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Effect of micronutrients on leaf composition, fruit quality and yield of Kinnow mandarin

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Abstract: Effect of micronutrients on leaf composition, quality parameters and fruit yield of Kinnow mandarin was studied at Regional Research Station, Abohar. Foliar application of 1000 ppm Zn + 1000 ppm Mn on Kinnow mandarin during the end of April and mid of August gave maximum fruit yield (862 fruits / tree) and good quality fruits (Higher TSS/Acid: 14.23) by correcting these micronutrient deficiencies. Therefore, application of this dose of micronutrient combination will improve yield and fruit quality in Kinnow mandarin by correcting the deficiencies of these micronutrients as a result of which the orchardist will be economically benefited.

Keywords: Kinnow, Leaf composition, Micronutrients, Quality, Yield

INTRODUCTION

Citrus fruits hold an important place in the economy of the country and these fruits form the third largest fruit industry (Anonymous, 2013). 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 (Singh and Singh 2006).

In central India, Nagpur mandarin (*Citrus reticulata* Blanco) and Mosambi (*C. sinensis*) are the major cultivated citrus varieties. Sathgudi orange (*C. sinensis*) and Darjeeling mandarin (*C. reticulata* Blanco) are the major cultivated citrus varieties in south and north eastern India, respectively. The north-west Indian citrus industry resides on the high yielding Kinnow mandarin (Singh *et al,* 2003; Josan and Thatai 2008).

The nutrition constitutes an important component of successful and healthy citrus cultivation. An inadequate nutrition leads to the improper growth and reduced productivity of the citrus trees. The mineral nutrients are composed of major and micro- nutrients. Among the major nutrients, N, P and K are the primary nutrients and are required in large amount while, Ca, Mg and S are the secondary nutrients and most of them are supplied to the trees along with the primary nutrients through the synthetic fertilizers (Singh and Khan 2012).

The micronutrients on the other hand though 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 are the activators for various enzymes. For instance, Zn is involved in the biosynthesis of Tryptophan, a precursor of naturally occurring auxin, indole acetic acid (IAA) (Swietlik, 2002), 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).

In north western India, most of the Kinnow is being cultivated in the south western districts of Punjab. The growers in this region generally apply the major nutrients (N, P and K) in abundance and pay little attention towards micro-nutrition. Their problem is further complicated by the high pH and calcareous conditions of the soil in this region, which hinders the availability of the basal applied micronutrients. Due to the inclination of pH of the soil of this region towards the basic side, Kinnow growing on these soils frequently show interveinal chlorosis, reduced growth of young shoots and mottling of leaves. These are the typical deficiency symptoms of zinc, manganese and iron deficiency. The deficiency of Cu generally do not appear in Kinnow, as the tree need of this micronutrient is accomplished by the spray of copper based fun-

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gicides in the post monsoon period and post pruning period in the winters (Sharma *et al.* 1990).

Besides being involved in the functioning of the various plant enzymes, the foliar application of the micronutrients has also significant effect on the yield and quality of fruits in citrus (Kazi *et al*., 2012; Sarrwy *et al*., 2012). Keeping in view of the importance of Kinnow mandarin in the north- western India,the study has been carried out to see the effect of micronutrients on it leaf composition, fruit quality and yield.

MATERIALS AND METHODS

Micronutrient studies were initiated on three year old trees of Kinnow mandarin budded on Jatti Khatti (*C. jambhiri* lush) rootstock and continued till 2012 at Regional Research Station, Abohar. The soil nutrient level of the experimental area was determined prior to the layout of the experiment. The soil was sandy loam with pH ranging from 7.8 to 8.6, organic carbon compound varied from 0.040 % to 0.210 % , phosphorus from 2.72 to 6.2 kg / acre, potassium from 122 to 270 kg/ acre, zinc from 0.30 to 1.80 mg / kg of soil, manganese from 2.4 to 5.6 mg / kg of soil, electrical conductance 0.20 to 0.30 milli mho / cm at various depths in the soil profile. There were 20 treatments comprising of soil application of Zn alone as well as foliar spray of Zn, Mn and Fe alone and in combinations as per detailed as, Zn (500 ppm, 1000 ppm and 1500 ppm); Mn (500 ppm, 1000 ppm and 1500 ppm); Fe (250 ppm, 500 ppm and 750 ppm); Zn (500 ppm) + Mn (500 ppm) + Fe (250 ppm); Zn (1000 ppm) + Mn (1000 ppm); Zn (1000 ppm) + Fe (500 ppm); Mn (1000 ppm) +Fe (500 ppm); $ZnSO_4$ (12.5 g / tree/ year tree age); $ZnSO_4$ (25.0 g / tree/ year tree age); $ZnSO_4$ (37.5 g / tree/ year tree age); $ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Mn (1000 ppm); $ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Fe (500 ppm); $ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Mn (1000 ppm) + Spray of Fe (500 ppm); and Control.

The experiment was laid out in randomized block design with two trees as a unit and replicated thrice. Foliar applications were given during the months of end April and mid - August while $ZnSO_4$ was applied in the soil during the month of April every year. A basal dose of 1.6 kg urea and I kg Diammonium phosphate (DAP) was given to each tree. Seven months old leaves were collected in the third week of September from non – bearing terminals of current season growth. The leaf samples were processed following the method of Chapmann (1964) and digested in a diacid mixture of nitric acid and perchloric acid (5:1). The plant extracts were analysed for Zinc, Iron and Manganese with the help of Atomic Absorption Spectrophotometer. The fruit yield was recorded in the second week of January and fruit quality was determined using standard methods (AOAC, 1990).

RESULTS AND DISCUSSION

Leaf composition: The leaf analysis data (Table 1) revealed that deficiencies of Zn and Mn occur in Kinnow while Fe content is in optimum productive range. The contents of Zn and Mn increased in Kinnow leaves with the foliar application of these micronutrients and attained the optimum productive range. Zn content also increased with the soil application of $ZnSO_4$ over control but remained in the deficient range. The maximum Zn status (49.69 ppm) was attained with foliar application of Zn (1500 ppm) followed by 45.76 ppm by Zn (1000 ppm) and 44.90 ppm by Zn (1000 ppm) + Mn (1000 ppm). Among $ZnSO_4$ treatments, maximum Zn status was attained with $ZnSO_4$ (37.5 g / tree/ year tree age). There is a significant decline in Zn status of leaves when spray of Zn is done in combination with other micronutrients. This decline might be due to interaction of Zn with other micronutrients. Similar studies have earlier been done in sweet orange (Mann *et al*., 1985). Highest concentration of Mn (58.75 ppm) was observed in leaves of the plants sprayed with Mn (1500 ppm) followed by 55.46 ppm by Mn (1000 ppm) and 53.63 ppm with combination spray of Zn (1000 ppm + Mn (1000 ppm). A similar trend was observed in the plants sprayed with Iron. With a maximum leaf Fe status (218.38 ppm) recorded with Fe (750 ppm). There was an increase in respective micronutrient in the leaves with the spray of the corresponding micronutrient alone as well as when sprayed in combination with other micronutrients. The increased concentration of micronutrient did not alter the level of N, P and K in the leaves. Earlier, Dixit *et al.* (1977) reported similar behaviour of Kinnow leaves when given foliar application of Zn and Fe. The foliar application of $ZnSO_4$ (0.5, 0.75 and 1.0 %) and $FeSO_4$ (0.5, 0.75 and 1.0 %) given to the Kinnow leaves showed that 1.0 % Zn SO_4 and 0.5 % $FeSO_4$ were most effective.

Fruit yield and quality: The fruit yield (Table 2) varied significantly by the application of micronutrients. Fruit yield increased with the application of micronutrients and significantly higher fruit yield (No. of Fruits / Tree) was obtained with the foliar application of micronutrients over control as well as soil application of $ZnSO_4$ alone and in combination of foliar application of $MnSO_4$ and $FeSO_4$. However, maximum fruit yield (862 fruits / tree) was obtained with the foliar application of 1000 ppm Zn + 1000 ppm Mn treatment followed by (814 fruits/ tree) by 1000 Mn and 1000ppm Zn + 500ppm Fe (783 fruits / tree) which were significant at par with 1500 ppm Zn (718 fruits / tree) and 500 ppm Mn (723 fruits/ tree). However, the fruit weight and fruit size varied non-significantly. A non significant effect of micronutrients on fruit quality of sweet orange has earlier been reported by Mann *et al*. (1985).

The data presented in table 3 reveals a non significant

Table 1. Effect of micronutrients on the composition of Zn, Mn and Fe of Kinnow leaves.

Treatments	Zn (ppm)	Mn (ppm)	Fe (ppm)
Zn (500 ppm)	41.21	31.92	190.46
Zn (1000 ppm)	45.76	27.92	189.25
Zn (1500 ppm)	49.69	27.54	190.68
Mn (500 ppm)	27.28	46.17	188.67
Mn (1000 ppm)	24.04	55.46	191.04
Mn (1500 ppm)	22.27	58.75	189.00
Fe (250 ppm)	22.23	30.04	198.09
Fe (500 ppm)	21.99	30.71	205.92
Fe (750 ppm)	25.43	28.67	218.38
Zn (500 ppm) +Mn(500 ppm)+Fe(250 ppm)	39.54	40.42	193.04
Zn (1000 ppm) + Mn (1000 ppm)	44.90	53.63	190.25
Zn (1000 ppm) + Fe (500 ppm)	43.44	28.99	209.71
Mn (1000 ppm) + Fe (500 ppm)	35.28	45.72	189.15
$ZnSO_4$ (12.5 g / tree/ year tree age)	26.58	28.21	187.08
$ZnSO_4$ (25.0 g / tree/ year tree age)	26.88	32.79	196.81
$ZnSO_4$ (37.5 g / tree/ year tree age)	28.92	40.21	194.42
$ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Mn (1000 ppm)	24.15	45.96	189.81
$ZnSO_4$ (25.0 g / tree/ year tree age) +Spray of Fe (500 ppm)	23.79	39.62	212.04
$ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Mn (1000 ppm) + Spray of Fe (500 ppm)	27.96	45.92	210.00
Control	21.63	25.71	182.65
CD (5 %)	12.44	13.82	NS

Values are mean of three replicates; optimum productive range in ppm, Zn:35 -93; Mn:45–93; Fe:83 -183.

Table 2. Effect of micronutrients on the fruit weight, fruit size and ultimate yield of Kinnow.

Treatments	Fruit weight(g)	Fruit length(cm)	Fruit breadth(cm)	Fruit yield (Fruits/tree)
Zn (500 ppm)	195.2	6.72	7.63	614
Zn (1000 ppm)	186.6	6.60	7.42	632
Zn (1500 ppm)	185.0	6.52	7.46	718
Mn (500 ppm)	188.4	6.50	7.41	723
Mn (1000 ppm)	191.3	6.70	7.54	814
Mn (1500 ppm)	181.9	6.49	7.37	709
Fe (250 ppm)	190.6	6.51	7.39	685
Fe (500 ppm)	187.1	6.56	7.46	688
Fe (750 ppm)	189.1	6.53	7.53	624
Zn (500 ppm) +Mn(500 ppm)+Fe(250 ppm)	189.2	6.51	7.42	629
Zn (1000 ppm) + Mn (1000 ppm)	191.0	6.59	7.44	862
Zn (1000 ppm) + Fe (500 ppm)	193.5	6.59	7.64	783
Mn (1000 ppm) + Fe (500 ppm)	184.1	6.54	7.57	624
$ZnSO_4$ (12.5 g / tree/ year tree age)	179.8	6.56	7.62	551
$ZnSO_4$ (25.0 g / tree/ year tree age)	192.6	6.59	7.59	535
$ZnSO_4$ (37.5 g / tree/ year tree age)	178.7	6.51	7.48	533
$ZnSO_4$ (25.0 g/tree/year tree age)+ Spray of Mn (1000 ppm)	192.7	6.57	7.55	547
$ZnSO_4$ (25.0 g/tree/year tree age)+ Spray of Fe (500 ppm)	189.6	6.55	7.50	522
$ZnSO_4$ (25.0 g/tree/year tree age)+ Spray of Mn (1000 ppm) + Spray of Fe (500 ppm)	200.2	6.59	7.53	512
Control	197.2	6.56	7.60	484
CD (5 %)	NS	NS	NS	84

variation in peel thickness and rag per cent, whereas, a significant variation in juice per cent. Maximum juice content (53.50 %) was recoded in plants given treatment of Zn (1000 ppm) + Fe (500 ppm). Similar increase in juice content with micronutrients has earlier been reported by Rama and Bose (2000).

Table 3. Effect of micronutrients on the physical composition of the fruit of Kinnow.

Treatments	Peel (%)	Peel thickness (cm)	Rag (%)	Juice (%)
Zn (500 ppm)	27.03	0.543	22.38	50.59
Zn (1000 ppm)	26.33	0.550	21.75	51.92
Zn (1500 ppm)	27.43	0.557	21.53	51.04
Mn (500 ppm)	26.44	0.563	22.04	51.52
Mn (1000 ppm)	26.68	0.578	21.12	52.30
Mn (1500 ppm)	26.93	0.576	22.13	50.94
Fe (250 ppm)	27.02	0.576	21.45	51.53
Fe (500 ppm)	26.95	0.588	22.02	51.03
Fe (750 ppm)	27.18	0.568	21.83	50.99
Zn (500 ppm) +Mn(500 ppm)+Fe(250 ppm)	26.82	0.573	21.70	51.38
Zn (1000 ppm) + Mn (1000 ppm)	25.72	0.570	23.45	50.73
Zn (1000 ppm) + Fe (500 ppm)	25.22	0.571	21.27	53.50
Mn (1000 ppm) + Fe (500 ppm)	26.67	0.573	22.09	51.25
$ZnSO_4$ (12.5 g / tree/ year tree age)	24.81	0.561	23.40	51.79
$ZnSO_4$ (25.0 g / tree/ year tree age)	26.75	0.561	22.30	51.05
$ZnSO_4$ (37.5 g / tree/ year tree age)	26.81	0.561	22.75	50.45
$ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Mn (1000 ppm)	25.84	0.556	22.66	51.51
$ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Fe (500 ppm)	25.02	0.552	22.59	52.39
$ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Mn (1000 ppm) + Spray of Fe (500 ppm)	25.32	0.559	22.29	52.39
Control	25.71	0.573	22.88	51.32
CD (5 %)	1.59	NS	NS	NS

Table 4. Effect of micronutrients on quality attributes of Kinnow.

Treatments	TSS (%)	Acidity (%)	Reducing sugars (%)	TSS: Acid ratio
Zn (500 ppm)	10.48	0.756	2.77	13.86
Zn (1000 ppm)	10.43	0.750	2.79	13.91
Zn (1500 ppm)	10.54	0.774	2.83	13.62
Mn (500 ppm)	10.50	0.770	2.77	13.64
Mn (1000 ppm)	10.43	0.774	2.74	13.48
Mn (1500 ppm)	10.44	0.740	2.66	14.11
Fe (250 ppm)	10.47	0.770	2.75	13.60
Fe (500 ppm)	10.42	0.761	2.62	13.69
Fe (750 ppm)	10.36	0.770	2.55	13.45
Zn (500 ppm) +Mn(500 ppm)+Fe(250 ppm)	10.39	0.774	2.68	13.42
Zn (1000 ppm) + Mn (1000 ppm)	10.53	0.740	2.91	14.23
Zn (1000 ppm) + Fe (500 ppm)	10.43	0.750	2.98	13.91
Mn (1000 ppm) + Fe (500 ppm)	10.36	0.750	2.99	13.81
$ZnSO_4$ (12.5 g / tree/ year tree age)	10.40	0.750	2.82	13.87
$ZnSO_4$ (25.0 g / tree/ year tree age)	10.40	0.739	2.93	14.07
$ZnSO_4$ (37.5 g / tree/ year tree age)	10.47	0.750	2.87	13.96
$ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Mn (1000 ppm)	10.49	0.757	2.95	13.85
$ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Fe (500 ppm)	10.42	0.778	2.97	13.39
$ZnSO_4$ (25.0 g / tree/ year tree age) + Spray of Mn (1000 ppm) + Spray of Fe (500 ppm)	10.46	0.756	2.96	13.84
Control	10.07	0.780	2.87	12.91
CD (5 %)	NS	0.059	0.24	--

TSS content increased while acidity content decreased (Table 4) in all the treatments over control. The maximum TSS (10.54 %) was observed in Zn (1500 ppm) and higher TSS / acid ratio (14.23) was obtained with the foliar application of 1000 ppm Zn + 1000 ppm Mn. The reduction in acidity content might be due to its inverse relation with fruit size as reported by Dixit *et al.* (1977). Foliar application of Zinc sulphate upto 0.6 per cent has earlier been reported to improve fruit yield and quality in Kinnow mandarin by Razzaq *et al*. (2013).

Conclusion

The foliar application of 1000 ppm Zn + 1000 ppm Mn on Kinnow mandarin during end - April and mid – August gave maximum fruit yield and good quality fruits and higher profit gain by correcting these micronutrient deficiencies. Therefore, the application of this dose of micronutrients will improve yield and fruit quality in Kinnow mandarin by correcting the deficiencies of zinc and manganese and the orchardist will be economically benefited

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