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Effect of Mn and Fe on Yield, Fruit Quality and Economic Feasibility of Mandarin (*Citrus reticulata* Blanco) cv. Kinnow

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A B S T R A C T

The experiment was carried out at KVK, Chittorgarh, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan during the year 2016-17. 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 fruit through foliar spray. Among the treatments, treatment T_8 (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$) was best for higher yield and produced best quality fruits. As far as relative economics of treatments is concerned highest B:C (4.68) was obtained in T_8 (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$) and this treatment gave the highest net returns (Rs. 348114 ha^{-1}) with maximum yield/ ha.

Introduction

Kinnow Mandarin" is one of the most important and finest variety of mandarin especially grown 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 was developed by H.B. Frost at Regional Fruit Station, California, USA. It was first introduced in India during 1959's at the Fruit Experiment Station, Punjab and Agriculture College and Research Institute, Lyallpur by S. Bhadur Lal Singh (Singh *et al*., 1978). Since then it has assumed 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).

Kinnow is very useful citrus fruit and rich source of vitamin C (63 mg/100ml) to fulfill daily need. 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 flavonoides, 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).

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 shortcoming, it is regarded as the best method under certain conditions (Marschner and Marschner, 2012). The micronutrients are required in small amount but play a great role in plant metabolism (Katyal, 2004; Kazi *et al*., 2012). These are involved in the synthesis of many compounds essential for plant growth and productivity and act as activators for various enzymes. Manganese is required in the process of photosynthesis (Mengel and Kirkby, 1987) and Ferrous plays a key role in several enzyme-systems, in which haeme or haemin is the prosthetic group (Khurshid *et al*., 2008).Foliar application of micro and macronutrient like Zn, Cu, Mn, B, Fe and K_2Ohas 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).

Recently numerous complaints have been received from kinnow growers regarding poor fruit set, uneven fruiting, poor quality and low yield of fruits. In different commercially growing regions of Rajasthan, farmers are not applying nutrients in proper quantity, and therefore, some healthy orchards are turning into unproductive orchards with poor yield and poor quality of the produce. The efficient use of nutrients is essential because of their high cost as well as concerns regarding pollution. In Southern Rajasthan, the fruit growers generally apply major nutrients (N, P and K) in kinnow plants and give little attention towards micronutrients. Due to high pH and calcareous soil in this region, hinders the availability of the basal applied micronutrients. 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 in the Southern- Rajasthan, the study has been carried out to see the effect of Mn and Fe on it fruit yield, quality and economic feasibility.

Materials 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 (king x willow leaf) 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 fruit through foliar spray. These treatments were evaluated under RBD replicated thrice with adopting uniform cultural schedules during the experimentation.

The fruit yield parameters *viz.* fruit volume was measured by water displacement method. For this purpose, the fruits were dipped in a fully filled jar of water and the water displaced

by the fruits was collected and measured by graduated glass jar and the recorded readings was averaged.For fruit retention, total numbers of fruits set on the plant were counted, then the total numbers of fruits were again counted at the time of fruit maturity. The per cent fruit retention was calculated on the basis of initial number of fruit set. The yield plant^{-1} was recorded on the basis of mature fruits 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, reducing sugar content was measured using dinitrosalicylic acid. Sugars were extracted with hot 80 per cent ethanol in 100 mg sample. Supernatant was collected and evaporated by keeping on a water bath at 80˚C and 10 ml water was added.

After dissolving of sugars, 3 ml extract was pipette out and 3 ml DNS reagent was added in 3 ml extract. 1 ml of 40 per cent Rochelle salt solution was added in hot DNS- extract mixture. After cooling, absorbance was measured on spectrophotometer (Double beam SL 210 UV Visible Spectrophotometer) at 510 nm. Total sugar content was determined by using anthrone reagents method. One ml of diluted sample (100 times), 4 ml of anthrone reagent was added, then heated for 10 to 15 minutes on a water bath, cooled to room temperature and absorbance was measured at 630 nm on spectrophotometer (Systronics UV-VIS spectrophotometer 108).

Ascorbic acid was determined by diluting the known volume of clean juice and titrated against 2, 6-dichlorophenol indophenol dye solution. For rind thickness, ten fruits were randomly selected and peeled out with the help of hand and then it's measured by digital Vernier caliper and expressed in mm.

Results and Discussion

Effect of manganese and ferrous on fruit yield attributes of kinnow mandarin

The data presented in Table 1 revealed that maximum fruit volume (198.00 cc), fruit retention (69.74 %), yield plant^{-1} (78.23 kg) and estimated yield ha^{-1} (31.29 t) were recorded in treatment T_8 (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$) closely followed by T_9 over the treatment T_1(control). It might be due to 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) found that zinc + boron + iron resulted in 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). The increase in yield is obviously due to the consolidated effect of increased size and weight of fruits caused by foliar spray of manganese and ferrous. It is in conformity with the findings of Devi *et al.*, (1997) in satgudi orange, Ingle *et al.,* (2002) in acid lime, Tariq *et al.,* (2007) in sweet orange, Aboutalebi and Hassanzadeh (2013) in sweet lime, Kaur *et al.*, (2015) in kinnow mandarin for various yield attributes.

Effect of manganese and ferrous on fruit quality of kinnow mandarin

The data presented in Table 2 revealed that maximum TSS (10.93 ^{o}B), reducing sugar (2.96 %), total sugar (6.59 %), ascorbic acid

content (27.08 mg/100 g) with minimum rind thickness (2.79 mm) were recorded in treatment T_8 (1.0 % $MnSO_4$ + 0.5 % $FeSO_4$) closely followed by T_9over 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 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 Balakrishnan *et al.*, (1996) in pomegranate, 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, Kaur *et al.*, (2015) in kinnow mandarin for various qualities attributes.

Table.1 Effect of manganese and ferrous on fruit yield attributes of kinnow mandarin

Treatments	Fruit volume (cc)	Fruit retention (%)	Yield plant^{-1} (kg)	Estimated yield (t/ha)
T_1	165.00	58.00	62.26	24.90
T_2	168.00	68.42	63.49	25.39
T_3	171.00	67.97	65.02	26.00
T_4	179.11	67.70	69.06	27.62
T_5	178.00	68.50	67.22	26.88
T_6	181.21	67.65	69.68	27.87
T_7	180.88	69.00	75.07	30.02
T_8	198.00	69.74	78.23	31.29
T_9	194.66	68.80	77.26	30.90
SEm±	5.51	1.64	2.65	1.22
CD (p=0.05)	16.52	4.91	7.93	3.64

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

Treatments	TSS (^{0}Brix)	Reducing sugar (%)	Total sugar (%)	Non reducing sugar (%)	Ascorbic acid (mg/100 g)	Rind thickness (mm)
T_1	9.90	2.83	5.58	2.75	19.81	3.14
T_2	10.10	2.74	5.96	3.22	23.42	3.20
T_3	10.80	2.77	6.15	3.38	21.62	2.95
T_4	10.50	2.62	5.89	3.27	21.62	3.25
T_5	10.70	2.68	6.10	3.42	23.42	2.86
T_6	10.70	2.75	6.21	3.46	25.22	2.92
T_7	10.80	2.83	6.43	3.60	27.02	2.99
T_8	10.93	2.96	6.59	3.63	27.08	2.79
T_9	10.90	2.95	6.55	3.60	27.02	2.79
SEm±	0.20	0.01	0.09	0.05	0.35	0.04
CD (p=0.05)	0.60	0.04	0.28	0.15	1.06	0.13

Table.3 Economic feasibility of kinnow mandarin

Treatments	General cost (A)	Cost due to treatment (B)	Total cost of cultivation (A+B)	Estimated yield (t/ha)	Gross return (Rs. ha^{-1})	Net return (Rs.ha^{-1})	B:C
T_1	73760.64	-	73760.64	24.90	336150	262389	3.55
T_2	73760.64	99	73859.64	25.39	342802	268942	3.64
T_3	73760.64	198	73958.64	26.00	350994	277036	3.74
T_4	73760.64	341.88	74102.52	27.62	372863	298761	4.03
T_5	73760.64	683.87	74444.51	26.88	362880	288436	3.87
T_6	73760.64	440.88	74201.52	27.87	376246	302045	4.07
T_7	73760.64	782.87	74543.51	30.02	405274	330731	4.43
T_8	73760.64	539.88	74300.52	31.29	422415	348114	4.68
T_9	73760.64	881.87	74642.51	30.90	417143	342501	4.58

Sale of kinnow fruits @ Rs.13.50 /kg.

Economic feasibility in kinnow mandarin

Data presented in Table 3 revealed that among the treatments maximum net returns (Rs. 348114 ha^{-1}) was obtained under treatment T_8 (1.0% $MnSO_4$ + 0.5 % $FeSO_4$), while minimum net returns (Rs. 262389 ha^{-1}) was obtained in control, with respect to maximum B:C ratio (4.68) was recorded in T_8 (1.0% $MnSO_4$ + 0.5 % $FeSO_4$) closely followed by treatment T_9 (4.58), T_7 (4.43), T_6 (4.07) and T_4 (4.03) as compared to minimum (3.26) in control.

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