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Effect of soil and foliar application of zinc on growth and yield 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 growth and yield 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 growth and yield characteristics of sweet orange. The results were revealed that, there were significant variations in growth, and yield of sweet orange due to application soil and foliar application of zinc.The values of vegetative growth parameters stem girth, plant spread and number of branches per tree showed the non- significant effect by treatments and plant height and canopy volume no.of flowers per branch and fruit drop showed significant effect by the treatments. The height of tree, canopy volume showed most effective in T_{10} (Soil application of$ZnSO_4$@150gm+ Foliar spray of$ZnSO_4$@0.50%) and all treatment superior over the control except ($T_1$and T_4) and minimum effective in T_1 i.e. control. The physical parameter of fruit like average diameter of fruit most effective in T_{10} (Soil application of$ZnSO_4$@150gm+ Foliar spray of $ZnSO_4$@0.50%) followed by treatment T_{11}(Soil application of $ZnSO_4$@100gm+ Foliar spray of $ZnSO_4$@0.75%) and T_{12}(Soil application of$ZnSO_4$ @150gm+ Foliar spray of $ZnSO_4$@0.75%) and minimum effective in T_1 (control).the yield parameters number of fruit per tree and weight of fruit per tree, weight of one fruit and weight of five fruit were noticed maximum in T_{10} (Soil application of$ZnSO_4$@150gm+ Foliar spray of $ZnSO_4$@0.50%) followed by treatment T_{11}(Soil application of $ZnSO_4$@100gm+ Foliar spray of $ZnSO_4$@0.75%) and T_{12}(Soil application of$ZnSO_4$ @150gm+ Foliar spray of $ZnSO_4$@0.75%) and minimum effective in T_1 (control).application of T_{10} (Soil application of$ZnSO_4$@150gm+ Foliar spray of $ZnSO_4$@0.50%) improved economics in sweet orange.

Keywords: Foliar application, zinc, growth, yield parameter, sweet orange var. Nucellar, (*Citrus sinensis* L. Osbeck)

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) [25]. 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 world the global production of oranges at record 48.8 m. MT (Anonymous 2015). United States of America is having the largest area i.e. about 40 percent of total acreage under various citrus fruit in the world. Asia particularly, Himalayan region and South China are the places of origin for the most of the citrus fruits. Among the most common fruits sweet orange occupy nearly two third of the world's total area. The total area of sweet orange in India is 278 thousand ha with production 4526 tone.

Commercially, Sweet orange, mandarin and acid lime are grown in different agro-climatic regions. Andhra Pradesh, Maharashtra, Karnataka, Punjab, Haryana, and Rajasthan are the main sweet orange growing states. Maximum area under sweet orange in the Andhra Pradesh followed by Maharashtra and Karnataka.

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 (NHM 2013). 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) [10]. In Jalna district of Maharashtra area under sweet orange is 18028 ha with the production 191145 MT and productivity is 10600 kg ha^{-1} (M.A.C.P. 2008-2013). Deficient micronutrients not only reduce the productivity of crops but also reduce the use efficiency of applied major nutrients. Micronutrient deficiencies are increasing and can be expected to continue. Higher yields are being obtained putting greater demand on soil nutrients.

For immediate result, foliar application of nutrient has gained importance in recent year to rectify the deficiencies of nutrient as soil application is not effective because of the fact that some part of nutrient leaches down and some other do not become available to the plants due to complex chemicals and biochemical reactions in soil.

Deficiency of zinc is globally considered as the most crunch nutritional problem in citrus growing belts for sustainable citrus production (Srivastava and Singh, 2005) [25]. 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) [11].

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) [14].

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.

Hence, considering the need, the present investigation study on the effect of soil and foliar application of zinc on growth and yield parameters of sweet orange has been conducted.

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 15.25^0C and 43.85^0C 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}).The height of a plant was measured with the help of a measuring bamboo having meter marking from the ground level to the tip of the highest shoot of the plant in each replication and average was worked out and was expressed in meter. The volume occupied by plant canopy was measured in E-W and N-S direction and canopy height with the help of measuring scale and plant canopy volume was calculated by taking E-W and N-S plant spread in $(m)^3$

Canopy volume = canopy height X (East west spread + North south spread)^2

The fruit set from above tagged flowers were used for studying the intensity of fruit drop up to the time of harvesting and percentage were worked out.

$$\text{Fruit drop (\%)} = \frac{\text{(Total number of fruit set – No. of fruits at harvest time)}}{\text{Total no. of fruit set}} \text{ X100}$$

The total number of fruits was harvested from the tree and total number of fruits was counted. The weight of individual five fruit was recorded with help of electrical balance. The weight of five fruits was recorded with the help of electrical balance The size of the fruit was measured in terms of length and breadth in cm. with the help of vernier caliper.

Results and discussion

Data present in table, among various treatments, Maximum plant height was observed in T_{10} (4.52) Soil application of $ZnSO_4$ 150gm+Foliar spray of $ZnSO_4$@0.50% which was significantly superior over the control and Minimum plant height was observed T_1 (4.31) i.e control which was statistically at par with T_4 Soil application of $ZnSO_4$ 200gm

(4.22), T_{10} was statistically significant with all over the treatment. These findings are in conformity with those of Nithin kumar *et al.,* (2017) [13] that foliar application of micronutrients on yield and quality of mandarin orange under pulney hills. Was recorded that foliar application of $ZnSO_4$ (0.20%), $FeSO_4$ (0.2%), H_3BO_4 (0.2%), $MnSO_4$ ((0.3%) and CuSO4 (0.4%) alone or combination for very effective in increasing vegetative growth as compaird to control. Increase in plant height in kinnow mandarin with the application of Zinc was reported by Dixit (1961) [5]. Our result also conformed Babu *et al.,* (2007) [4] in kagzi lime and kinnow respectively, to the increase vegetative growth of the plant. The maximum canopy volume was observed in T_{10} (21.26) Soil application of $ZnSO_4$ **@** 150gm+ Foliar spray of $ZnSO_4$@0.50%which was significantly superior over the control and at par with treatment T_{12} (20.24) Soil application of $ZnSO_4$ 150 gm + Foliar spray of $ZnSO_4$@ 0.75% respectively. The maximum number of fruits per tree (329.7) was observed in treatment T_{10} i.e. Soil application of $ZnSO_4$ @150gm + Foliar spray of $ZnSO_4$ @0.50% and it was significantly superior over the control followed by the treatment T_{11} (323.0) i.e. Soil application of $ZnSO_4$ @100gm+ Foliar spray of $ZnSO_4$ @0.75%. Gurjar *et al.,* (2015) [6] found that maximum number of fruits per plant (486.24) were recorded with foliar application of 0.2 percent boric acid + 0.5 percent Zinc Sulphate at fruit set and peach size stage of fruit as compared to minimum in control in kinnow mandarin. Gurjar and Rana (2014) [7] reported the highest number of fruits per tree in kinnow (279.4) was obtained with the foliar application of 0.5 percent $ZnSO_4$ + 10 ppm 2, 4-D resulted and minimum number of fruits (238.6) under control. The highest weight of five fruits was recorded in the treatment T_{10} (1376.83 g) i.e. Soil application of $ZnSO_4$ @ 150gm + Foliar spray of $ZnSO_4$ @ 0.50% and it was significantly superior over the control followed by treatment T_{11} (1290.17g) i.e. Soil application of $ZnSO_4$ @ 100gm+ Foliar spray of $ZnSO_4$ @ 0.75%, T_6 (1277g) i.e. Foliar spray of $ZnSO_4$ @ 0.50% and T_9 (1221.67g) i.e. Soil application of $ZnSO_4$ @ 100gm+ Foliar spray of $ZnSO_4$@ 0.50%. Javaid *et al.,* (2004) [9] stated that the effect of micronutrient application on yield and size of fruit statistically significant. The result showed that highest weight of one fruit(233.75g/fruit) and size (l/b – 7.73/7.65 cm) due to application of 60g each of $CuSO_4$, $MnSO_4$, $FeSO_4$ and100 gm of $ZnSO_4$ in Kinnow mandarin alone or combination gives better result as compared to control. Babu *et al*., (2007) [4] in kagzi lime and kinnow respectively the effect of micronutrients ($MgSO_4$, $ZnSO_4$ and $MnSO_4$ each at 0.5% alone or in combinations) on quality of ten years old kinnow mandarin trees at ICAR research complex for NEH region, Meghalaya during 2000 to 2002. They observed maximum fruit weight (140.05 g) and maximum fruit volume (154.50 ml) with the application of 0.5% $MgSO_4$ + 0.5% $ZnSO_4$ + 0.5% $MnSO_4$ whereas maximum fruit diameter (69.24 mm) was recorded in the trees treated with 0.5% $ZnSO_4$ + 0.5% $MnSO_4$. The highest yield was recorded in the treatment T_{10} (120.02kg) i.e. Soil application of $ZnSO_4$ @ 150gm + Foliar spray of $ZnSO_4$ @ 0.50%. Jagtap *et al.,* (2013) [8] found that the yield of fruit in kg / tree of acid lime cv. KAGZI, as increasing maximum yield kg par tree (46.38kg) was found due to application of $ZnSO_4$ (0.5% and 1%) consequently higher yield (kg/tree) as compared to control. Amro and Salama (2015) [1], also concluded that significantly increasing in fruits in kg / tree due to increment of chlorophyll production and photosynthesis processes lead to increased in yield kg / tree of Valencia orange trees, with application of Zinc. The maximum fruit diameter recorded in treatment T_{10} (9.64 cm) i.e. Soil application of $ZnSO_4$ 150gm+ Foliar spray of $ZnSO_4$ @0.50%, which was at par with treatment T_{11} (9.52 cm) i.e. Soil application of $ZnSO_4$ 100gm+ Foliar spray of $ZnSO_4$ @0.75%. Concluded that Spraying of micronutrients (Cu, Zn and B) alone and their combinations significantly increased the number of fruit diameter and yield of mandarin orange. Meena *et al*., (2014) [12] found that maximum fruit diameter (4.46 cm) at harvest was recorded with foliar spray of 0.8 % Zinc Sulphate and 0.4 % Zinc Sulphate treatment in aonla.

Table 1: Effect of soil and foliar application of $ZnSO_4$ on Various Growth Characteristic of Sweet Orange.

S. No.	Treatment details	Plant Height (cm)	Tree canopy (m) ^{3}	Number of fruits per tree	Weight of five fruits (gm)	Yield of fruits per tree(kg)	Average diameter of fruit (cm)
T_1	Control	4.31	13.85	183.7	984.1	37.36	7.27
T_2	Soil application of $ZnSO_4$ **@** 100 gm+RDF	4.48	15.10	193.3	1075.17	52.66	7.50
T_3	Soil application of $ZnSO_4$@ 150gm+RDF	3.91	15.05	190.3	997.86	46.09	7.42
T_4	Soil application of $ZnSO_4$@ 200gm+RDF	4.22	13.97	257.0	1140.67	68.32	7.44
T_5	Soil application of $ZnSO_4$ **@** 250gm+RDF	4.12	17.92	206.0	1134.67	53.51	7.48
T_6	Foliar spray of $ZnSO_4$@0.50%+RDF	4.43	16.44	222.3	1277	53.28	7.74
T_7	Foliar spray of $ZnSO_4$@0.75%+RDF	4.52	17.63	220.7	1071.17	55.58	7.86
T_8	Foliar spray of $ZnSO_4$ @1%+RDF	4.23	16.77	212.7	1069.5	60.49	8.02
T_9	Soil application of $ZnSO_4$ **@** 100gm+ Foliar spray of $ZnSO_4$ @ 0.50%	4.21	14.41	252.7	1221.67	81.01	8.12
T_{10}	Soil application of $ZnSO_4$ **@** 150gm+ Foliar spray of $ZnSO_4$@0.50%	4.45	21.26	329.7	1376.83	120.02	9.64
T_{11}	Soil application of $ZnSO_4$ **@** 100gm+ Foliar spray of $ZnSO_4$@0.75%	4.52	17.27	323.0	1290.17	111.4	9.52
T_{12}	Soil application of $ZnSO_4$ @ 150gm+ Foliar spray of $ZnSO_4$@0.75%	4.21	20.24	267.0	1202	88.96	8.81
SE ±C.D.at 5%		0.28	0.99	9.73	54.74	5.50	0.24
		0.82	1.40	28.54	160.56	16.14	0.71

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