International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(5): 279-282

Received: 12-07-2020
Accepted: 22-08-2020

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Studies on effect of soil and foliar application of micronutrients on growth and yield parameters of sweet orange Var. Nucellar (*Citrus sinensis* Osbeck)

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DOI: https://doi.org/10.22271/chemi.2020.v8.i5d.10310

Abstract
An experiment was conducted to study the effect of soil and foliar application of micronutrients on growth and yield parameters of sweet orange (*Citrus sinensis* Osbeck) Var. Nucellar." was carried out at Sweet Orange Research Station, Badnapur, Dist. Jalna during 2018-19. The experiment was laid out in Randomized Block Design (RBD) with 15 treatments and three replication. Observations were recorded on growth and yield characters of sweet orange. The results were revealed that, the growth and yield parameters like plant height, number of fruits per tree, average weight of fruit, yield of fruit per tree, fruit diameter, fruit volume are most effective in T_{13} Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % followed by T_{14} Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%.

Keywords: Zinc, volume, yield

Introduction
Citrus is the leading fruit crop of the world. Citrus fruits are a fair source of vitamin C and their daily consumption protects mankind from scurvy, a disease commonly associated with inadequate availability of vitamin C in the dietary foods. Citrus fruits are cultivated in India in four different zones i.e. Central India (Maharashtra, Gujarat and Madhya Pradesh), Southern India (Andhra Pradesh and Karnataka), North-Western India (Punjab, Rajasthan, Haryana and Western UP) and North-Eastern India (Meghalaya, Assam and Sikkim).

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* Osbeck) belongs to family Rutaceae. Sweet orange is native of Southern China. It is now widely distributed and naturalized in sub-tropical zone of India. India, especially Maharashtra has wide variety of climate and soil on which large number of horticultural crops such as fruits, vegetables, mushrooms, ornamental crops etc. are grown. Among all the horticultural crops; fruit crops occupy the prime position. The citrus especially sweet orange has its own identity in all fruit crops.

Citrus is micro nutrient loving fruit crop. Presently the yield of citrus crop is reducing due to some nutrient *Viz*., Zn, Mn, Fe, B, etc. among these Zn and Mn plays very significant role in growth, yield and quality of citrus. Deficient micronutrients not only reduce the productivity of crops but also reduce the efficiency of applied major nutrients. Micronutrients deficiencies are increasing and can be expected to continue. Higher yields are being obtained putting greater demand on soil nutrients.

The productivity of sweet orange in India is significantly lower than in some of the frontline citrus growing countries like Brazil, USA, Spain and Italy (30 to 35 t/ha). Similarly, the average productivity of sweet orange orchards (14.9 t/ha) is comparatively lower among the different sweet orange varieties. One of the main reasons for low sweet orange orchard productivity of Marathwada region is nutrient deficiencies.

Manganese deficiency is usually seen on young leaves as a mottled yellowing of the leaf. The veins stay green whilst the interveinal areas are light green to yellow. In extreme cases white spots can also be found between veins.

The usual practice is to apply Mn foliar sprays with zinc to overcome any deficiency. Mn and Zn have strong interactions; plants deficient in Mn will be high in Zn and vice versa. Severe manganese deficiency reduces cropping, growth and yield. Manganese is involved with photosynthesis, efficient use of N, protein metabolism and enzyme activation. Both soil application and foliar sprays increase yields in deficient trees. This is mainly as a result of increasing the number of fruit per tree. In addition, foliar application of Zn and Mn alone or in combination with each other showed significant increase in fruit yield of sweet oranges (Tariq *et al*., 2007) [14]. 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 and manganese application for optimum and good quality production of sweet orange.

Material and Methods

The experiment was conducted during 2018-19, on uniform 8 years old plants of Var. 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 2018 is 437 mm. Experiment was laid out in a Randomized Block Design (RBD) with three replication and fifteen treatments these are control i.e.(T_1), Soil application of $ZnSO_4$ **@** 100 gm/plant(T_2), Soil application of $ZnSO_4$@ 150gm/plant (T_3), Soil application of $ZnSO_4$@ 200gm/plant (T_4), Soil application of $MnSO_4$ **@** 100g/plant (T_5), Soil application of $MnSO_4$ @ 150gm/plant (T_6), Soil application of $MnSO_4$ @ 200gm/plant (T_7), Foliar spray of $ZnSO_4$ @ 0.5%/plant (T_8), Foliar spray of $ZnSO_4$ @1%/plant (T_9), Foliar spray of $MnSO_4$ @ 0.5 % plant (T_{10}), Foliar spray of $MnSO_4$@1%/plant (T_{11}), Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % (T_{12}), Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % (T_{13}), Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1% (T_{14}), Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1% (T_{15}). The height of plant was measured with the help of 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 total number of fruits was harvested from the tree and total number of fruits counted. The weight of fruits was recorded with the help of electric balance. Yield of fruit per tree are recorded by number of fruits counted at the time of harvesting were weighed and yield in term of kilogram per plant was worked out. The size of fruit was measured in terms of length and breadth in cm with the help of Vernier caliper. Volume of the fruit was measured by displacement method.

Results and discussion

The data given in table that, the maximum plant height (4.47) was recorded in the treatment T_{13} i.e., Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % followed by treatment T_{14} i.e. Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%. The minimum plant height was recorded in T_1 (4.01) i.e. control, and T_{13} was statistically superior over the control. Our result also conformed Babu *et al.,* (2007) [3] in kagzi lime and kinnow respectively, to the increase the vegetative growth of the plant. Nithin kumar *et al.,* (2017) [13] was reported 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.

The maximum number of fruits per tree (394.67) was recorded in the treatment T_{13} i.e., Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % followed by treatment T_{14} (391.33) i.e. Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%. The minimum number of fruits per tree was recorded in T_1 (203.33) i.e. control, and T_{13} was statistically superior over the control. Kachave and Bhosale (2007) [10] Combined application of micronutrients increased the yield parameters because the rate of translocation of nutrients from source leaf to sink fruits is increased with enhancement in photosynthesis rate observed in Kagzi lime. Gurjar *et al*., (2015) [4] found that maximum number of fruits per plant (486.24) were recorded with foliar application of 0.2 per cent boric acid + 0.5 per cent Zinc Sulphate at fruit set and peach size stage of fruit as compared to minimum in control in kinnow mandarin. Gurjar and Rana (2014) [5] reported the highest number of fruits per tree in kinnow (279.4) was obtained with the foliar application of 0.5 per cent $ZnSO_4$ + 10 ppm 2, 4-D resulted and minimum number of fruits (238.6) under control.

The maximum average weight of fruit (325.83g) was recorded in the treatment T_{13} i.e., Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % followed by treatment i.e. Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%. The minimum average weight of fruit was recorded in T_1 (173.3g) i.e. control, and was statistically superior over the control. Khurshid *et al.,* (2008) [11] reported that the highest fruit weight of 237.1 g/ tree was obtained from trees sprayed with Zn + Fe + Cu + Mn in citrus. 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.

The maximum yield per tree (116.11 kg) was recorded in the treatment T_{13} i.e., Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % followed by treatment T_{14} (108.03kg) i.e. Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%. The minimum yield per tree was recorded in T_1 (46.49kg) i.e. control, and T_{13} was statistically superior over the control. 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 S.M. Salama (2015) [2], 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 (9.65cm) was recorded in the treatment T_{13} i.e., Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % followed by treatment T_{14} (9.58cm) i.e. Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%. The minimum fruit diameter was recorded in T_1 (7.55cm) i.e. control, and T_{13} was statistically superior over the control. Haque *et al*., 2000 [7] 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.

The maximum fruit volume (303.7ml) was recorded in the treatment T_{13} i.e., Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 % followed by treatment T_{14} (294.59ml) i.e. Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%. The minimum fruit volume was recorded in T_1 (204.71ml) i.e. control and T_{13} was statistically superior over the control. Ali *et al*., (2014) [1] reported that fruit diameter, fruit volume was maximum in treatment Zn + Cu + Mn + B in peach.

Table 1: Effect of soil and foliar application of micronutrients on Different growth and yield attributes of Sweet Orange fruits.

T. No.	Treatment details	Plant height (cm)	Number of fruits per tree	Average weight of fruit (g)	Yield of fruits per tree (kg)	Average fruit diameter (cm)	Fruit volume
T1	Control	4.01	203.33	173.3	46.49	7.55	204.71
T2	Soil application of $ZnSO_4$ @ 100 gm/plant	4.73	223.67	191.46	56.54	7.74	244.5
T3	Soil application of $ZnSO_4$@ 150gm/plant	3.94	260.67	208.45	57.13	7.91	224.54
T4	Soil application of $ZnSO_4$@ 200gm/plant	4.35	245.67	263.23	63.73	8.31	232.16
T5	Soil application of $MnSO_4$ @ 100g/plant	4.11	275.33	236.14	64.14	7.79	249.31
T6	Soil application of $MnSO_4$ @ 150gm/plant	4.45	289	217.62	62.31	7.88	242.87
T7	Soil application of $MnSO_4$ @ 200gm/plant	4.41	302.33	235.24	65.76	8.33	239.3
T8	Soil application of $MnSO_4$ @ 200gm/plant	4.33	321.67	248.42	76.82	8.43	267.51
T9	Foliar spray of $ZnSO_4$ @1%/plant	4.48	308.33	249.02	69.9	8.21	259.58
T10	Foliar spray of $MnSO_4$ @ 0.5 %plant	4.32	282.33	243.28	69.21	8.55	264.68
T11	Foliar spray of $MnSO_4$@1%/plant	4.52	354.33	247.75	83.83	9.31	269.52
T_{12}	Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 %	4.57	364	258.8	84.09	9.27	276.58
T13	Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 0.5 % + $MnSO_4$ @ 0.5 %	4.47	394.67	325.83	116.11	9.65	303.7
T_{14}	Soil application of $ZnSO_4$ @ 100 gm + $MnSO_4$ @ 100 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%	4.74	391.33	319.99	108.03	9.58	294.59
T_{15}	Soil application of $ZnSO_4$ @ 150 gm + $MnSO_4$ @ 150 gm + Foliar spray of $ZnSO_4$ @ 1% + $MnSO_4$ @ 1%	4.58	381.33	264.69	92.57	8.87	284.52
SE ± C.D.at 5%		0.12	11.15	8.55	4.33	0.25	9.03
		0.37	31.9	24.45	12.51	0.72	25.83

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