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Effect of exogenous application of micronutrients on growth and yield of sweet orange CV. Blood Red

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Abstract
An experiment was conducted during 2016-17 and 2017-18 to assess the performance of sweet orange cv. Blood Red to foliar application of micronutrients. The study comprised of thirteen treatments *viz*., $ZnSO_4$ 0.25%, $ZnSO_4$ 0.50%, $ZnSO_4$ 1.00%, $FeSO_4$ 1.5%, $FeSO_4$ 2.0%, $FeSO_4$ 2.5%, $MnSO_4$ 0.25%, $MnSO_4$ 0.50%, $MnSO_4$ 1.00%, H_3BO_3 0.1%, H_3BO_3 0.2%, H_3BO_3 0.3% and Control (No micronutrients). The plants were sprayed with micronutrients on first week of april and first week of july. All the micronutrients treated plants produced higher magnitude of growth and fruit yield over control. However, foliar application of $ZnSO_4$ 1.00% produced significantly higher number of fruits (256.99), fruit weight (195.55g), yield (50.25 kg/plant) and increased the plant height by (9.62%) and spread EW (10.78%) and NS (10.32%).

Keywords: Foliar application, micronutrients, manganese sulphate, ferrous sulphate, boric acid, zinc sulphate

Introduction
Citrus is the leading group of fruit crops in the world, mainly grown in Brazil, China, India, United States and Argentina. The genus *Citrus* includes more than 159 species belonging to order Sapindales, family Rutaceae, sub-family Aurantioideae, tribe *Citrae* and subtribe-*Citrinae* (Swingle, 1943) [11]. Citrus is a commercially important fruit crop of India and grown across its length and breadth with a production of 11419 thousand MT from an area of 985 thousand hectares during year of 2016-17 (Anonymous, 2017) [2]. Sweet orange (*Citrus sinensis* (L.) Osbeck) has been reported to be originated in Southern China and it was introduced to India during thirteenth century (Swingle, 1943; Webber, 1948) [11, 13]. It is the second largest citrus fruit, cultivated in tropical and subtropical regions of the country. In India, sweet orange is mainly cultivated in Andhra Pardesh, Maharashtra, Karnataka, Punjab, Rajasthan and Haryana. The survey conducted by Ahlawat *et al.* (1982) [1] and Chauhan *et al*. (1984) [3] revealed that the entire citrus belt of Haryana is deficient in various nutrients which needs immediate attention for its rectification. The micronutrients are needed in smaller amounts as compared to primary nutrients but these are equally important for plant metabolism (Katyal, 2004) [6]. In semi-arid states like Haryana, the physiological availability of these trace elements to plants absorption is hindered due to soil alkalinity, lower organic matter content and competition from other nutrients. Foliar application of micronutrients like Zn, Cu, Mn, B and Fe has advantages over soil application because of high effectiveness, rapid plant response, convenience and elimination of toxicity symptoms brought about by excessive soil accumulation of such nutrients (Obreza *et al.*, 2010) [9]. The beneficial effects of amelioration of zinc, iron, manganese and boron deficiencies by foliar application have been documented by previous studies (Hippler *et al*., 2015 and Kaur *et al.*, 2015) [5, 7]. Keeping in view that the micronutrients increases the productivity of sweet orange, the present experiment was undertaken.

Material and Methods
The present investigation was carried out on fifteen years old sweet orange cv. Blood Red trees planted at a spacing of 6m X 6m in experimental orchard of Department of Horticulture, CCS HAU, Hisar situated at 215.2 m above mean sea level with coordinates of 29º10′ N latitude and 75º46′ E longitudes, during the year 2016-17 and 2017-18. The experiment comprised of thirteen treatments. Treatments were allocated in randomized block design (RBD) with three replications in each treatment. The study was comprised of thirteen treatments *viz*., $ZnSO_4$ 0.25%, $ZnSO_4$ 0.50%, $ZnSO_4$ 1.00%, $FeSO_4$ 1.5%, $FeSO_4$ 2.0%, $FeSO_4$ 2.5%, $MnSO_4$ 0.25%, $MnSO_4$ 0.50%, $MnSO_4$ 1.00%, H_3BO_3 0.1%, H_3BO_3 0.2%, H_3BO_3 0.3% and Control

(No micronutrients). For foliar application, spray solutions were prepared by thoroughly dissolving in appropriate quantity of water. The treatments were given twice; first week of april and first week of july. The recommended standard package of practises and plant protection measures were adopted to keep the plants in good health. The plant height and spread were recorded during start of experiment and after harvest. The plant height was measured with the help of measuring pole up to the maximum point of height, ignoring only the off type shoots, if any and expressed in percent increase. The plant spread was measured as distance between point to which most of the branches of the tree had grown in the east-west and north-south direction and expressed as percent increase. The fruit weight, number of fruits per tree and yield were recorded at harvesting time. Five randomly selected fruits from different position of the tree were picked and weighed on top pan electric balance. The average weight was calculated by dividing the total fruit weight by total number of fruits taken and expressed in gram (g). The number of fruits per tree was calculated by visually dividing the canopy of the tree into two equal halves and then counting the number of fruits on both halves and total number of fruits is obtained by adding the number of fruits of two halves. The total fruit yield per tree was calculated by multiplying total number of fruits per tree with the average fruit weight and expressed in (kg/tree).

Results and Discussion

Table 1: Effect of foliar application of micronutrients on percent increase in plant spread and height of sweet orange cv. Blood Red

Treatments	Spread		Height	Spread		Height
	EW	NS		EW	NS	
	2016-17			2017-18		
$ZnSO_4$ 0.25%	9.98	9.65	8.96	9.89	9.51	9.26
$ZnSO_4$ 0.50%	10.38	10.01	9.32	10.18	9.81	9.56
$ZnSO_4$ 1.00%	10.78	10.32	9.62	10.52	10.17	9.87
$FeSO_4$ 1.5%	8.98	8.72	8.08	8.99	8.71	8.37
$FeSO_4$ 2.00 %	9.34	8.98	8.32	9.32	8.96	8.61
$FeSO_4$ 2.5%	9.69	9.29	8.58	9.61	9.23	8.89
$MnSO_4$ 0.25%	8.15	7.84	7.21	8.16	7.87	7.66
$MnSO_4$ 0.50%	8.42	8.12	7.52	8.44	8.21	7.91
$MnSO_4$ 1.00%	8.71	8.46	7.78	8.75	8.43	8.16
H_3BO_3 0.1%	7.30	7.12	6.50	7.26	7.02	6.90
H_3BO_3 0.2%	7.56	7.32	6.77	7.54	7.28	7.12
H_3BO_3 0.3%	7.83	7.56	6.98	7.87	7.64	7.40
Control	7.22	6.89	6.34	7.18	6.86	6.78
C.D. at 5%	0.22	0.17	0.19	0.23	0.18	0.19

The data on effect of foliar application of micronutrients on percent increase in plant spread and height of sweet orange cv. Blood Red is presented in Table 1. All micronutrient treatments showed significant increase in plant spread and height during both the years. In year 2016-17, maximum percent increase in plant spread EW (10.78%) and NS (10.32%) was recorded under $ZnSO_4$ 1.00% followed by $ZnSO_4$ 0.50% (10.38 and 10.01%) and minimum (7.22 and 6.89%) in control, respectively. Maximum percent increase in plant height (9.62%) was recorded under $ZnSO_4$ 1.00% followed by $ZnSO_4$ 0.50% (9.32%) and minimum (6.34%) in control. Similar trends were recorded during the year 2017-18 with all the parameters. The increase might be due to synthesis of tryptophan with foliar application of micronutrients, which serves as precursor for auxin synthesis and auxin promotes growth and development. The results are in close agreement with Razzaq *et al.* (2013) [10] and Ullah *et al*. (2012) [12] in kinnow mandarin.

Table 2: Effect of foliar application of micronutrients on fruit weight, number of fruits and yield of sweet orange cv. Blood Red

Treatments	Fruit Weight (g)	Number of fruits	Yield (kg/ plant)	Fruit Weight (g)	Number of fruits	Yield (kg/ plant)
	2016-17			2017-18		
$ZnSO_4$ 0.25%	189.35	248.13	46.98	191.32	249.89	47.81
$ZnSO_4$ 0.50%	192.59	253.89	48.90	194.02	253.66	49.22
$ZnSO_4$ 1.00%	195.55	256.99	50.25	198.88	256.66	51.04
$FeSO_4$ 1.5%	179.89	239.32	43.05	182.87	239.76	43.84
$FeSO_4$ 2.00 %	183.56	241.89	44.40	185.46	242.69	45.01
$FeSO_4$ 2.5%	186.66	245.10	45.75	188.12	246.13	46.30
$MnSO_4$ 0.25%	171.95	230.88	39.70	174.54	231.59	40.42
$MnSO_4$ 0.50%	173.58	234.03	40.62	176.69	234.71	41.41
$MnSO_4$ 1.00%	175.88	236.72	41.63	179.42	237.46	42.61
H_3BO_3 0.1%	166.12	221.98	36.88	168.46	222.96	37.56
H_3BO_3 0.2%	168.10	224.95	37.81	170.58	225.98	38.55
H_3BO_3 0.3%	170.04	227.88	38.75	172.22	228.26	39.31
Control	164.45	216.96	35.68	166.88	218.58	36.48
C.D. at 5%	1.32	2.42	0.78	1.44	2.02	0.56

The perusal of data presented in Table 2 revealed that different concentrations of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and H_3BO_3 significantly affected fruit weight, number of fruits and yield of sweet orange cv. Blood Red during both the years. In year 2016-17, maximum fruit weight (195.55) was recorded with $ZnSO_4$ 1.00% followed by $ZnSO_4$ 0.50% (192.59) and minimum (164.45) in control. The maximum number of fruits (256.99) were observed in $ZnSO_4$ 1.00% followed by $ZnSO_4$

0.50% (253.89) and minimum (216.96) in control, respectively. The yield was found highest (50.25) with $ZnSO_4$ 1.00% followed by $ZnSO_4$ 0.50% (48.90) and lowest (35.68) in control. Similar trend was observed in next year for all the parameters. The reason behind improvement in fruit yield may be due to improved reproductive capacity of plants *viz*., maximum number of flowers, fruit set and fruit retention as a consequence of synthesis of more growth promoting substances (auxins & gibberellins) and less abscisic acid due to enhanced absorption and translocation of micronutrients when applied as a foliar spray (Bahadur *et al*., 1998 in mango and Kaur *et al*., 2016 in kinnow) [7, 4].

In conclusion, all the micronutrients treated plants produced higher magnitude of growth and fruit yield. However, foliar application of $ZnSO_4$ 1.00% found most effective in increasing plant height, spread, fruit weight, number of fruits per tree and yield.

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