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Effect of micronutrients on fruit set, yield and quality of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi in the Gangetic alluvial region of West Bengal

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Abstract
The present investigation was carried out for two consecutive years of 2017 and 2018 at Horticulture Research Station, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia to study the effect of micronutrients on fruit set, yield and quality of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi in the Gangetic alluvial region of West Bengal. The experiment was laid out in RBD, replicated 3 times with seven treatments, *viz*., Boric acid @ 0.2 & 0.4%, Zinc sulphate ($ZnSO_4$) @ 0.3 & 0.6%; Copper sulphate ($CuSO_4$) @ 0.2 & 0.4% and control (water spray only) and imposed two times as foliar spray- 1st at onset of flowering and 2nd at 30 days after 1st spray on 4 years old sweet orange plants cv. Mosambi. The results revealed that, application of $ZnSO_4$ @ 0.6%, followed by $ZnSO_4$ @ 0.3% significantly improved fruit retention percent (20.43% and 18.46%, respectively) over control (12.35%). The highest fruit yield was obtained with foliar application of $ZnSO_4$ @ 0.6% (33.93 kg/ha), followed by $ZnSO_4$ @ 0.3% and Boric acid @ 0.4%. The application of $ZnSO_4$ @ 0.6% was found to be most effective in improving physico-chemical properties of fruits in terms of fruit size, Juice %, TSS (^{0}Brix), ascorbic acid content (mg/100g pulp). From this study, foliar spray of $ZnSO_4$ @ 0.6% at onset of flowering and 30 days after 1st spray was suggested for improvement of fruit set, fruit retention, yield and fruit quality of sweet orange cv. Mosambi grown in the Gangetic alluvial region of West Bengal.

Keywords: Sweet orange, Mosambi, micronutrients, fruit set, yield and fruit quality

Introduction
Citrus belonging to family Rutaceae, having somatic chromosome no. 18, is one of the choicest fruit with high consumer preference both as fresh fruit as well as for its refreshing processed juice. It is extensively grown in tropical and sub-tropical regions. The principle edible portion of a citrus fruit is the juice present in the juice vesicle. Mandarin, sweet orange and grape fruits are highly valued as table fruits. Sweet orange (*Citrus sinensis* Osbeck.) is one of the important commercial citrus species in terms of nutritional and antioxidant value. The juice contains: 8.36% total sugar,1.8% reducing sugar, 0.51% acidity and 46.5 mg ascorbic acid per 100 ml of juice (Shravan *et al.*,2018) [11]. Sweet orange is cultivated throughout India in an area of 179 thousand hectares with an annual production of 2876 thousand metric tonnes (Anon, 2018) [1]. Sweet orange occupies an important place in the fruit industry, but yield levels of citrus orchards are still very low (Srivastava and Singh, 2009) [12]. The productivity of sweet orange mainly depends on adequate supply of plant nutrients seems to be a very important factor in regulating cropping and influencing the quality of sweet orange. 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. In sweet orange, more than 85% flowers were dropped after bloom and only 0.5%-2% flowers set into mature fruits. Maximum fruit drop was observed in April-May and continued Upto June in Ambe Bahar, which ultimately resulted in less yield. Foliar application of mineral nutrients is a method for quick supply of the elements for the higher plants. This technique allows the plants to consume nutrients much faster than their uptake from soil by their roots. The micronutrients are required in small amounts, but play a great role in plant metabolism (Katyal, 2004; Kazi *et al*., 2012) [4, 5]. These are involved in the synthesis of many compounds essential for plant growth and productivity and act as activators for various enzymes and their deficiencies often limit crop productivity and quality. Foliar application of mineral nutrients is a method for quick supply of the elements for the higher plants. This technique allows the plants to consume nutrients much faster than their uptake from soil by their roots.

The micronutrients are required in small amounts, but play a great role in plant metabolism (Katyal, 2004; Kazi *et al*., 2012) [4, 5]. These are involved in the synthesis of many compounds essential for plant growth and productivity and act as activators for various enzymes and their deficiencies often limit crop productivity and quality. Foliar application of mineral nutrients is a method for quick supply of the elements for the higher plants. This technique allows the plants to consume nutrients much faster than their uptake from soil by their roots. Despite some shortcomings, it is regarded as the best method under certain conditions (Marschner and Marschner, 2012) [7]. Keeping in view the present investigation was planned to standardize the dosage of micronutrients to overcome the problem of fruit drop and inferior quality of sweet orange cv. Mosambi.

Materials and Method

The present investigation on the effect of micronutrients on fruit set, yield and quality of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi in the Gangetic alluvial region of West Bengal was carried out at Horticulture Research Station, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia, West Bengal, during the year 2016-2018. The location of experiment is situated at 9.75 m above mean sea level, latitude $22^0$56’10.90” N and longitude $88^0$30’31.55” E. The soil was loamy in texture and moderately fertile (Sand- 55.40%, Silt-23.00%, Clay- 21.60%) and field capacity (% v/v)- 26.37, pH- 6.80, available N- 0.06%, available P- 29 ppm, available K- 42 ppm and organic C- 0.65%. The experimental area belongs to sub-tropical humid climate under Gangetic new alluvial plains of West Bengal. The experiment was laid out in Randomized Block Design (RBD), replicated thrice with seven treatments (T_1- Boric acid @ 0.2%; T_2- Boric acid @ 0.4%; T_3- Zinc sulphate @ 0.3%; T_4- Zinc sulphate @ 0.6%; T_5- Copper sulphate @ 0.2%; T_6- Copper sulphate @ 0.4%; and T_9-Control as water spray only). The treatments were imposed for two times-1st at onset of flowering and 2nd at 30 days after 1st spray on 4years old plants. Recommended dose of fertilizer was applied, followed by irrigation. The data obtained from the experiment were analyzed statistically by the analysis of variance method for Randomized Block Design (RBD) Gomez and Gomez (1983) [2].

Results and Discussion

Results presented in Table 1 showed significant increase on yield characters of sweet orange cv. Mosambi *viz*., fruit set (%), average number of fruits per tree, fruit retention %, fruit weight and yield. An inquisition of the data in the study revealed that 0.6% $ZnSO_4$ [T_4] application resulted in increasing fruit set (%), average number of fruits per tree, fruit retention %, fruit weight and yield. The highest (28.17%) fruit set (%) was obtained from 0.6% $ZnSO_4$ [T_4] application, followed by 26.08% under the treatment 0.3% $ZnSO_4$ (T_3). Treatment with 0.6% $ZnSO_4$ [T_4] resulted in maximum number of fruits per tree (178.49), which was at par (176.21) with 0.3% $ZnSO_4$ [T_3]. The application of $ZnSO_4$ @ 0.6% [T_4] effectively influenced fruit drop (%) (79.27), followed by [T_3] 0.3% $ZnSO_4$ (80.00) in comparison to control (87.16). Maximum fruit retention %, fruit weight and yield were obtained by the application of [T_4] $ZnSO_4$ @ 0.6% (20.53%, 188.76g and 33.93 kg per tree, respectively), whereas control plants showed minimum fruit retention % (12.35%), fruit weight (173.13g) and yield (28.42kg per tree). Zinc is the activator of various enzymes, involved in protein synthesis and has direct effect on the level of auxin in plants (Ram and Bose, 2000) [9], leading to prevention of abscission layer formation, thereby diminishing the drop rate. Zinc also assists the translocation of metabolites from source to sink, which leads to retention of more number of fruits on tree. Reduction in the fruit drop and increase in the fruit retention due to application of micronutrients might have increased the number of fruits per tree, thereby increase in yield in the present investigation. These results are in line with the finding of Singh and Misra (1986).

Table 1: Effect of micronutrients on yield and yield attributing characters of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi

Treatments	Fruit set (%)	Average no. of fruits /tree	Fruit drop (%)	Fruit retention (%)	Fruit weight (g)	Yield (kg/tree)
T_1	23.50	167.13	84.75	15.24	179.21	30.45
T_2	23.92	171.65	83.18	16.75	182.38	31.32
T_3	26.08	176.21	80.00	18.46	185.43	32.10
T_4	28.17	178.49	79.27	20.53	188.76	33.93
T_5	23.18	171.10	85.32	14.81	176.00	29.75
T_6	24.26	173.27	84.53	15.47	180.52	31.27
T_7	22.38	163.00	87.16	12.35	173.13	28.42
SEm (±)	0.35	2.18	1.04	0.20	2.28	0.37
CD (5%)	1.10	6.77	3.24	0.64	7.10	1.16

*T_1-Boric acid @ 0.2%; T_2-Boric acid @ 0.4%; T_3-Zinc sulphate @ 0.3%; T_4- Zinc sulphate @ 0.6%; T_5- Copper sulphate @ 0.2%; T_6- Copper sulphate @ 0.4% and T_7- control (water spray).

The observations recorded on physico-chemical quality (Table 2) such as fruit length and breadth, juice %, total soluble solids (TSS), acidity, total sugar and ascorbic acid (vitamin C) content of fruit indicated that the micronutrient treatments significantly improved the fruit size as well as fruit quality parameters, with respect to increased juice %, TSS, total sugar and ascorbic acid content but reduced the acidity percentage of fruit as compared with no micronutrient treatment. Maximum fruit length (69.56 mm) and fruit breadth (72.01mm) were observed on the plants treated with [T_4] $ZnSO_4$ @ 0.6%, which were statistically at par with [T_2] Boric acid @ 0.4% (67.32 mm) and [T_3] $ZnSO_4$ @ 0.3% (71.54 mm), respectively. It appears that micronutrient zinc rapidly increases the photosynthetic activity and translocation of photosynthates, resulting in enlargement of fruit size (Graham *et al*., 2000) [3]. The application of 0.6% $ZnSO_4$ [T_4] resulted in highest juice % (49.27%), TSS (10.57^0 Brix), ascorbic acid content (55.15 mg 100g pulp^{-1}) and minimum acidity (0.58%) of the fruit. Whereas, minimum TSS (8.03^0 Brix) and ascorbic acid content (45.33mg per 100g pulp) and maximum acidity (0.66%) of fruit were obtained from the control plants [T_7].

Table 2: Effect of micronutrients on physico-chemical properties of sweet orange (*Citrus sinensis* Osbeck) cv. mosambi.

Treatments	Fruit length (mm)	Fruit breadth (mm)	Juice (%)	TSS (^{0} Brix)	Total Sugar (%)	Reducing Sugar (%)	Acidity (%)	Ascorbic acid content (mg/100 g)
T_1	64.10	66.67	44.60	9.78	4.85	2.72	0.61	48.67
T_2	67.32	68.32	46.47	10.21	4.95	2.81	0.62	51.50
T_3	67.01	71.54	48.78	10.42	4.76	2.72	0.60	53.59
T_4	69.56	72.01	49.27	10.57	5.22	3.13	0.58	55.15
T_5	62.73	64.86	41.82	8.36	4.65	2.42	0.63	47.96
T_6	63.44	65.20	43.59	9.18	4.75	2.64	0.63	52.42
T_7	59.85	62.00	39.67	8.03	4.35	2.48	0.66	45.33
SEm (±)	1.17	0.78	0.54	0.13	0.02	0.06	0.01	0.74
CD (5%)	3.64	2.44	1.68	0.41	0.06	0.19	0.03	2.29

*T_1-Boric acid @ 0.2%; T_2-Boric acid @ 0.4%; T_3-Zinc sulphate @ 0.3%; T_4- Zinc sulphate @ 0.6%; T_5- Copper sulphate @ 0.2%; T_6- Copper sulphate @ 0.4% and T_7- control (water spray).

The increase in juice per cent of the fruit due to application of micronutrients might be due to role of zinc in plant metabolism. Zinc regulates the semi permeability of cell wall by which more water was mobilized into the fruits, thereby increasing the percentage of juice (Sharma *et al*., 2003) [10]. Lower acidity in fruits might have resulted due to higher accumulation of sugars, better translocation of sugars into fruit tissues and conversion of organic acids into sugars (Kumar *et al*., 2015) [6]. These biological processes are supposed to be related with enzymatic activities and carbohydrate metabolism. As a component of proteins, zinc acts as a functional, structural, or regulatory cofactor of a large number of enzymes and involved in carbohydrate metabolism (Mousavi *et al*., 2013) [8]. Our present finding regarding effect of micronutrients on fruit quality confirms the earlier findings by Chaturvedi *et al*. (2005) in strawberry and Arora and Singh (1970) in guava.

Conclusion
On the basis of the results obtained in the present investigation, the inference can be drawn that different levels of micronutrients had considerable effect on fruit set %, yield and qualitative parameters of sweet orange cv. Mosambi. From this study, foliar spray of $ZnSO_4$ @ 0.6% at onset of flowering and 30 days after 1st spray was suggested for improvement of fruit set %, yield and fruit quality of sweet orange cv. Mosambi grown in the Gangetic alluvial region of West Bengal.

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