ @ 250gm+RDF</td>
<td>7.48</td>
<td>41.75</td>
<td>44.76</td>
<td>2.56</td>
<td>3.74</td>
<td>6.3</td>
<td>4.24</td>
<td>0.53</td>
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<tr>
<td>T6</td>
<td>Foliar spray of ZnSO₄@0.50%+RDF</td>
<td>7.74</td>
<td>49.35</td>
<td>44.8</td>
<td>2.70</td>
<td>4.46</td>
<td>7.16</td>
<td>4.29</td>
<td>0.54</td>
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<tr>
<td>T7</td>
<td>Foliar spray of ZnSO₄@0.75%+RDF</td>
<td>7.86</td>
<td>40.93</td>
<td>46.23</td>
<td>2.48</td>
<td>4.32</td>
<td>6.8</td>
<td>4.32</td>
<td>0.54</td>
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<td>T8</td>
<td>Foliar spray of ZnSO₄ @1%+RDF</td>
<td>8.02</td>
<td>44.77</td>
<td>46.3</td>
<td>2.85</td>
<td>4.47</td>
<td>7.32</td>
<td>4.47</td>
<td>0.54</td>
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<td>T9</td>
<td>Soil application of ZnSO₄ @ 100gm+</td>
<td>8.12</td>
<td>44.79</td>
<td>48.96</td>
<td>2.99</td>
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<td>7.46</td>
<td>4.48</td>
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<td>T10</td>
<td>Soil application of ZnSO₄ @ 150gm+</td>
<td>9.64</td>
<td>53.51</td>
<td>53.23</td>
<td>3.09</td>
<td>4.84</td>
<td>7.93</td>
<td>4.82</td>
<td>0.63</td>
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<td>T11</td>
<td>Soil application of ZnSO₄ @ 100gm+</td>
<td>9.52</td>
<td>51.80</td>
<td>53.00</td>
<td>3.01</td>
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<td>7.55</td>
<td>4.49</td>
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<tr>
<td>T12</td>
<td>Soil application of ZnSO₄ @ 150gm+</td>
<td>9.16</td>
<td>51.73</td>
<td>52.5</td>
<td>2.96</td>
<td>4.80</td>
<td>7.80</td>
<td>4.48</td>
<td>0.58</td>
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<tr>
<td>SE ±</td>
<td>C.D.at 5%</td>
<td>0.26</td>
<td>1.20</td>
<td>1.44</td>
<td>0.088</td>
<td>0.17</td>
<td>0.16</td>
<td>0.14</td>
<td>0.014</td>
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References