Int.J.Curr.Microbiol.App.Sci (2019) *8*(11): 2524-2531

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 8 Number 11 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.811.291

Effect of Micronutrients on Growth, Yield and Quality Parameters of Sweet Orange (*Citrus sinensis* L.) cv. Mosambi

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Keywords

Sweet orange, Micronutrients, Quality, Canopy volume, Fruit weight

Article Info

Accepted:
26 October 2019
Available Online:
10 November 2019

A B S T R A C T

An investigation was carried out at Experimental field of department of Horticulture, Collage of Agriculture, RVSKVV, Gwalior (M.P.) during 2017 to study the effect of micronutrients on growth, yield and quality parameters of sweet orange. Foliar application of 4g - Copper sulfate) + 2g - Ferrous sulfate), + 2g Borax + 4g (Zinc sulfate) + 4g (Magnesium sulfate) + 10g lime per liter water during the mid of March and 1st week of July with 600 N + 500 P + 300 K g/tree on sweet orange gave maximum Canopy volume (3.07 m^3), Leaf area (39.19 cm^2), Fruit set (79.81%), Fruit weight (167 g), Fruit length (11.8 cm), Fruit diameter (21.8 cm), Number of fruits/tree (248), Yield per tree (41.03 kg) and good quality fruits Juice (56.08 %) Acidity (0.78%), Ascorbic acid (58.04 mg/100ml) with Total Soluble Solids (11.6 ^oBrix). Therefore, application of this dose of micronutrient combination will improve yield and fruit quality in sweet orange of these micronutrients as a result of which the orchardist will be economically benefited.

Introduction

Sweet orange (*Citrus sinensis* L.) is one of the most important crops in the world; it is mainly used for extraction and consumption of its fresh juice. Citrus fruits hold an important place in the economy of the country and these fruits form the third largest fruit industry (Anonymous, 2016). The fruit, which may be globose to oval, is typically 6.5 to 9.5 cm wide, and ripens to orange or yellow. The fruit skin (rind or peel) contains numerous small oil glands. The flesh or pulp of the fruit is typically juicy and sweet, divided into 10 to 14 segments (although there are seedless varieties) and ranges in color from yellow to orange to red (Khehra and Bal, 2014). Citrus fruits are cultivated in India in four different zones i.e. central India (Madhya Pradesh, Maharashtra and Gujarat), southern India (Andhra Pradesh and Karnataka), north-western India (Punjab, Rajasthan, Haryana and western UP) and north-eastern India (Meghalaya, Assam and Sikkim). These zones have different leading cultivar(s) that occupies a place of prominence in the respective area (Etebu and Nwauzoma, 2014). Citrus occupies an important place in the fruit industry, but yield levels of citrus orchards are still very low Srivastava and Singh (2009). Nutrient refers to all those compounds, which are required by the plant as a source of body

building material and for the energy, without which, it will not be able to complete its life cycle (Ibrahim *et al.,* 2011). Consequent to the global energy crisis, efficient and judicious use of the fertilizers is imperative not only for obtaining more yields per unit area on a sustainable basis, but also to conserve the energy and to avoid the problem of environment quality (Sarrwy *et al.,* 2012). Therefore, it is a holistic approach, where we first know what exactly is required by the plant for an optimum level of production in what different forms these nutrients should be applied in soil and at what different timings in the best possible method; and how best these forms should be integrated to obtain highest productive efficiency on the economically acceptable limits in an environment friendly manner.

Materials and Methods

Experimental design and fertilizers

The experiment was conducted on 8 year old sweet orange orchards at Experimental field of department of Horticulture, Collage of Agriculture, RVSKVV, Gwalior (M.P.) during 2017. Sixty four trees were selected for this purpose. Sixteen treatments with four replications were applied. A basal dose of 600 N + 200 P+300 K g/tree was applied. Foliar application of micronutrients 4g $CuSO_4$ (Copper sulfate) + 2g $FeSO_4$ (Ferrous sulfate), + 2g Borax+ 4g $ZnSO_4$ (Zinc sulfate) + 4g MgS O_4 (Magnesium Sulphate) + 10g lime per liter water during the mid of March and 1st week of July with RDF 600 N + 200 P+300 K g/tree only the treatment combination of phosphorus (400, 500 and 600) was changed in dose. The various treatments used in the study is presented in table 1: After harvesting the fruit length (cm), diameter (cm), No. of fruits/tree, yield/tree, Juice acidity, Total Soluble Solids and Vitamin C were recorded. The fruit analysis was performed at edible maturity stage. Fruit samples were taken from the plants under different treatments at the time of maturity and analyzed for various physical characteristics. At the time of harvest, ten fully developed fruits were selected randomly from each tree. Length of these fruits was measured longitudinally, fruit diameter transversely with the help of Vernier callipers, mean value per fruit calculated and expressed in cm. Weight of the selected fruits was also recorded with the help of physical balance, mean value per fruit calculated and expressed in g $fruit^{-1}$. For computing the yield of fruits per plant, the matured fruits were harvested and weighed periodically and yield was expressed in kg per tree. The chemical properties of fruit were determined according to the methods of AOAC. Data were subjected to analysis of variance and differences among treatments were evaluated.

Results and Discussion

The data with respect of plant growth and fruit quantity parameters like Tree height (m), Canopy volume (m^3), Leaf area (cm^2), Days to appearance of first flower, Fruit set (%), number of fruits per tree, weight of fruit, fruit yield and quality of fruits as influenced by use of multi-micronutrient are presented in Table 2. Data recorded has revealed that phosphorus with soil application and micronutrients levels have significant effect on different plant growth, yield and quality parameters. The maximum Tree height (5.05m) was recorded in T_{14} 600:600:300 (N:P:K g/tree) + 4g $CuSO_4$+2g $FeSO_4$, + 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water followed by T_{12} 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water (5.01m). These results are in close conformity with those reported by Singh *et al.,* (2000) in sweet orange. In the case of Canopy volume maximum in (3.07 m^3) and Leaf area (39.19 cm^2) T_{12} 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water. However

minimum was recorded in T_0 control (Water spray + 600:200:300, NPK g/tree) (Canopy volume 2.85 m^3) and Leaf area (29.21cm^2). The results obtained in present investigation are supported by the findings of Kazi *et al.,* (2012) and Srivastava (2012) in sweet orange. The influence of micronutrients and phosphorus on Days to appearance of first flower of fruit in Table 2. Among the various micronutrients treatments, the minimum Days to appearance of first flower (146) was recorded in T_{12} 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water. Whereas, the maximum Days to appearance of first flower (160) was observed under control. The present results are in close conformity with the finding of Singh and Khan (2012) in sweet orange. The application of phosphorus with soil application and micronutrients through foliar spray had a positive effect on the Fruit set (%). The maximum fruit set (79.81%) was recorded in T_{12} 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water. The increase in Fruit set (%) of sweet orange fruit tree due to micronutrients treatment were also recorded by Khurshid *et al.,* (2008) in sweet orange.

The maximum fruit weight (168g) was recorded in T_{15} - 600:600:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water followed by T_{12} 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water (167g). However minimum fruit weight was recorded T_0 control (Water spray + 600:200:300, NPK g/tree) (147g). The obtained results are in agreement with those reported by Patel *et al.,* (2009) and Boman, 2001 and Rattanpal *et al.,* 2015 in sweat orange. The increase in yield parameters could be due to the application of phosphorus with soil application and micronutrients through foliar application at critical stages which ultimately could have favoured fruit growth and quality. Similar observations were also recorded in sweet orange (Vijay, 2016; Wei *et al.,* 2002). The effect of phosphorus with soil application and micronutrients levels with different treatments on fruit length and fruit diameter were monitored with fruit analysis. The maximum fruit length (13.5cm) and fruit diameter (22.4cm) were recorded in T_{15} -600:600:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax+ 4g $ZnSO_4$+ 4g$MgSO_4$+ 10g lime per liter water followed by T_{12} 600:500:300 + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water were recorded fruit length (11.8cm) and fruit diameter (21.8cm). However minimum fruit length (8.6cm) and fruit diameter (19.5cm) were recorded T_0 control (Water spray + 600:200:300, NPK g /tree) (147 g). These results are in line with the findings of Sangwan *et al.,* (2008). In Kinnow, Balal *et al.,* (2011) in acid lime and Mostafa and Saleh (2006) in sweet orange. The application of phosphorus with soil application and micronutrients through foliar spray had a positive effect on the yield as well as fruit quality of the sweet orange during 2017. The sweet orange fruits were harvested during November and December months in the year. The average number of fruits per plant, yield, TSS, Juice content, and acidity was analysed for the study period and mean values were presented. The study was revealed that fruit yield and quality were significantly influenced by the different phosphorus and micronutrients treatments Gill *et al.,* (2005). The highest number of fruits per plants (248 fruits/plant) and fruit yield (41.03 kg/tree) was in T_{12} 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$+2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water followed by T_{15} - 600:600:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water (235 fruits/plant and 36.04 kg/tree).

Table.1 Treatment combination of micronutrients for growth, yield and quality parameters of sweet orange) cv. Mosambi

Treatment	Treatment details	Month of application
T_0	Water spray + 600:200:300(RDFof NPK g /tree)	March and July
T_1	600:400:300 (N:P:K g/tree)	
T_2	600:500:300 (N:P:K g/tree)	
T_3	600:600:300 (N:P:K g/tree)	
T_4	4g $CuSO_4$ +2g $FeSO_4$,+2gBorax+4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water +RDFof N:P:K g/tree	March
T_5	4g $CuSO_4$ +2g $FeSO_4$,+2gBorax+4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water +RDFof N:P:K g/tree	July
T_6	4g $CuSO_4$ +2g $FeSO_4$,+2gBorax+4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water +RDFof N:P:K g/tree	March and July
T_7	T_1 + 4g $CuSO_4$+2g $FeSO_4$, + 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water	March
T_8	T_1 + 4g $CuSO_4$+2g $FeSO_4$, + 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water	July
T_9	T_1 + 4g $CuSO_4$+2g $FeSO_4$, + 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water	March & July
T_{10}	T_2 + 4g $CuSO_4$+ 2g $FeSO_4$,+ 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water	March
T_{11}	T_2 + 4g $CuSO_4$+ 2g $FeSO_4$, + 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water	July
T_{12}	T_2 + 4g $CuSO_4$+2g $FeSO_4$, + 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4 + 10g lime per liter water	March & July
T_{13}	T_3 + 4g $CuSO_4$+2g $FeSO_4$,+ 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water	March
T_{14}	T_3 + 4g $CuSO_4$+2g $FeSO_4$, + 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water	July
T_{15}	T_3 + 4g $CuSO_4$+2g $FeSO_4$,+ 2g Borax+ 4g $ZnSO_4$+ 4gMgS O_4+ 10g lime per liter water	March & July

Table.2 Effect of micronutrients on growth, yield and quality parameters of sweet orange) cv. Mosambi

Treatments	Tree height (m)	Canopy volume (m^3)	Leaf area (cm^2)	Days to appearance of first flower	Fruit set (%)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Number of fruits/tree	Yield per tree (kg)	Juice acidity	Total Soluble Solids	Juice (%)	Vitamin C
T_0	4.95	2.85	29.21	160	49.61	147.12	08.6	19.5	142	20.87	1.09	09.02	47.37	46.33
T_1	4.97	2.85	31.59	151	55.18	152.84	09.5	20.0	190	34.97	0.86	10.34	53.52	52.01
T_2	4.91	2.86	33.91	150	57.68	159.24	10.6	20.7	214	37.11	0.82	10.68	54.77	54.42
T_3	4.96	3.00	32.37	145	59.72	164.47	11.2	21.5	215	33.34	0.90	10.26	52.02	50.04
T_4	4.94	3.03	34.86	153	64.45	148.95	08.8	19.7	168	22.07	0.97	09.07	52.78	51.91
T_5	4.91	2.89	33.44	155	67.83	150.71	09.4	19.9	165	25.96	1.01	10.03	49.14	47.56
T_6	4.98	3.05	35.15	157	72.72	160.28	10.9	20.9	170	30.12	0.95	10.18	50.56	48.43
T_7	4.98	2.97	35.75	153	74.16	153.43	09.7	20.2	235	35.33	0.84	10.41	54.30	52.48
T_8	4.94	3.05	34.96	151	68.55	154.29	10.3	20.4	232	36.97	0.83	10.55	54.39	53.02
T_9	4.92	2.86	37.82	153	74.29	159.71	10.5	20.8	233	38.05	0.81	10.75	55.25	56.55
T_{10}	5.02	2.93	37.46	149	75.61	165.35	10.8	21.0	241	38.81	0.81	11.01	56.36	57.73
T_{11}	4.99	2.98	36.51	150	77.89	164.11	11.1	21.3	243	40.94	0.79	10.87	56.24	57.04
T_{12}	5.01	3.07	39.19	146	79.81	167.49	11.8	21.8	248	41.03	0.78	11.60	56.08	58.04
T_{13}	4.95	3.07	36.64	148	67.46	167.25	13.1	22.2	234	34.38	0.93	10.29	52.54	51.23
T_{14}	5.05	2.97	35.23	144	70.39	166.31	12.4	21.9	230	33.16	0.88	10.21	51.35	49.15
T_{15}	4.97	2.99	37.98	148	72.64	168.27	13.5	22.4	235	36.04	0.87	10.33	53.02	52.77
S. Ed. (±)	0.03	0.02	0.40	0.19	3.34	02.13	03.95	01.48	01.07	01.01	0.32	0.43	0.26	0.411
C. D. at 5%	0.05	0.06	0.11	0.41	7.51	07.38	07.74	1.14	2.85	1.18	1.21	1.45	1.357	1.650

The lowest number of fruits per plant was with Water spray + 600:200:300, NPK g /tree (142 fruits/ tree). The present findings are also in agreement with the results of Wang *et al.*, (2004) and Dalal *et al.*, (2017) in sweet orange.

However, the best quality fruits (Juice 56.08%, TSS 11.60 ^{0}Brix, acidity 0.78 % and Vitamin C 58.04 mg/100ml) observed in T_{12} - 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$+2g $FeSO_4$ + 2g Borax+ 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water. The medium quality parameters were recorded in T_9 -600:400:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$+ 4g$MgSO_4$ + 10g lime per liter water (Juice 55.25%, TSS 10.75 o Brix, acidity 0.81% and Vitamin C 56.55 mg/100ml). The similar results were observed by Abd-Allah (2006) in Washington Navel orange and Yaseen and Ahmad (2010) in Kinnow. The present findings are also reported by Vijay *et al.*, (2016) in sweet orange.

On the basis of obtained experimental findings, it can be concluded that among different treatments of integrated nutrient management, application of T_{12} 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$+2g $FeSO_4$ + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water was found to be the best in terms of maximum highest number of fruits per tree (248), highest number of fruits (248 fruits/plant) and fruit yield (41.03 kg/tree) Juice (56.08%), TSS (11.60 ^{0}Brix), acidity (0.78 %) and Vitamin C (58.04 mg/100ml) is the best doses among all the treatment combinations for sweet orange fruit crop. Therefore, application of this dose of micronutrient combination is highly recommended to enhance growth of trees and consequently produce high yield of good quality fruits. Hence, these treatment combinations are recommended particularly in northern area of Gwalior, Madhya Pradesh.

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How to cite this article:

Purnima Singh Sikarwar and Tomar, K.S. 2018. Effect of Micronutrients on Growth, Yield and Quality Parameters of Sweet Orange (*Citrus sinensis* L.) cv. Mosambi. *Int.J.Curr.Microbiol.App.Sci.* 8(11): 2524-2531. doi: https://doi.org/10.20546/ijcmas.2019.811.291