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Research Article

INFLUENCE OF FOLIAR APPLICATION OF MICRONUTRIENTS ON YIELD AND QUALITY OF MANDARIN ORANGE (*Citrus reticulata* Blanco.) UNDER LOWER PULNEY HILLS

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Abstract- The experiment was carried out on mandarin orange (*Citrus reticulata* Blanco.) to investigate the effects of spraying micronutrients on yield and quality parameters. Fifteen treatments comprising 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 with control (water spray) were used as foliar spray solution at vegetative, flowering and fruitset stage. The experiment was laid out in randomized block design(RBD) with three replication and two trees under each replication. Data were recorded on fruit set per cent, number of fruits per tree, yield and quality attributes. The obtained data were statistically evaluated by using standard procedure. The result revealed that foliar application of micronutrients found very effective for increased yield and physio-chemical attributes. Maximum fruit yield and improved quality parameters were observed in combination of all the micronutrients (T_{15}).

Keywords- Mandarin orange, Micronutrients, Foliar spray, Physio-chemical attributes

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Introduction

Citrus is a popular, prominent fruit crop of tropical and sub-tropical climate. Citrus is valued for segments in the fruit, used as fresh fruit, juice, beverages and also used in culinary for sour taste. The fruits are well known for their dietary, nutritional, medicinal and cosmetic properties and are also good source of citric acid, flavonoids, phenolics, pectin, limonoids, ascorbic acid etc. in addition to potassium, folate, calcium, thiamin, niacin, vitamin B6, phosphorus, magnesium, copper, riboflavin, pantothenic acid and a variety of phytochemicals. Citrus fruits posses' greater adaptability to different agro climatic condition so are grown with equal success in tropical and subtropical even in some favorable parts of the temperate of the world [19].

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 [2]. 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. Micronutrient deficiencies often tend to limit the productivity in this crop. It has been shown by several workers that low nutritional levels of micronutrients cause die-back, chlorosis, reduction in yield, quality and other ailments in mandarin orange [4, 25, 27]. Therefore, citrus requires judicious application of fertilizers for better growth and sustained production of high quality fruits [14,17]. Application of these micronutrient quickly increased the uptake of macronutrients in the tissue and organs of the plants, decreased the nutritional deficiencies and improved the fruit quality [1]. Also micronutrients can tremendously boost horticultural crop yield and improve quality and post- harvest life of horticultural produce [18] particularly citrus.

Material 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 $ZnSO_4$ (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 was applied as a foliar spray 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 fruitset 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 N, P, K, Zn, Fe, Mn and Cu by the following standard procedure laid out by [10, 9].

Treatment details:

T1: Control (Water spray), T2: $ZnSO_4$ (0.2%), T3: $FeSO_4$ (0.2%), T4: H_3BO_4 (0.2%), T5: $MnSO_4$ (0.3%), T6: $CuSO_4$ (0.4%), T7: $ZnSO_4$ (0.2%) + $FeSO_4$ (0.2%),T8: $ZnSO_4$ (0.2%) + H_3BO_4 (0.2%), T9: $ZnSO_4$ (0.2%) + $MnSO_4$ (0.3%), 10: $ZnSO_4$ (0.2%) + $CuSO_4$ (0.4%), T11: $ZnSO_4$ (0.2%) + $FeSO_4$ (0.2%) + H3BO4 (0.2%), T12: $FeSO_4$ (0.2%) + H3BO4 (0.2%) + $CuSO_4$ (0.4%), T13: $ZnSO_4$ (0.2%) + $MnSO_4$ (0.3%) + $CuSO_4$ (0.4%), T14: $FeSO_4$ (0.2%) + H_3BO_4 (0.2%) + $MnSO_4$ (0.3%) and T15: $ZnSO_4$ (0.2%) + $FeSO_4$ (0.2%) + H_3BO_4 (0.2%) + $MnSO_4$ (0.3%) + $CuSO_4$ (0.4%).

Result and Discussion

Yield and yield attributing characters

From the [Table-1] effectiveness of zinc, iron, boron, manganese and copper was found to be significant in increasing the yield characters of mandarin orange. The foliar application of these $ZnSO_4$ (0.2%) + $FeSO_4$ (0.2%) + H_3BO_4 (0.2%) + $MnSO_4$ (0.3%) + $CuSO_4$ (0.4%) in T_{15} significantly increased the yield parameters *viz.,* fruit set percentage (52.49), number of fruits per tree (81.05), yield (7.82 kg /tree), fruit weight (96.43 g), fruit length (6.24 cm), fruit breadth (7.45 cm).

Table-1 *Effect of foliar application of micronutrients on fruit set (%), number of fruits per tree, yield (Kg/tree), fruit weight (g), fruit length (cm) and fruit breadth (cm).*

Treatments	Fruit set (per cent)	No. of fruits per tree	Yield (kg / tree)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)
T1	32.72	51.33	3.66	71.34	4.46	5.13
T2	33.58	53.98	4.02	74.46	4.52	5.23
T3	33.45	54.52	4.17	76.46	4.64	5.26
T4	34.65	60.58	4.65	76.84	4.77	5.39
T5	33.98	54.80	4.27	78.01	4.88	5.43
T6	34.05	56.23	4.47	79.47	5.11	5.54
T7	39.72	61.00	4.95	81.12	5.37	5.84
T8	43.42	63.42	5.27	83.06	5.40	5.88
T9	38.06	61.02	5.16	84.63	5.46	5.94
T10	42.08	65.75	5.66	86.12	5.54	5.99
T11	50.25	73.35	6.92	94.32	5.94	7.05
T12	47.19	66.84	5.96	89.12	5.64	6.45
T13	47.56	68.51	6.24	91.01	5.66	6.64
T14	48.86	70.34	6.49	92.43	5.73	6.85
T15	52.49	81.05	7.82	96.43	6.24	7.45
SEd	0.471	0.551	0.080	0.514	0.035	0.048
CD (0.05)	0.966	1.122	0.164	1.054	0.073	0.099

Table-2 *Effect of foliar application of micronutrients on rind thickness (mm), pulp weight (g), juice content (ml) per fruit. TSS, acidity, ascorbic acid, total sugar, reducing sugar and non-reducing sugar (%)*

Treatments	Rind thickness (mm)	Pulp weight (g)	Juice content (ml)	TSS (^oB)	Acidity (%)	Ascorbic acid (mg / 100 g)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
T1	3.09	20.52	31.20	9.03	0.99	20.60	6.04	2.02	4.02
T2	3.07	23.43	32.40	9.40	0.95	23.12	6.91	2.46	4.45
T3	3.07	25.61	33.60	9.37	0.96	23.03	6.75	2.38	4.37
T4	3.06	26.90	34.50	9.30	0.97	22.67	6.51	2.25	4.26
T5	3.06	29.20	36.20	9.27	0.97	22.26	6.31	2.16	4.15
T6	3.05	31.40	37.70	9.20	0.98	21.43	6.17	2.09	4.08
T7	3.05	33.20	38.60	9.97	0.93	23.92	7.83	2.89	4.94
T8	3.05	35.30	40.50	9.83	0.94	23.83	7.58	2.78	4.80
T9	3.05	38.40	42.40	9.53	0.94	23.68	7.34	2.66	4.68
T10	3.04	40.60	44.60	9.50	0.95	23.45	7.13	2.57	4.56
T11	3.00	48.40	50.60	10.37	0.89	24.85	8.71	3.45	5.26
T12	3.04	42.60	46.80	10.23	0.90	24.66	8.41	3.26	5.17
T13	3.04	45.10	47.80	10.17	0.91	24.52	8.24	3.15	5.09
T14	3.03	46.30	49.20	10.07	0.92	24.41	8.08	3.07	5.01
T15	2.89	50.20	52.30	10.43	0.88	25.10	8.93	3.60	5.38
SEd	0.004	0.639	0.469	0.031	0.004	0.087	0.064	0.034	0.030
CD (0.05)	0.008	1.309	0.960	0.064	0.008	0.178	0.131	0.069	0.062

The possible reason may be due to micro-element ascribed to better photosynthesis, lesser fruit drop, improve fruit size and quality characters. The beneficial role of boron in pollination, zinc in growth promoting substance, iron in electron transport chain system and copper in carbohydrate similar results was also observed by [26] in mango and [31] in peach *cv.* Sharbati. Similar findings, [20] obtained that in *cv.* NA-7 aonla the combination of micronutrients has significant increase in fruit set and number of fruits per tree due to direct or indirect involvement in setting, retention, reduction in fruit drop as well as growth and development of fruits. [12] combined application of micronutrients increased the yield parameters because the rate of translocation of nutrients from source leaf to sink fruits is increased with enhancement in photosynthesis rate observed in Kagzi lime.

Applications of these micronutrients are effective as it increases the physical character such as fruit weight, fruit length and fruit breadth. This might be due to foliar application of micronutrient which helps in improvement of quality and increased the synthesis and transportation of photosynthates. Subsequent conversion into carbohydrates and protein in the initial stages (vegetative growth) which influence the activity of metabolism in plant attributes to better development of fruit. The present finding are in line with the studies of [20] in anola *cv.* NA- 7, [7] in guava *cv.* Sarder, [6] and [28] in anola *cv.* Banarasi with application of zinc sulphate, magnesium sulphate and copper sulphate. The findings are also confirmed with [11], who also observed that enhancement of fruit weight, length and breadth due to multiplication and enlargement of cell and higher accumulation of food material like sugar and water in expanded cells due to foliar application of zinc, iron and boron. These results are in agreement with the [5] in Sarder guava and also [31] in peach *cv.* Sharbati. Zinc has been identified as compound of almost 60 enzymes and it has role in synthesis of growth promoter hormone which directly associated with improvement of fresh weight of fruit [26]. Application of boron helps in cell division, cell elongation, sugar metabolism and accumulation of carbohydrates [29] in Valance orange. [21] Increased berry volume with application of 0.5 % ferrous sulphate in grapes. It might be due to increased chlorophyll content in leaf which is associated with production of photosythate in plant.

Quality parameters

The data on fruit quality are furnished in [Table-2] in respect to rind thickness, pulp weight (g), juice content, total soluble solids, titrable acidity, total sugar, reducing sugar, Non-reducing sugar. Application of, zinc, iron, boron, manganese and copper recorded significantly higher in case of pulp weight (50.20 g), juice content (52.30 ml) where as in case of rind thickness it decrease (2.89 mm) in T_{15}. It might be due to production of large sized fruits with larger juice vesicles. Similar finding by [31] in peach reported decrease in peel thickness of fruit may due to improve in the internal developing of fruit in terms of better supply of water, nutrient and other compounds vital for their proper growth and development. The findings are also coincide with [28] in aonla who reported maximum amount of pulp content was might be due to foliar application of micronutrient which made rapid synthesis of metabolites particularly carbohydrate and their translocation to fruit causing relatively greater pulp content. Whereas, in case of juice content in the treatment T_{15} was increased due to accelerated rate of fruit growth more metabolites might have been diverted from leaves to fruit. The finding is in line with [12] in Kagzilime.

It is concluded that the foliar application of the combination of $ZnSO_4$, $FeSO_4$, H_3BO_4, $MnSO_4$ and $CuSO_4$ resulted in less acidic fruits having more TSS, ascorbic acid content and sugars. Increased in concentration of $ZnSO_4$ caused the increase in TSS of the fruit and in increase in the concentration of $FeSO_4$ and $ZnSO_4$ enhanced the total sugar percentage [1]. The lower acidity content may be due to high accumulation of sugar in the fruit which might have increased the TSS. It was also reported by [3] in Kinnow mandarin and [8] in pomegranate. Similar findings coincided with [15], Zinc plays an active role in the production of auxin in plant, as production of auxin increases, ascorbic acid content also increasing the TSS in Kinnow mandarin, similarly increase in the level of ascorbic acid found in sweet orange with application of micronutrient observed by [22, 30, 13]. Where as in case of sugars involvement of micronutrient in translocation of more sugar to fruits reported by [24] in papaya

Combination of micronutrient sprays proved highly helpful in the process of photosynthesis and mobilization of food material leading to accumulation of quality constituents like carbohydrates which ultimately promoted the quality attributes and quick metabolic transformation of starch and pectin into soluble compounds and rapid transformation of sugar from leaves to developing fruit [16] in mango.

Conclusion

All the treatments resulted positively with respect to yield and quality attributes. Yield maximization should be the prime objective from the farmer's point of view. Under such conditions, the treatment T_{15} ($ZnSo_4$ (0.2%) + $FeSO_4$ (0.2%) + H_3BO_3 (0.2%) + $CuSO_4$ (0.4%) + $MnSO_4$ (0.3%)) with combined micronutrients spray exhibited a superior performance regarding yield and other yield contributing characters.

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