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Effect of foliar application of manganese and ferrous on vegetative growth, fruit yield and quality of mandarin (*Citrus reticulata* Blanco) *cv.* Kinnow

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Abstract

A field experiment was conducted at Krishi Vigyan Kendra, Chittorgarh and Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur during 2016-2017. The results revealed that all treatments (except T_1) significantly increased the vegetative growth, fruit yield and quality attributes. The maximum increase in shoot length (78.87 %), canopy area E-W (4.75 %), canopy area N-S (4.27 %), and tree height (9.49 %) recorded in treatment T_9 (1.0 % $MnSO_4$ + 1.0 % $FeSO_4$) over the treatment T_1(control). The maximum fruit diameter (7.96 cm & 6.37 cm), fruit weight (170.13 g), fruit retention (69.74 %), yield plant^{-1} (78.23 kg) was recorded in treatment T_8 (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$) closely followed by treatment T_9 and minimum in treatment T_1(control). The maximum TSS (10.93 ^{o}B), TSS:Acid (14.39), ascorbic acid content (27.08 mg/100 g), juice content (41.05 %), and minimum acidity (0.76 %) was recorded in treatment T_8 (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$) closely followed by treatment T_9 compare to control.

Key words: Ferrous, foliar application, fruit yield, manganese, quality

Introduction

Mandarin (*Citrus reticulate* Blanco) is most common among citrus fruits grown in India. It is originated from South Eastern Asia (China). Major producing states of mandarin are Punjab, Madhya Pradesh, Andhra Pradesh, Maharashtra, Rajasthan, Assam, and Karnataka. It is grown widely in many districts of Rajasthan particularly in Jhalawar, Sriganganagar, Hanumangarh, Bhilwara, Chittorgarh, Kota and Baran (Anon. IHD, 2014).

Kinnow Mandarin is one of the most important and finest variety of mandarin grown especially in north India. It is the first generation hybrid of king mandarin (*C. nobilis* Lour) and willow leaf mandarin (*C. deliciosa* Tenora) (Sharma *et al.*, 2007). It has great importance among north Indian growers and a large acreage is being brought under its cultivation particularly in Punjab, Haryana, Rajasthan and Himachal Pradesh (Khurdiya and Lotha., 1994).Its pulp is used to make delicious desserts, jams and sauces and the skin can be used to make cosmetics and essence. It has lycopene and flavonoids, which are known to reduce prostate and breast cancer, viral affects and cholesterol level and improve capillary activity. It is rich in fiber, which is important for production and maintenance of collagen (Sharma *et al.*, 2007).

Productivity of citrus trees depends on many abiotic (climate, site, soil, nutrition, and irrigation management) and biotic (rootstock, cultivar, insect pest and disease management) factors. Among them, adequate supply of micronutrients is most important to produce good quality fruits (Babu and Yadav, 2005). Generally, farmers are not applying nutrients in balanced quantity, and therefore, some healthy orchards are turning into unproductive orchards with poor yield and poor quality of the produce. The fruit grower's mainly apply macro nutrients (N, P and K) in kinnow plants and give little attention towards micronutrients. High pH and calcareous soil hinders the availability of micronutrients applied through soil placement. Therefore, kinnow plants show micronutrient deficiency symptoms like interveinal chlorosis, reduced growth of young shoot and mottling of leaves (Sharma *et al.*, 1990). Keeping in view of the importance of kinnow mandarin, the study has been carried out to see the effect of micronutrients on its vegetative growth, fruit yield and quality.

Material and Methods

The experiment was carried out at Krishi Vigyan Kendra, Chittorgarh and Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur during 2016-17. Eight year old, twenty seven uniform and healthy kinnow mandarin trees grafted on rough lemon (*Citrus jambhiri* L.) root stock planted according to square system of layout at 5 m x 5 m distance and grown under uniform soil conditions were selected. The experiment consisted of 9 treatments comprising T_1 - (water spray), T_2 - (0.5% Manganese sulphate), T_3 - (1.0% Manganese sulphate), T_4 - (0.5% Ferrous sulphate), T_5 - (1.0 % Ferrous sulphate), T_6 - (0.5 % $MnSO_4$ + 0.5 % $FeSO_4$), T_7 - (0.5 % $MnSO_4$ + 1.0 % $FeSO_4$), T_8 - (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$), T_9- (1.0 % $MnSO_4$ + 1.0 % $FeSO_4$) applied at fruit set and pea size stage of fruits through foliar spray. These treatments were evaluated under RBD replicated thrice with adopting uniform cultural schedules during the experimentation.

The vegetative growth parameters like shoot length, canopy area, stem girth and tree height were observed before the application of treatment and after the application of treatment and expressed in percent increase. For shoot length, five newly emerged uniform sized shoots were randomly selected and tagged in each treatment and measured with the help of meter scale. Stem girth was measured on ½ feet upper portion from ground level with the help of meter scale and tree height was measured from the base of stem to first newly emerged leaf of the growing shoot with the help of meter scale and expressed in percent increase. The fruit diameter (equatorial and polar) was measured by the help of vernier caliper. Fruit weight was measured with the help of an electronic balance. The per cent fruit retention was calculated on the basis of initial number of fruit set and fruits harvested at maturity. The yield plant^{-1}was recorded on the basis of mature fruits were harvested periodically in each treatment separately and the weight was recorded with the help of electronic balance then the total yield (kg/plant) was calculated. The quality attributes such as TSS were determined by using a hand refractometer, acidity was determined by diluting the known volume of clean juice against standard N/10 sodium hydroxide solution using phenolphthalein as an indicator (A.O.A.C., 2007).TSS:Acid was calculated by dividing the value of total soluble solids content (%) by per cent acidity. Ascorbic acid was determined by diluting the known volume of clean juice and titrated against 2, 6-dichlorophenol indophenol dye solution.

Results and Discussion

Effect of manganese and ferrous on vegetative growth

The data on vegetative growth attributes such as

Table 1. Effect of manganese and ferrous on vegetative growth attributes of kinnow mandarin

Treatments	Shoot length (cm)		Canopy spread (m) E-W		Canopy spread (m) N-S		Stem girth (cm)		Tree height (m)	
	B.T.	A.T. (%)	B.T.	A.T. (%)	B.T.	A.T (%)	B.T.	A.T. (%)	B.T.	A.T. (%)
T_1	44.8	70.25 (56.80)	4.47	4.61 (3.24)	4.48	4.61 (2.99)	52.00	56.20 (8.12)	4.25	4.52 (6.51)
T_2	37.2	64.55 (73.52)	4.39	4.56 (4.00)	4.24	4.39 (3.72)	48.60	53.00 (9.25)	4.03	4.35 (8.13)
T_3	47.8	79.05 (66.31)	4.54	4.73 (4.27)	4.58	4.74 (3.58)	59.30	64.00 (7.92)	4.22	4.57 (8.34)
T_4	37.2	64.10 (72.31)	4.34	4.50 (3.77)	4.58	4.73 (3.42)	53.60	58.00 (8.20)	4.31	4.60 (6.93)
T_5	43.2	73.20 (69.44)	4.07	4.25 (4.49)	4.17	4.34 (4.14)	49.00	53.50 (9.31)	3.86	4.20 (8.96)
T_6	46.2	78.30 (69.48)	4.53	4.71 (4.01)	4.34	4.51 (4.07)	48.30	53.00 (9.73)	4.42	4.78 (8.21)
T_7	44.4	77.10 (73.64)	4.63	4.81 (4.08)	4.31	4.49 (4.22)	34.00	37.30 (9.83)	4.26	4.64 (9.01)
T_8	43.4	77.00 (77.41)	4.69	4.88 (4.24)	4.34	4.52 (4.26)	57.60	64.60 (8.68)	4.29	4.68 (9.20)
T_9	46.4	83.00 (78.87)	4.37	4.57 (4.75)	4.40	4.58 (4.27)	56.60	61.80 (9.18)	4.52	4.93 (9.49)
SEm±		1.86		0.10		0.09		0.47		0.20
CD (p=0.05)		5.58		0.31		0.28		NS		0.61

Table 2. Effect of manganese and ferrous on fruit yield attributes of kinnow mandarin

Treatments	Fruit diameter (cm)		Fruit weight (g)	Fruit retention (%)	Yield plant^{-1}(kg)
	Equatorial	Polar			
T_1	6.49	5.51	134.88	58.00	62.26
T_2	7.05	5.97	139.85	68.42	63.49
T_3	6.74	5.70	143.76	67.97	65.02
T_4	6.97	5.59	150.86	67.70	69.06
T_5	6.67	5.90	148.31	68.50	67.22
T_6	7.31	6.08	151.81	67.65	69.68
T_7	7.37	5.97	159.81	69.00	75.07
T_8	7.96	6.37	170.13	69.74	78.23
T_9	7.45	6.09	164.27	68.80	77.26
SEm±	0.18	0.16	5.14	1.64	2.65
CD (p=0.05)	0.54	0.48	15.41	4.91	7.93

shoot length (cm), canopy area (m), stem girth (cm) and tree height (m) were recorded and presented in Table 1. The highest increase in shoot length (78.87 %), canopy area E-W (4.75 %), canopy area N-S (4.27 %), and tree height (9.49 %) were recorded in treatment T_9 (1.0 % $MnSO_4$ + 1.0 % $FeSO_4$) over the treatment T_1(control). It might be due to that manganese and ferrous are major contributor to various biological systems including photosynthesis, respiration, and nitrogen assimilation. Further, involvement of Mn as activates decarboxylase, dehydrogenase and oxidase enzymes in plants which are important in photosynthesis, nitrogen metabolism and nitrogen assimilation. The greater production of photosynthesis increase the vegetative growth attributes of plant. Results are similar to those achieved by El-Saida (2001) in Washington navel orange, Ingle *et al.* (2002) in acid lime and Sarolia *et al*. (2007) in guava.

Effect of manganese and ferrous on fruit yield attributes

The Table 2 showed that maximum fruit diameter (7.96cm & 6.37 cm), fruit weight (170.13 g), fruit retention (69.74 %),yield plant^{-1} (78.23 kg), were recorded in treatment T_8 (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$) closely followed by treatment T_9 over the treatment T_1(control). It might be due to that manganese is involved in photosynthesis, efficient use of N, protein metabolism and enzyme activation. Iron acts as a catalyst in oxidation/reduction reactions, involved in respiration, photosynthesis and the reduction of nitrate and sulfate. It is also a cofactor in many enzymes. These are leads to more fruit retention and yield. The present results were supported by the findings obtained by Ghosh and Besra (2000) revealed that zinc + boron + iron influenced highest fruit retention (78.6 %) and fruit plant^{-1} (205) in sweet orange cv. Mosambi. Mn is required in the process of photosynthesis (Mengel and Kirkby, 1987) and Fe plays a key role in several enzyme-systems, in which haeme or haemin is the prosthetic group (Khurshid *et al*., 2008).

Effect of manganese and ferrous on fruit quality

Table 3 revealed that maximumTSS (10.93 ^{o}B), TSS:Acid (14.39), ascorbic acid content (27.08 mg/100 g), juice content (41.05 %), and minimum acidity (0.76) was recorded in treatment T_8 (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$) closely followed by treatment T_9 over the treatment T_1(control). The improvement in quality of fruit is might be due to the fact that nutrients directly play an important role in plant metabolism. Manganese activates decarboxylase, dehydrogenase and oxidase enzymes in plants which are important in photosynthesis, nitrogen metabolism and nitrogen assimilation. It is an essential element in respiration and involved in the destruction or oxidation of indole-3-acetic acid (Singh, 2014). The decrease in fruit acidity owing to the application of their treatments might be because of the acids that might have been quickly converted into sugars and its derivatives. The increase in juice percentage due to manganese and ferrous application can be attributed because it might have regulated the water relations in plants. The augmentation of ascorbic acid percentage of kinnow fruit might have been due to higher synthesis of nucleic acid, on account of maximum availability of plant metabolism. The findings of present study are in accordance with those of Ghosh and Besra (2000) in sweet orange cv. Mosambi, Monga and Josan (2000) in kinnow mandarin, Perveen and Haffez-ur-Rehman (2000) in sweet orange, Aboutalebi and Hassanzadeh (2013) in sweet lime and Kaur *et al.* (2015) in kinnow mandarin for various qualities attributes.

Table 3. Effect of manganese and ferrous on fruit quality of kinnow mandarin

Treatments	TSS (^{0}Brix)	Acidity (%)	TSS:Acid	Ascorbic acid (mg/100 g)	Juice content (%)
T_1	9.90	0.90	11.00	19.81	35.96
T_2	10.10	0.89	11.34	23.42	36.10
T_3	10.80	0.89	12.13	21.62	37.00
T_4	10.50	0.78	13.45	21.62	37.06
T_5	10.70	0.88	12.15	23.42	38.47
T_6	10.70	0.83	12.89	25.22	38.63
T_7	10.80	0.84	12.85	27.02	39.55
T_8	10.93	0.76	14.39	27.08	41.05
T_9	10.90	0.77	14.15	27.02	40.88
SEm±	0.20	0.01	0.14	0.35	0.60
CD (p=0.05)	0.60	0.04	0.43	1.06	1.81

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