Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 2217-2219
Received: 05-01-2018
Accepted: 06-02-2018

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Nutrient management study in sweet orange (*Citrus sinensis* L) cv. mosambi

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Abstract
Effect of micronutrients on growth, yield and quality parameters of sweet orange was studied at Experimental field of department of Horticulture, Collage of Agriculture, RVSKVV, Gwalior (M.P.). Foliar application of 4g $CuSO_4$ (Copper sulfate)+ 2g $FeSO_4$ (Ferrous sulfate), + 2g Borax+ 4g $ZnSO_4$ (Zinc sulfate) + 4g $MgSO_4$ (Magnesium sulphate) + 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 Yield per tree (41.03 kg), Number of fruits/tree (248), Fruit weight (167 g), Fruit length (11.8 cm), Fruit diameter (21.8 cm) and good quality fruits Juice (56.08 %) (Titratable 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.

Keywords: sweet orange, micronutrients, quality, ascorbic acid, fruit weight

Introduction
Citrus fruits hold an important place in the economy of the country and these fruits form the third largest fruit industry NHB database (2016) [10]. These 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 (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) [5]. Citrus occupies an important place in the fruit industry, but yield levels of citrus orchards are still very low Srivastava and Singh (2009) [15]. Out of many factors, poor nutrient status of the soil as well as malnutrition is considered to be the major factors responsible for citrus decline and low yield. 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) [7]. Fertilizer is one of the major inputs accounting for nearly one-third of the cost of cultivation and its production consumes a lot of energy used in agriculture. 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) [14]. The new thinking about the soil management technologies needed for the continuous enhancement of the productivity, sustainability of land, arresting the process of land degradation, accelerating the process of land degradation, accelerating the rate of reclamation and restoration of the productivity of lands which have degraded in the past (Khehra and Bal, 2014) [8]. 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 CuSO4 (Copper sulfate) + 2g FeSO4 (Ferrous sulfate), + 2g Borax+ 4g ZnSO4 (Zinc sulfate) + 4g MgSO4 (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 include: T_0 -Water spray + 600:200:300(RDF of NPK g /tree), 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 FeSO4 + 2gBorax + 4g $ZnSO_4$+ 4g$MgSO_4$ + 10g lime per liter water +RDF of N:P:K g/tree, T_5 -4g $CuSO_4$ +2g FeSO4,+2gBorax+4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water +RDF of N:P:K g/tree, T_6 -4g $CuSO_4$ + 2g FeSO4 + 2gBorax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water +RDF of N:P:K g/tree, T_7 -600:400:300 (N:P:K g/tree) + 4g $CuSO_4$+2g FeSO4 + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water, T_8 -600:400:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g FeSO4 + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water, T_9 -600:400:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g FeSO4 + 2g Borax + 4g $ZnSO_4$+ 4g$MgSO_4$ + 10g lime per liter water, T_{10} - 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$+ 2g FeSO4 + 2g Borax+ 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water, T_{11} - 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$+ 2g FeSO4 + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water, T_{12} -600:500:300 (N:P:K g/tree) + 4g $CuSO_4$+2g FeSO4 + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water, T_{13} -600:600:300 (N:P:K g/tree) + 4g $CuSO_4$ +2g FeSO4,+ 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water, T_{14} - 600:600:300 (N:P:K g/tree) + 4g $CuSO_4$ +2g FeSO4 + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water, T_{15} -600:600:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g FeSO4 + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water. 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. 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 fruit quantity parameters like 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 1. Data recorded has revealed that phosphorus with soil application and micronutrients levels have significant effect on different yield and quality parameters. The maximum fruit weight (168g) was recorded in T_{15} - 600:600:300 (N:P:K g/tree) + 4g $CuSO_4$ + 2g FeSO4 + 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 FeSO4 + 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) [11] and Boman, 2001 [3] and Rattanpal *et al.*, 2015 [12] 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) [16]. (Wei *et al.* (2002) [18].

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 FeSO4 + 2g Borax+ 4g $ZnSO_4$+ 4g$MgSO_4$+ 10g lime per liter water followed by T_{12} 600:500:300 + 4g $CuSO_4$ + 2g FeSO4 + 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) [13]. in Kinnow, Balal *et al.* (2011) [1] in acid lime and Mostafa and Saleh (2006) [9] 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) [6]. 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 FeSO4 + 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 FeSO4 + 2g Borax + 4g $ZnSO_4$ + 4g$MgSO_4$ + 10g lime per liter water (235 fruits/plant and 36.04 kg/tree). 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) [17] and Dalal *et al.* (2017) [4] 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 FeSO4 + 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 FeSO4 + 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) [2] in Washington Navel orange and Yaseen and Ahmad (2010) [19] in Kinnow. The present findings are also reported by Vijay *et al.* (2016) [16] in sweet orange.

Table 1: Effect of micronutrients on yield and quality parameters of sweet orange) cv. Mosambi

Treatments	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	147	08.6	19.5	142	20.87	1.09	09.02	47.37	46.33
T_1	152	09.5	20.0	190	34.97	0.86	10.34	53.52	52.01
T_2	159	10.6	20.7	214	37.11	0.82	10.68	54.77	54.42
T_3	164	11.2	21.5	215	33.34	0.90	10.26	52.02	50.04
T_4	148	08.8	19.7	168	22.07	0.97	09.07	52.78	51.91

T_5	150	09.4	19.9	165	25.96	1.01	10.03	49.14	47.56
T_6	160	10.9	20.9	170	30.12	0.95	10.18	50.56	48.43
T_7	153	09.7	20.2	235	35.33	0.84	10.41	54.30	52.48
T_8	154	10.3	20.4	232	36.97	0.83	10.55	54.39	53.02
T_9	159	10.5	20.8	233	38.05	0.81	10.75	55.25	56.55
T_{10}	165	10.8	21.0	241	38.81	0.81	11.01	56.36	57.73
T_{11}	164	11.1	21.3	243	40.94	0.79	10.87	56.24	57.04
T_{12}	167	11.8	21.8	248	41.03	0.78	11.60	56.08	58.04
T_{13}	167	13.1	22.2	234	34.38	0.93	10.29	52.54	51.23
T_{14}	166	12.4	21.9	230	33.16	0.88	10.21	51.35	49.15
T_{15}	168	13.5	22.4	235	36.04	0.87	10.33	53.02	52.77
F- test	S	S	S	S	S	S	S		S
S. Ed. (±)	02.13	03.95	01.48	01.07	01.01	0.32	0.43	0.26	0.411
C. D. at 5%	2.38	07.74	1.14	2.85	1.18	1.21	1.45	1.357	1.650

Conclusion

In view of the experimental results obtained during the present investigation, the treatment T_{12} 600:500:300 (N:P:K g/tree) + 4g $CuSO_4$+2g FeSO4 + 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 will improve yield and fruit quality in sweet orange of these micronutrients as a result of which the orchardist will be economically benefited. Hence, these treatment combinations are recommended particularly in northern area of Gwalior, Madhya Pradesh.

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