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Influence of Foliar Fertilization of Micronutrients on Leaf Micro Nutrient Status of Mandarin Orange (*Citrus reticulata Blanco.*) in Lower Pulney Hills

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A B S T R A C T

Experiment on effect of foliar application of micronutrients (Zn, Fe, B, Mn and Cu) on mandarin orange leaf micro nutrient status was carried out during 2015-16 at lower pulney hills of Tamilnadu, India. The results showed that foliar application of micronutrient alone significantly increased the individual micronutrient content and micronutrients in combination compare to control. Therefore application of micronutrients as foliar spray reduces incidence of deficiency calamities, in turn flourishes the growth and yield attributes subsequently.

Introduction

Fruits are nature's gift to mankind. These are not only delicious and refreshing but are also the chief source of vitamins and minerals. Among them Citrus (*Citrus reticulata* Blanco.) is one of the most important fruit crops of the globe, extensively cultivated in tropical and sub-tropical climate. In India, there are 26 states involved in citrus production but nine states cover more than 70% of area and 89% of total production. India is the fourth largest citrus producing country in the world contributing 6.5 percent of production. In India, citrus ranks 3rd in area and production, area of citrus fruit was about 0.98 million hectares with a production of 11.06 million tons and average productivity of 9.69 tons/ha (Anon, 2016). Total mandarin production in India is 3.86 million tons with 0.35 million ha area and 9.3 tons/ha as productivity. Citrus requires 17 essential elements for the normal growth and production. Deficiency of' micronutrients occur at various stages of growth and developments of citrus plants. Micronutrients are required in very small quantities, yet they are very effective in regulating plant growth. Application of these mineral nutrients in deficiency condition improves the growth and development of citrus tree and also physico-chemical composition of fruits. A number of studies on micronutrient deficiencies in citrus have been reported and detailed investigations were done on the effect of application of micronutrients especially zinc, iron, boron, manganese and copper on growth and development of citrus trees. Application of these nutrients through foliar spray have resulted perceptible changes in several aspects of growth, flowering, fruit set, yield and quality of citrus species (Babu and Yadav, 2005). Foliar application of nutrients often gives a quicker response than application to soil (Obreza *et al.*, 2010; Anees *et al.*, 2011), since plant nutrients are readily absorbed through the leaf surface. Swietlik (2002) reported that mineral nutrient enter into leaf in three steps: (1) penetration through the cuticle and epidermal walls; (2) adsorption on the surface of the plasmalemma and (3) passage through the plasmalemma into cytoplasm. Foliar treatments are also necessary in cases of immobilization processes which make application to the soils ineffective. Foliar absorption of nutrient is influenced by various factor, among which plant species, leaf age, nutrient type and concentration, product formulation, climatic conditions and the nutritional status of the plant (Swietlik and Faust, 1984).Growth of citrus also influenced by micronutrient such as Zinc (Zn), Iron (Fe), Boron (B), Manganese (Mn) and Copper (Cu) application. These elements effect metabolic functions in plant system. Zinc (Zn) is an important micro element essential for plants due to its involvement in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis (Ahmad *et al.*, 2012). Zn is required for the activity of various enzymes, such as dehydrogenases, aldolases, isomerases, transphosphorylases, RNA and DNA polymerases (Swietlik, 1999). It has important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Alloway, 2008). Bergmann (1992) reported that, zinc is believed to be involved in chlorophyll synthesis through its influence on protein, carbohydrate and energy metabolism. Taiz and Zeiger (1994) reported that, many enzymes require zinc ions (Zn^{2+}) for their activity, and zinc may be required for chlorophyll biosynthesis in some plants. Iron (Fe) is one of the most important micronutrients for plant growth. It is involved in various physiological processes of plant systems, namely chlorophyll formation and degradation synthesis of protein which contains chloroplasts and electron carriers in enzyme systems (Somasundaram *et al.*, 2011). In addition, Fe is part of protein ferredoxin and is required in nitrate and sulfate reduction. Fe is essential in maintenance of chlorophyll in plant and also plant metabolism (Photosynthesis and respiration). Boron (B) as a micronutrient plays significant role in growth, productivity of citrus and resistance to disease infection. It increases pollen grain germination, pollen tube elongation, consequently increasing fruit set percentage and seeds, fruit development and finally the yield (Abd-Allah, 2006). It is necessary in the synthesis of the base for RNA and in cellular activities and shown to promote root growth. B is important in the Translocation of sugar from leave is important to enhance photosynthesis Srivastava and Singh (2003). Manganese (Mn) plays a vital role in plant physiological processes *(viz.*, photosynthesis, respiration, and nitrogen metabolism/assimilation). Manganese (Mn) primarily functions as part of the plant enzyme system, activating several metabolic functions (Somasundaram *et al.*, 2011). It is involved in the oxygen-evolving step of photosynthesis and membrane function, as well as serving as an important activator of numerious enzyme in the cell (Wiedenhoeft, 2006). Copper (Cu) is involved in stimulation of lignification of all plant cell walls, photosynthesis and electron carriers in enzyme systems of plant (Somasundaram *et al.*, 2011). It plays an important role in the synthesis and or stability of chlorophyll land other plant pigments.

Materials and Methods

The field experiment was conducted in farmer field under lower Pulney hills of Kaanalkadu (Thadiyankudisai), Tamilnadu during the year 2014-16. For conducting this study six year old uniform trees of mandarin orange were selected. Soils of pulney hill region are red laterite having brown to dark brown colour. They are deep well drained and possess sandy clay loam structure which is appropriate for citrus cultivation. An altitude of 1098 m above MSL and the annual rainfall is around 1400 mm. The mean maximum and minimum temperature were 32.6 ºC and 17.7 ºC respectively with mean relative humidity of 66.5 %.

There were 15 treatment replicated thrice tested in randomized block design. The effects of ZnSO4 (0.2%), $FeSO_4$ (0.2%), H_3BO_4 (0.2%), $MnSO_4$ (0.3%) and $CuSO_4$ (0.4%) alone or in combination was studied. The micronutrient were applied as a foliar sprays thrice at monthly interval from July to October 2015 and spray was given in the evening hours between 3.00-5.00 pm by using a hand sprayer**.** The required quantities of micronutrients were dissolved in water separately and then pH of these nutrient solutions was adjusted by lime and sprayed in vegetative, flowering and fruit set stages. The simple water spray was done on the tree under control treatment. In each spray treatment Teepol was added as sticking agent in prepared solution. The four to five months old 30-50 leaf sample were collected for analysis. The leaf samples were analyzed for Zn, Fe, Mn and Cu by the following standard procedure lay out by Jackson (1973) and Humphries (1956). Observation of growth and estimation of leaf micro nutrient content were recorded and data were subjected to statistical analysis.

Treatment details

$T_{1:}$ Control (Water spray)**,**
$T_{2:}$ $ZnSO_4$ (0.2%)**,**
T_3: $FeSO_4$ (0.2%)**,**
T_4: H_3BO_4 (0.2%)**,**
T_5: $MnSO_4$ (0.3%)**,**
T_6: $CuSO_4$ (0.4%)**,**
T_7: $ZnSO_4$ (0.2%) + $FeSO_4$ (0.2%)**,**
T_8: $ZnSO_4$ (0.2%) + H_3BO_4 (0.2%),
T_9: $ZnSO_4$ (0.2%) + $MnSO_4$ (0.3%)**,**
T_{10}: $ZnSO_4$ (0.2%) + $CuSO_4$ (0.4%)**,**
T_{11}: $ZnSO_4$ (0.2%) + $FeSO_4$ (0.2%) + H_3BO_4 (0.2%)**,**
$T_{12:}$ $FeSO_4$ (0.2%) + H_3BO_4 (0.2%) + $CuSO_4$ (0.4%)**,**
T_{13}: $ZnSO_4$ (0.2%) + $MnSO_4$ (0.3%) + $CuSO_4$ (0.4%)**,**
T_{14}: $FeSO_4$ (0.2%) + H_3BO_4 (0.2%) + $MnSO_4$ (0.3%) and
T_{15}: $ZnSO_4$ (0.2%) + $FeSO_4$ (0.2%) + H_3BO_4 (0.2%) + $MnSO_4$ (0.3%) + $CuSO_4$ (0.4%).

Results and Discussion

Leaf Nutrient content

Zinc is one of the important micronutrient for its role in enzyme activity in various crop plants. Zinc plays a key role in auxin and protein synthesis, cell membrane integrity and involved in ion transport. The data on leaf zinc varied significantly among the treatments at different stages (Table 1).

Table.1 Effect of foliar application of micronutrients on leaf zinc content (ppm)

Treatments	Vegetative stage	Flowering stage	Fruit set stage
T_1	12.20	11.24	10.23
T_2	35.08	34.54	34.01
T_3	15.03	14.47	14.05
T_4	14.23	14.02	13.89
T_5	14.36	13.32	12.45
T_6	14.76	13.67	13.13
T_7	33.05	32.43	31.76
T_8	28.01	27.68	26.87
T_9	26.97	26.08	26.73
T_{10}	27.43	27.18	26.77
T_{11}	34.53	33.73	32.78
T_{12}	17.12	16.94	16.53
T_{13}	32.92	32.65	32.01
T_{14}	17.13	16.23	15.67
T_{15}	33.42	33.20	32.42
SEd	0.603	0.602	0.602
CD (0.05)	1.235	1.232	1.218

Table.2 Effect of foliar application of micronutrients on leaf iron content (ppm)

Treatments	Vegetative stage	Flowering stage	Fruit set stage
T_1	103.2	102.3	100.8
T_2	108.2	106.2	105.2
T_3	162.1	159.2	158.2
T_4	107.8	105.4	104.3
T_5	106.2	105.2	103.2
T_6	106.8	105.2	104.5
T_7	150.2	148.3	145.3
T_8	118.3	116.6	114.3
T_9	111.3	110.4	109.8
T_{10}	119.2	116.5	113.5
T_{11}	160.1	157.2	154.4
T_{12}	155.7	154.8	153.5
T_{13}	119.5	115.2	114.3
T_{14}	155.1	154.6	152.6
T_{15}	156.3	154.1	153.2
SEd	1.584	1.572	1.561
CD (0.05)	3.246	3.220	3.198

Table.3 Effect of foliar application of micronutrient on leaf manganese content (ppm)

Treatments	Vegetative stage	Flowering stage	Fruit set stage
T_1	30.34	30.25	30.16
T_2	31.26	31.16	31.08
T_3	31.28	31.24	31.17
T_4	31.72	31.67	31.62
T_5	46.28	45.78	44.40
T_6	31.42	31.38	31.29
T_7	31.60	31.52	31.45
T_8	32.17	32.09	31.98
T_9	43.22	42.99	42.74
T_{10}	31.96	31.90	31.84
T_{11}	32.17	32.09	31.98
T_{12}	31.40	32.24	32.12
T_{13}	41.63	41.38	41.22
T_{14}	42.59	42.38	42.21
T_{15}	41.48	40.92	40.84
SEd	0.382	0.370	0.357
CD (0.05)	0.783	0.758	0.732

Table.4 Effect of foliar application of micronutrient on leaf copper content (ppm)

Treatments	Vegetative stage	Flowering stage	Fruit set stage
T_1	6.15	6.10	5.90
T_2	7.82	7.57	6.25
T_3	7.65	7.45	6.19
T_4	7.72	7.48	6.16
T_5	7.57	7.36	6.12
T_6	13.88	13.32	10.83
T_7	8.45	8.24	6.42
T_8	8.22	8.12	6.37
T_9	8.43	8.21	6.31
T_{10}	13.24	13.16	10.67
T_{11}	9.12	8.89	6.52
T_{12}	13.34	13.23	10.73
T_{13}	13.19	13.01	10.57
T_{14}	8.68	8.35	6.49
T_{15}	13.26	13.11	10.61
SEd	0.181	0.180	0.144
CD (0.05)	0.372	0.369	0.295

The significantly highest Zn at vegetative, flowering and fruit set stage (35.08, 34.54 and 34.01 ppm) was found in T_2 and the lowest observed in case of T_1 (12.20, 11.24 and 10.23ppm) respectively. Increase in leaves Zn content may be due to its maximum absorption from Zn source and less translocation to the other parts of the plant reported by Sajida and Hafeez (2000) in Kinnow mandarin. Similar trend was observed by Nanaya *et al*., (1985) in Coorg mandarin and Tariq *et al*., (2007) in sweet orange, increase in the zinc concentration of treated trees suggested the potential benefit of exogenous application of Zn in the form of zinc sulfate to these trees.

Leaf Fe content also varied significantly among the treatments. The highest leaf iron content (162.1, 159.2 and 158.2 ppm) was registered in T_3. The lowest leaf iron content of (103.2, 102.3 and 100.8 ppm) was recorded in the treatment T_1 (Table 2). Increase in leaf iron content due to application of $FeSO_4$ nutrient to leaves reported by Kaur *et al.*, (2015) in Kinnow mandarin. The difference among treatments was significant with respect to manganese, highest leaf manganese content (46.28, 45.78 and 44.40 ppm) was found in T_5 and the lowest observed in T_1 (30.34, 30.25 and 30.16 ppm) respectively. This increase in leaf Mn content was due to the better uptake of Mn ion by sweet orange leaves (Labanwskas *et al.*, 1969). The highest concentration of Mn was applied alone and combination with Zn, Fe, Cu and boron. Manganese combined with Zn, Fe and Cu in foliar spray mixture increased the Mn content in sprayed leaves but not to the same degree as Mn alone. Similar results were also reported by El-shazly and Hennawy (1983) and Hafeez and Izhar (2006) who suggested that Mn combined with Zn, Fe, Cu and B foliar spray mixture was not as effective in increasing leaf Mn content as compared to Mn alone. In case of copper, the elevated leaf copper content (13.88, 13.32 and 10.83 ppm) in T_6 and reduced content (6.15, 6.10 and 5.90ppm) was noticed in T_1. Increase in leaves copper content may be due to its readily available of respective nutrients and maximum absorption from nutrient source and less translocation to the other parts of the plant similar results findings were reported by Hassan (1995).

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