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Studies on use of micronutrients in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi

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Abstract
This field experiment on studies on use of micronutrients in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi was conducted at ICAR-All India Coordinated Research Project on Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the *Ambia bahar*, 2019. The experiment was conducted in Randomized Block Design (RBD) with eight treatments replicated three times. Treatment details were T_1: RDF + soil application of $ZnSO_4$ 50 g/plant, T_2: RDF + soil application of $FeSO_4$ 50 g/plant, T_3: RDF + soil application of $MnSO_4$ 50 g/plant, T_4: RDF + soil application of micro grade-I 50 g/plant, T_5: RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant, T_6: RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant + foliar spray of micro grade-II, T_7: RDF + only foliar spray of micro grade-II, T_8: RDF only (control). The experiment was conducted on 22 years old, healthy and vigorous tree. The micronutrients were applied in February-2019. Observations regarding growth, yield and fruit quality were recorded. The study revealed that, the treatment T_6 i. e. use of RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant + foliar spray of micro grade-II proved superior and recorded the maximum plant height (3.30 m), canopy volume (18.07 m^3), number of fruits/tree (338.40), fruit weight (191.58 g), fruit yield (64.80 kg/tree and 17.95 t/ha), juice (51.18%), TSS (10.25 ^oB), ascorbic acid (55.07 mg/100 ml juice), reducing sugars (4.05%), non-reducing sugars (3.11%) and total sugars (7.02%) with minimum acidity (0.43%), rind (24.20%) and rind thickness (3.38 mm). There was non-significant difference between the treatments for yield efficiency, rag, weight of seeds/fruit and shelf life of fruits.

Keywords: Sweet orange, micronutrients, Ambia bahar, growth, yield, fruit quality

Introduction
Sweet orange (*Citrus sinensis* Osbeck) is the second important citrus fruit cultivated in India. Andhra Pradesh, Maharashtra, Karnataka, Telangana, Madhya Pradesh, Bihar, Punjab, Assam and Jammu-Kashmir are the main sweet orange growing states. The maximum area under sweet orange cultivation is in Andhra Pradesh followed by Maharashtra and Karnataka. Well marked belts of sweet orange cultivation in Maharashtra is Marathwada region in central Maharashtra, Ahmednagar, Pune and Nashik districts in Western Maharashtra. In India, sweet orange is grown on an area of 217 thousand hectares with total production of 3988 thousand MT with productivity of 18.37 MT/ha, In Maharashtra, sweet orange is grown on an area of 61 thousand hectares with total production of 611 thousand MT with productivity of 10.01 MT/ha [2]. Sweet orange belongs to family *Rutaceae*. It is an important source of vitamin C. It is mostly consumed as fresh. One of the main reason for low sweet orange orchard productivity is multiple nutrient deficient soils in Maharashtra state. The micronutrients play a significant role in growth, yield and fruit quality of sweet orange. Sweet orange is very sensitive to nutrients. Relatively, small amount of micronutrient is required as compared to those of primary nutrients, these are equally important for plant metabolism, Katyal 2004 [9]. Even though micronutrients are present in soil but their absorption may be hindered by other nutrients due to interaction between the nutrients. The micronutrients affect on various metabolic functions such as starch metabolism, photosynthetic reaction, nucleic acid metabolism, chlorophyll synthesis and protein biosynthesis in plant system, Swietlik 2002 [15]. Application of zinc, iron and manganese sulphates in soil and foliar spray reduced the leaf chlorosis and significantly increased the yield in sweet orange Devi *et al*. 1997 [5]. Under various application techniques and their effect on Indian conditions, very less work was carried out on the role of micronutrients in sweet orange for quantitative as well as qualitative production. Hence, the present investigation was planned to study the effect of micronutrients on growth, yield and fruit quality in sweet orange cv. Mosambi.

Material and Methods

The present experiment was conducted at ICAR-All India Coordinated Research Project on Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the *Ambia bahar*, 2019. The experiment was laid out in a Randomized Block Design (RBD) with eight treatments replicated three times. Treatment details were T_1: RDF + soil application of $ZnSO_4$ 50 g/plant, T_2: RDF + soil application of $FeSO_4$ 50 g/plant, T_3: RDF + soil application of $MnSO_4$ 50 g/plant, T_4: RDF + soil application of micro grade-I 50 g/plant, T_5: RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant, T_6: RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant + foliar spray of micro grade-II, T_7: RDF + only foliar spray of micro grade-II, T_8: RDF only (control). Plant unit used was 2 plants/treatment. Mosambi variety of sweet orange was used for study. Tree age was 22 years during study period. Plant spacing was 6 x 6 m. Season was *Ambia bahar*, 2019. Recommended dose of fertilizer for sweet orange was 20 kg FYM + 15 kg neem cake + 800:300:600 g NPK/plant/year. The micronutrients were applied in February-2019. Soil application of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and micro grade-I were applied with organic manures. Observations on growth, yield and fruit quality were recorded. The growth parameter like canopy volume of sweet orange tree was calculated based on Castle's [3] formula. The fruit quality parameter like acidity was determined according to the method given in A.O.A.C. [1]. Ascorbic acid, reducing and total sugars content in the fruit was estimated by the procedure described by Ranganna [14]. The data was statistically analysed following the standard procedure suggested by Panse and Sukhatme [12].

Results and Discussion

In the present study, the use of micronutrients in sweet orange significantly increased the growth, yield and fruit quality. The use of RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant + foliar spray of micro grade-II plays an important role in improvement of growth, yield and fruit quality in sweet orange.

The growth and yield data presented in Table 1 revealed that, the maximum plant height (3.30 m), canopy volume (18.07 m^3), number of fruits/tree (338.40), fruit weight (191.58 g) and fruit yield (64.80 kg/tree and 17.95 t/ha) were recorded by the treatment T_6 i. e. use of RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant + foliar spray of micro grade-II. This increase in growth and yield by application of micronutrients might have been due to its important role in photosynthesis, development of reproductive stage, regulating plant growth hormones and reactions involving cell division and growth in sweet orange. Similar results were also reported by Jagtap *et al*. 2013 [8] in acid lime, Gurjar *et al*. 2015 [6], Ilyas *et al*. 2015 [7] and Vijaya *et al*. 2017 [17] in Kinnow mandarin and Pawar *et al*. 2017 [13] in sweet orange. The treatment T_8 i. e. RDF only (control) recorded the minimum plant height (3.00 m), canopy volume (13.48 m^3), number of fruits/tree (315.80), fruit weight (158.03 g) and fruit yield (49.91 kg/tree and 13.82 t/ha). There was non-significant difference between the treatments for yield efficiency.

The fruit quality data presented in Table 2 revealed that, the maximum juice (51.18%), TSS (10.25 ^oB), ascorbic acid (55.07 mg/100 ml juice), reducing sugars (4.05%), non-reducing sugars (3.11%) and total sugars (7.02%) with minimum acidity (0.43%), rind (24.20%) and rind thickness (3.38 mm) were recorded by the treatment T_6 i. e. use of RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant + foliar spray of micro grade-II. The use of micronutrients in sweet orange enhanced the photosynthetic rate and auxin production which in turn improved the fruit quality in terms of juice, TSS, ascorbic acid and sugars. Use of zinc increased photosynthetic activity and chlorophyll content of leaves, iron accelerated the fruit development due to which more metabolites might have diverted from leaves to fruit thereby increasing fruit quality, manganese also plays an important role in various metabolic activities and improved the fruit quality in sweet orange. Similar results were also reported by Kazi *et al*. 2012 [10] in sweet orange, Venu *et al*. 2014 [16] in acid lime, Chaudhari *et al*. 2016 [4] in Kinnow mandarin and Kumar *et al*. 2017 [11] in mandarin orange. The treatment T_8 i. e. RDF only (control) recorded the minimum juice (45.77%), TSS (9.25 ^oB), ascorbic acid (50.03 mg/100 ml juice), reducing sugars (3.20%), non-reducing sugars (2.10%) and total sugars (5.10%) with maximum acidity (0.62%), rind (27.26%) and rind thickness (5.09 mm). There was non-significant difference between the treatments for rag, weight of seeds/fruit and shelf life of fruits.

Table 1: Effect of micronutrients on growth and yield in sweet orange.

Treatment	Plant height (m)	Canopy volume (m^3)	Number of fruits / tree	Fruit weight (g)	Fruit yield (kg/tree)	Fruit yield (t/ha)	Yield efficiency (kg/m^3)
T_1	3.15	15.98	325.20	178.12	57.93	16.04	3.68
T_2	3.20	15.41	321.85	169.23	54.49	15.09	3.55
T_3	3.22	15.86	327.30	175.95	57.62	15.96	3.63
T_4	3.25	16.27	330.75	183.77	60.81	16.86	3.73
T_5	3.28	16.82	335.90	190.87	64.16	17.77	3.81
T_6	3.30	18.07	338.40	191.58	64.80	17.95	3.58
T_7	3.26	16.61	331.60	185.63	61.56	17.05	3.71
T_8	3.00	13.48	315.80	158.03	49.91	13.82	3.71
S. E.(m) ±	0.08	0.75	2.80	6.08	2.32	0.64	0.20
C. D. at 5%	0.24	2.28	8.50	18.44	7.04	1.94	NS

Table 2: Effect of micronutrients on fruit quality in sweet orange.

Treatment	Juice (%)	TSS (ºB)	Acidity (%)	Ascorbic acid (mg/100 ml juice)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Rind (%)	Rag (%)	Weight of seeds / fruit (g)	Rind thickness (mm)	Shelf life of fruits (days)
T_1	46.51	9.92	0.58	51.58	3.28	2.80	5.90	26.50	16.17	3.89	4.45	13.83
T_2	45.84	9.37	0.61	50.25	3.22	2.85	6.19	26.69	16.05	4.23	4.55	14.67
T_3	46.10	9.73	0.60	51.00	3.21	2.82	6.11	26.44	16.09	4.14	4.13	14.83
T_4	49.33	9.98	0.55	52.75	3.32	2.90	6.47	25.63	15.86	3.70	4.03	15.00
T_5	50.25	10.23	0.45	54.22	4.02	3.06	6.95	24.32	14.09	3.51	3.40	15.50
T_6	51.18	10.25	0.43	55.07	4.05	3.11	7.02	24.20	13.64	3.17	3.38	15.83
T_7	50.00	10.17	0.48	53.07	4.00	2.97	6.67	24.79	15.62	3.57	3.60	15.03
T_8	45.77	9.25	0.62	50.03	3.20	2.10	5.10	27.26	16.50	4.24	5.09	12.67
S. E.(m) ±	1.35	0.19	0.03	1.09	0.09	0.06	0.10	0.69	1.27	0.37	0.34	1.07
C. D. at 5%	4.10	0.59	0.09	3.30	0.29	0.20	0.31	2.10	NS	NS	1.05	NS

Conclusion

The study thus revealed that, the use of RDF + soil application of $ZnSO_4$ 50 g + $FeSO_4$ 50 g + $MnSO_4$ 50 g + micro grade-I 50 g/plant + foliar spray of micro grade-II proved superior and recorded the best results with respect to growth, yield and fruit quality in sweet orange.

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