The number of tuberous root was more with the treatment ethrel 250 ppm and the variety Co.1 had the highest root number. The influence of ethrel in increasing the number of tuberous roots may be due to its effect on tuberisation. According to Hunt *et al.* (1977) the first sign of storage root formation is generally manifested when cambial activity causes the stele enlarge during the first month of growth of a plant regenerating from stem cuttings. Garcia and Gomez (1972), observed increased rate of tuberisation as a result of ethrel with higher rate of cell division leading to early tuberisation. The highest yield was met with CCC 10,000 ppm in Co.1 variety (Table 2). Higher yield in the present study following CCC treatment is due to rapid proliferation of xylem parenchyma in the tubers leading to formation of storage roots earlier and also in greater number. Further in the study, early formation of tubers and translocation of large amount of carbohydrates from leaf and stem to storage roots through CCC application was observed. Dyson (1972) observed similar findings in potato with CCC which caused earlier formation of more uniform tubers and diverted large proportion of photosynthates to tuber growth.

REFERENCES

DYSON, P.S. (1972). Effect of Cycocel (2 chloroethyl trimethyl ammonium chloride) and Alar (N-dimethyl amino succinamic acid) on the yield of carrots. **J. Hort. Sci., 47:** 215-220.

GARCIA, L.T. and GOMEZ, C.C. (1972). Increased tuberization in potatoes by ethrel (2. Chloroethyl Phosphonic acid). **Potato Res., 15:** 71-80.

HUNT, L.A., WHOLEY, D.W. and COCK, J.H. (1977). Growth physiology of cassava (*Manihot esculenta* Crantz). **Fld. Crop. Abstr. 30**(2):77-89.

JENNINGS, D.L. (1970). Cassava in Africa. **Fld. Crop Abstr. 23**:271-275.

JUNG, J. (1967). Naturwise 54, 356. In: Effects of cycocel on crop plants in Sierra-Leone. II. Cassava. **Exptl. Agric., 12**:321-328.

MAGOON, M.L., KRISHNAN, R. and LAKSHMI, K. (1970). Association of plant tuber characters with yield of cassava **Tropical Root and Tuber Crops Newsletter** 5:29-30

(Received : June 1989 Revised : April 1997)

Madras Agric. J., 84(8): 460-463 August 1997
https://doi.org/10.29321/MAJ.10.A00895

EFFECT OF ZINC, IRON AND MANGANESE ON YIELD AND QUALITY OF SWEET ORANGE CV. SATHGUDI

D. DURGA DEVI, P.S. SRINIVASAN and K. BALAKRISHNAN

Department of Crop Physiology
Horticultural College and Research Institute
Tamil Nadu Agricultural University
Coimbatore 641 003

ABSTRACT

An experiment was undertaken during 1993-94 in six years old micronutrient deficient chlorotic sweet orange cv. Sathgudi trees to find out the effect of soil, foliar and soil + foliar application of zinc sulphate, ferrous sulphate and manganese sulphate on yield and quality of fruits. The study revealed that the soil application of 50g/plant each of zinc sulphate, ferrous sulphate and manganese sulphate combined with foliar sprays of 0.5 per cent each of the above nutrients resulted in increased fruit yield, TSS, total sugars, ascorbic acid, juice content, reduced peel content, rind thickness and acidity.

KEY WORDS : Sathgudi, zinc, iron and manganese, TSS, acidity.

Micronutrient deficiencies are very common in citrus orchards in general and sweet oranges in particular. The sweet orange cv. Sathgudi has been cultivated both as an inter crop in coffee plantations in hills and as sole crop in plains of southern India. Micronutrient defiencies cause severe reduction in growth, yield and quality of the fruits. Earlier investigations in sweet orange revealed that the micronutrient deficiencies were due to zinc, iron and manganase in Ludhiana (Kanwar *et al.*, 1963) and zinc alone in Himachal Pradesh (Chadha *et al.*, 1970). However, no such studies have been conducted in sweet orange cv. Sathgudi. Hence, the present study was carried out to find out the effect of zinc, manganese and iron on the yield and quality of Sathgudi orange.

MATERIALS AND METHODS

The study was undertaken during 1993-94 at the Horticultural College and Research Institute, Coimbatore in six years old micronutrient deficient Sathgudi orchard. The texture of the soil was sandy loam with pH 7.4, EC 0.5 dSm^{-1} and available zinc (1.04 ppm), iron (2.50 ppm) and manganese (3.06 ppm). The crop was fertilized with N, P and K @ 600, 400 and 200 g/plant as urea, super phosphate and muriate of potash and the recommended packages of practices were followed. The experiment was laidout in randomised block design treatments replicated thrice and four trees were selected for each replication. The treatment details are as follows.

Treatments

1. Control
2. Foliar application of $ZnSO_4$ (0.5 per cent)
3. Soil application of $ZnSO_4$ (150g $tree^{-1}$)
4. Soil application of $ZnSO_4$ (75g $tree^{-1}$) + Foliar application of $ZnSO_4$ (0.5 per cent)
5. Foliar application of $MnSO_4$ (0.5 per cent)
6. Soil application of $MnSO_4$ (150g $tree^{-1}$)
7. Soil application of $MnSO_4$ (75g $tree^{-1}$ Foliar application of $MnSO_4$ (0.5 per cent)
8. Foliar application of $FeSO_4$ (0.5 per cent)
9. Soil application of $FeSO_4$ (150g $tree^{-1}$)
10. Soil application of $FeSO_4$ (75g $tree^{-1}$) + Foliar application of $FeSO_4$ (0.5 per cent)
11. Foliar application of $ZnSO_4$ (0.5 per cent) + $MnSO_4$ (0.5 per cent)
12. Soil application of $ZnSO_4$ (75g $tree^{-1}$) + $MnSO_4$ (75g $tree^{-1}$)
13. Soil application of $ZnSO_4$ (75g $tree^{-1}$) + $MnSO_4$ (75g $tree^{-1}$) and foliar application of $ZnSO_4$ (0.5 per cent) + $MnSO_4$ (0.5 per cent)
14. Foliar application of $ZnSO_4$ (0.5 per cent) + $FeSO_4$ (0.5 per cent)
15. Soil application of $ZnSO_4$ (75g $tree^{-1}$) + $FeSO_4$ (75g $tree^{-1}$)
16. Soil application of $ZnSO_4$ (75g $tree^{-1}$) + $FeSO_4$ (75g $tree^{-1}$) and foliar application of $ZnSO_4$(0.5 per cent) + $FeSO_4$ (0.5 per cent)
17. Foliar application of $MnSO_4$ (0.5 per cent) + $FeSO_4$ (0.5 per cent)
18. Soil application of $MnSO_4$ (75g $tree^{-1}$) + $FeSO_4$ (75g $tree^{-1}$)
19. Soil application of $MnSO_4$ (75g $tree^{-1}$) + $FeSO_4$ (75g $tree^{-1}$) and Foliar application of $MnSO_4$ (0.5 per cent) + $FeSO_4$ (0.5 per cent)
20. Foliar application of $ZnSO_4$ (0.5 per cent) + $MnSO_4$ (0.5 per cent) + $FeSO_4$ (0.5 per cent)
21. Soil application of $ZnSO_4$ (50g $tree^{-1}$) + $MnSO_4$ (50g $tree^{-1}$) + $FeSO_4$ (50g $tree^{-1}$)
22. Soil application of $ZnSO_4$ (50g $tree^{-1}$) + $MnSO_4$ (50g $tree^{-1}$) + $FeSO_4$ (50g $tree^{-1}$) and foliar application of $ZnSO_4$ (0.5 per cent) + $MnSO_4$ (0.5 per cent) + $FeSO_4$ (0.5 per cent).

The experiment was initiated during March 1993. The micronutrients *viz.*, zinc sulphate, manganese sulphate and ferrous sulphate were given as soil application during the first week of March 1993 and subsequently first foliar spray was given. The second and third foliar sprays were given during middle of June 1993 and September 1993 respectively. The fruits were harvested at maturity and analysed for its ascorbic acid content, TSS, titrable acidity and reducing, non-reducing and total sugars. The rind thickness was measured using vernier caliper and the fruit volume was measured by displacement of water. The collected data were analysed statistically.

RESULTS AND DISCUSSION

Micronutrient application in general significantly influenced the fruit quality attributes (Table 1). The highest peel per cent (34.50) was recorded in T_1 (control) which indicated that micronutrient deficient chlorotic trees produced poor quality fruits. The application of zinc, iron and manganese either as soil or foliar or combination of both significantly reduced the peel per cent. The lowest peel per cent (20.12) was recorded due to soil application of zinc sulphate, ferrous sulphate and manganese sulphate @ 50 g/tree and foliar

Table 1. Influence of zinc, iron and manganese on yield and quality of sweet orange cv. Sathgudi

Treatment	Peel (%)	Pulp (%)	Juice (%)	Rind thickness (mm)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (mg/100g)	TSS acid (°Brix)	Acidity (%)	TSS/Acid ratio	Yield of fruits (kg/ha)
T1	34.50	45.50	38.16	7.69	3.95	2.30	1.65	36.92	6.02	0.66	9.12	12.50
T2	31.95	68.05	50.32	4.28	5.28	2.87	2.41	55.48	8.56	0.49	17.47	30.39
T3	32.27	66.73	50.54	6.02	4.54	2.34	2.20	51.50	7.62	0.50	15.24	23.36
T4	31.79	68.21	51.54	4.23	5.09	2.95	2.14	55.92	8.41	0.52	16.17	31.50
T5	33.08	54.92	44.98	5.98	4.65	2.52	2.13	39.90	7.52	0.65	11.57	20.77
T6	31.58	56.57	46.59	4.21	5.21	3.01	2.20	46.55	8.21	0.59	13.91	26.10
T7	32.41	56.59	45.85	4.92	4.95	2.60	2.35	44.51	8.72	0.63	13.84	23.69
T8	32.23	57.77	46.02	4.71	5.04	2.65	2.39	36.20	8.67	0.61	14.21	23.68
T9	32.23	58.02	45.21	5.62	4.65	2.52	2.13	37.22	7.64	0.64	11.94	21.44
T10	32.08	67.92	48.19	4.34	5.30	2.82	2.48	39.41	8.49	0.64	13.27	24.36
T11	32.75	67.25	49.32	5.45	4.88	2.50	2.38	43.81	7.92	0.53	14.92	26.08
T12	32.61	67.39	49.64	5.21	4.94	2.59	2.35	44.22	8.41	0.52	16.17	25.76
T13	22.17	69.83	48.95	4.05	6.54	3.98	2.58	47.55	8.91	0.51	17.47	49.85
T14	21.10	49.99	48.16	4.04	6.72	4.02	2.70	49.32	9.54	0.54	17.67	50.43
T15	30.69	69.31	49.21	4.12	6.18	3.81	2.37	52.60	8.78	0.58	15.14	40.98
T16	20.92	71.08	48.25	4.02	6.85	4.17	2.68	50.95	9.82	0.52	18.89	46.72
T17	23.35	59.65	40.38	4.06	6.28	3.75	2.53	48.50	9.13	0.59	15.47	39.21
T18	24.28	58.72	39.63	4.07	6.49	4.10	2.39	53.23	9.00	0.60	15.00	38.91
T19	29.27	60.25	41.85	4.11	5.45	3.25	2.20	47.93	8.38	0.58	14.45	29.14
T20	25.98	69.02	50.02	4.09	5.65	3.51	2.14	48.54	8.54	0.48	17.79	37.05
T21	27.72	69.28	53.15	4.10	5.85	3.65	2.21	57.23	8.65	0.49	17.65	39.08
T22	20.21	71.79	55.82	3.98	6.95	4.25	2.69	59.63	9.84	0.47	20.94	56.96
SEd	0.974	2.470	2.732	0.711	0.556	0.306	0.865	3.073	0.661	0.033	2.453	2.451
CD (p=0.05)	2.026	5.138	5.680	1.435	1.122	0.618	1.746	6.392	1.333	0.068	5.101	5.132

Treatment details as in the text

sprays of 0.5 per cent each of the above three micronutrients (T_{22}). Similar reduction in peel content due to micronutrient application was also reported in mandarin orange by Singh and Chohan (1982). In contrast to peel per cent, the pulp per cent was significantly increased due to micronutrient application and the highest pulp per cent was recorded in T_{22}. The juice content also followed similar trend as that of pulp per cent. This was in close confirmity with the findings of Manchanda *et al.* (1972). The lowest rind thickness (3.98 mm) was recorded in T_{22} which indicated that micronutrient application had improved the juice content by reducing the peel per cent through lesser rind thickness.

The reducing, non-reducing and total sugars of the fruit juice was significantly increased due to Zn, Fe and Mn applications. The highest total sugar (6.95%) which is a desirable quality attribute of Sathgudi was observed in T_{22}. The highest TSS (9.84° Brix) in T_{22} was due to the increased total sugar content which might be due the efficient translocation of available photosynthates for fruit juice rather than to the other parts. Similar increase in sugar content due to micronutrient application was also reported by Desai *et al.* (1991). Significant reduction in acidity of the fruit juice due to Zn, Fe and Mn application in the present study was also confirmed by Manchanda (1967). The highest TSS/acid ratio (20.94) in T_{22} was possible because of high TSS coupled with low acidity. Ascorbic acid content was also significantly improved by the application of Zn, Fe and Mn. This was possible because of the biosynthesis of ascorbic acid which was controlled by micronutrient application (Nijjar and Brar, 1977).

The yield of fruit was significantly increased by application of Zn, Fe and Mn. The micronutrient deficient (control) trees recorded the lowest yield (12.50 kg/tree) and it was increased due to micronutrient application and the highest yield (56.96 kg/tree) was obtained in T_{22}. This may be attributed to the fact that the application of Zn, Fe

and Mn relieved the trees from chlorosis and produced the healthy green leaves which in turn resulted in higher assimilate synthesis and partitioning to the fruit growth and resulted in higher fruit yield.

REFERENCES

CHADHA, K.L., RANDHAWA, N.S., BINDARA, O.S., CHOHAN, J.S. and KNORR, L.C. (1970). Citrus decline in India causes and control. **Joint publication by Punjab Agricultural University. Ohio State University. United State Agency for International Development. Ludhiana India.** p.1.

DESAI, V.T., CHOUDHARI, S.M., SHIRSATH, N.S. and KALE, P.N. (1991). Studies on the effect of foliar application of micronutrients on Mosami sweet orange. **Maharashtra J. Hort., 5**: 29-31.

KANWAR, J.S., DHINGRA, D.R. and RANDHAWA, N.S. (1963). Chemical composition of healthy and chlorotic leaves of citrus plants in the Punjab. **Indian J. Agric. Sci., 32**: 268-271.

MANCHANDA, H.R. (1967). Effect of different micronutrient sprays on chlorosis, granulation, fruit fall, yield and fruit quality of sweet orange var. Blood Red. **J. Res. Punjab Agric. Univ., 4**: 508- 515.

MANCHANDA, H.R., SHUKLA, U.C. and RANDHAWA, N.S. (1972). Effect of soil and foliar application of Zn and foliar application of Cu, Mn, Fe alone and in combination with Zn on the incidence of chlorosis, fruit fall, granulation and fruit quality in sweet orange variety Blood Red. **Indian J. Hort., 29**: 19-29.

NIJJAR, G.S. and BRAR, S.S. (1977). Comparison of soil and foliar applied zinc in kinnow. **Indian J. Hort., 34**: 130-136.

SINGH, M.I. and CHOHAN, G.S. (1982). Effect of nutritional sprays on granulation in citrus fruits cv. Wilking mandarin. **Punjab Hort. J., 22** : 52-59.

(Received : July 1996 Revised : December 1996)

Madras Agric. J., 84(8): 463-465 August 1997

PHYSIOLOGY OF CHLOROSIS IN SATHGUDI ORANGE

D.DURGA DEVI, P.S.SRINIVASAN and K.BALAKRISHNAN

Horticultural College and Research Institute
Tamil Nadu Agricultural University
Coimbatore 641 003

ABSTRACT

Studies were conducted in chlorotic trees of Sathgudi orange to find out the physiological components of chlorosis. The results revealed that the chlorotic leaves recorded low levels of zinc, iron and manganese and a higher activity of chlorophyllase and thus low chlorophyll content (yellowing of leaves). Reduced photosynthetic rate combined with low yield was recorded in chlorotic trees. Correlation analysis revealed that chlorosis had positive association with chlorophyllase activity and negative association with zinc, iron and manganese content, photosynthetic rate, chlorophyll content and yield.

KEY WORDS : Sathgudi orange, chlorosis, physiology

In Tamil Nadu, chlorosis of Sathgudi orange is assuming a serious problem. The yellowing or reduction in chlorophyll content of the leaves (chlorosis) has been reported to be due to the micronutrient deficiency (Dhingra and Kanwar, 1963). Chlorosis generally increases with the decrease in chlorophyll content which is activated by an increase in the chlorophyllase activity (Purvis and Barmore, 1991). However, much work remains to be done to find out the changes in the chlorotic component which ultimately leads to chlorosis of the leaves due to micronutrient deficiency. Hence, the present study was undertaken to find out the physiological components of chlorosis in Sathgudi orange.

MATERIALS AND METHODS

The studies were conducted on six years old, chlorotic Sathgudi orange trees in the Horticultural College and Research Institute, Coimbatore during 1994-95. The soil was sandy loam, with pH 7.5 and low in available zinc (1.04 ppm), iron (1.50 ppm) and manganese (2.50 ppm). The percentage of the chlorosis was worked out as suggested by Manchanda *et al.*, (1972) in randomly selected 22 trees. The third leaf from the top of the branch was selected for the estimation of chlorophyll (Yoshida *et al.*, 1971), photosynthetic rate (Portable Photosynthesis System), chlorophyllase activity (Almela *et al.*, 1990) and zinc, iron and manganese content (Atomic absorption spectrophotometer). The data on the fruit yield was also collected and