JKAU: Met., Env., Arid Land Agric. Sci., **vol. 7**, pp. 1-11 (1416 A.H. / 1996 A.D.)

Response of Balady and Valencia Orange Trees to Foliar Applications of Iron, Zinc and Manganese When Grown in Calcareous Soils

S.M. SABBAH and M.A. BACHA
Plant Production Department, College of Agriculture
King Saud University, Riyadh, Saudi Arabia

ABSTRACT. This investigation was carried out during 1992 and 1993 growing seasons to study the effect of foliar applications of chelated- Fe, Zn and Mn (at the rates of 500, 250 and 250 ppm, respectively) before bloom, after fruit set and/or during fruit development on the yield, fruit quality and leaf mineral composition of Balady and Valencia orange cultivars (*Citrus sinensis*, Osbeck) when grown in calcareous soils in Riyadh, Saudi Arabia.

The results revealed that spraying Balady orange trees with Fe, Zn and Mn three times per year increased the number of fruits and the yield per tree, only in the first season. Whereas, spraying Valencia orange trees two times per year significantly increased the number of fruits and the yield per tree as compared with the control, during both seasons. Spraying Balady orange trees significantly increased the fruit weight, diameter and peel thickness, but not other fruit properties compared to the control. In Valencia orange the physical properties of fruits and the total soluble solids were affected most by micro nutrient sprays.

Leaf analyses showed no obvious trends in the concentration of macronutrients of Balady and Valencia orange trees with the different treatments. However, spraying Balady orange trees did not affect leaf Fe, but increased leaf Zn and Mn as compared with the control. Meantime, increasing the number of spraying Valencia orange cultivar, gradually, increased leaf Fe, Zn and Mn concentrations, as compared with the control in both seasons.

Introduction

Although only minor quantities of the micronutrients are needed, they are indispensable to growth, yield and fruit quality of citrus trees, Labanauskas *et al.* (1963) and Koo (1988). In addition, many investigators such as Embleton *et al.* (1965) and Saad-Alla *et al.* (1981) reported that micronutrient requirements vary from area to area and even from orchard to orchard in a given area; therefore, this factor cannot be ignored to get complete information about the optimum requirements of citrus trees.

Many citrus species and cultivars are grown successfully in certain districts of Saudi Arabia. Their total production amounted to 35233 tons in 1991. Soils of the central region of Saudi Arabia, being a part of arid and semi-arid regions, are coarse-textured, high in $CaCO_3$, and low in organic matter, available Zn and Fe (Modaihsh, 1992). Similarly, Al-Mustafa (1992) reported that the extractable- Mn was the lowest in Riyadh area. Koo (1988) reported that on calcareous soils, manganese and zinc should be applied as foliar sprays to citrus trees. Likewise, Bennett (1993) found that foliar sprays of iron are effective for citrus trees.

Our investigation determined whether foliar applications of chelated- Fe, Zn and Mn could increase leaf content of the elements and thereby improve the yield and quality of fruit from Balady and Valencia orange cultivars grown in Riyadh, Saudi Arabia.

Materials and Methods

The present study was carried out during 1992 and 1993 growing seasons on 20 and 13- year-old Balady and Valencia orange cultivars (*Citrus sinensis,* Osbeck), respectively budded on sour orange rootstock and grown at Dirab Experimental and Research Station, College of Agriculture, King Saud University. The soil of the experimental orchard was classified as calcareous sandy loam. Data Presented in Table (1) show some physical and chemical properties of the soil of the experimental orchard.

TABLE 1. The physical and the chemical properties of the experimental orchard.

Texture	pH	E.C. dS / m	$CaCO_3$ %	Organic matter %	DTPA - extractable ppm		
					Fe	Zn	Mn
Sandy-loam	7.5	7.15	33.80	0.25	0.38	0.29	1.37

All trees were nearly uniform in size and were under the cultural practices ordinarily followed in the commercial orchards in Saudi Arabia. The Balady and Valencia orange trees were grown in separate plots at the same orchard. Balady orange trees were spaced at 5×5 meters apart. While, Valencia orange trees were spaced at 10×10 meters apart and were grown under palm trees. Prior to the establishment and throughout this experiment, annual fertilizer applications per tree were 20 kg organic manure added in December along with 3 kg of NPK fertilizer mixture (18- 18-5) divided into three equal doses and applied n March, May and July in each year. The trees were irrigated by flood irrigation system using about 20000-23000 mg^3/ha/year sewage water. Table (2) show the analysis of final effluent from Riyadh sewage treatment plant.

Visual symptoms of micronutrient deficiencies especially Fe, Zn and Mn frequently appear on the leaves of Balady and Valencia orange trees grown on the calcareous soil of the experimental orchard. Therefore, foliar applications of Fe, Zn and Mn are being used as nutritional sprays.

Foliar spray treatments using chelated-iron [sodium ethylene diamine di-(O-hydroxy phenyl acetate), Fe-EDDHA, containing 6% Fe] at the rate of 500 ppm Fe, zinc [sodium ethylene diamine tetra acetate, Zn-EDTA, containing 14.2% Zn] at the rate of 250 ppm Zn and manganese [sodium ethylene tetra acetate, Mn-EDTA, containing 12%Mn]

TABLE 2. Analysis of final effluent of Riyadh sewage water.

Determination		Mean	Determination		Mean
pH		7.3	Cl	(meq/L)	4.9
E.C.	(mmhos)	1.6	SO_4	(meq/L)	6.9
NH_4-N	(mg/L)	20.6	HCO_3	(meq/L)	3.2
PO_4-P	(mg/L)	7.0	Fe	(ug/L)	251
K	(mg/L)	15.5	Zn	(ug/L)	135
Ca	(mg/L)	130	Mn	(ug/L)	40
Mg	(mg/L)	28	Pb	(ug/L)	<< 2
Na	(mg/L)	146	Co	(ug/L)	<< 2

at the rate of 250 ppm Mn. Tween-20 was added to the solutions as a surfactant. Each tree was sprayed with 10 liters of solution using back sprayer. Each experimental tree was surrounded by guard trees on all sides.

The treatments were as follows :

(1) Control (trees sprayed with water).

(2) Trees sprayed with a solution containing a combination of chelated-Fe, Zn and Mn, one time before bloom in mid-March.

(3) Trees sprayed with the same solution two times, before bloom in mid-March and after fruit set in mid-May.

(4) Trees sprayed with Fe, Zn and Mn three times in mid-March, mid-May and during fruit development in mid-July.

Yield was recorded at harvest time (October 15*th* and January 15*th* for Balady and Valencia orange cultivars, respectively) during both seasons. For the determination of fruit properties, 10 fruits were taken from each tree. Fruit volume, diameter, length, peel thickness and volume of juice per fruit were measured. In juice, total soluble solids were determined using a hand refractometer, percentage of acidity (as citric acid) by titration with 0.1 N sodium hydroxide, and vitamin-C by titration with 2,6-dichlorophenol indophenol blue dye (A.O.A.C., 1980).

To determine the mineral composition, leaf samples were collected during the last week of July in both seasons. Each sample was composed of 50 leaves taken at random from non-fruiting shoots of spring flush. The leaves were washed several times with tap water, distilled water and then oven dried at 70°. The dried leaves were ground and digested with hydrogen peroxide and sulfuric acid for nutrient elements determinations (Evanhuis and DeWaard, 1980). Total nitrogen was determined colorimetrically according to Evanhuis (1976). Phosphorus was determined colorimetrically by the ascorbic acid method (Murphy and Riley, 1962). Potassium was measured against a standard using air propane flame photometer (Chapman and Pratt, 1961). Calcium, magnesium, iron, zinc, and manganese were measured using Perkin-Elmer atomic absorption spectrophotometer Model 2380.

The experimental design for the present study was a completely randomized block design, with four replicates of one-tree plot, including sixteen trees of both Balady and Valencia orange cultivars.

Analysis of variance with Duncan's multiple range test at the 0.05 level of probability for means comparison were used as statistical procedures (Steel and Torrie, 1980). The statistical analysis were made for each of Balady and Valencia data separately using SAS computer package (1986).

Results and Discussion

Response of Balady and Valencia Orange Trees to Foliar Applications of Chelated-Fe, Zn, and Mn

(1) : Yield

Data presented in Table (3) show that foliar applications of Fe, Zn and Mn three times per year gave a significant increase in the number of fruits and the yield of Balady orange trees, in the first season, as compared only with those sprayed one time. However, no significant differences were found between treatments in the second season. In Valencia orange trees, spraying trees two times, during both seasons, significantly increased the number of fruits and the yield per trees when compared with the control.

TABLE 3. Productivity of Balady and Valencia orange trees as affected by foliar applications of Chelated-iron, zinc and manganese applied to the trees in 1992 and 1993 seasons.

Numbers of foliar applications of chelated-Fe, Zn and Mn	Balady orange		Valencia orange	
	Number of fruits per tree	Yield per tree (kg)	Number of fruits per tree	Yield per tree (kg)
1992				
0 (Control)	233.0 ab	29.0 ab	108.5 b	16.5 c
1	224.5 b	28.5 b	168.5 ab	27.0 ab
2	277.5 ab	36.6 ab	198.3 a	31.3 a
3	310.0 a	40.4 a	122.3 ab	20.0 bc
1993				
0 (Control)	226.3 ab	27.1 a	170.0 b	24.3 b
1	247.3 a	29.2 a	183.8 ab	28.8 ab
2	328.5 a	43.0 a	291.8 a	45.3 a
3	237.8 a	33.4 a	197.0 ab	34.7 ab

Means not sharing the same letter within columns are significantly different ($P < 0.05$), Duncan's multiple range test.

The results were in general agreement with those obtained by Labanauskas *et al.* (1963), El-Gazzar *et al.* (1979), Taha *et al.* (1979), Saad Alla *et al.* (1981), Koo (1988) and Razeto *et al.* (1988). They worked on different orange and mandarin cultivars and found that the foliar application of Fe, Zn and Mn was more effective either alone or in different combinations at various dates and increased the yield of fruits per tree. On the other hand, Manchanda *et al.* (1972) and El-Kassas (1984) found that soil or foliar applications of Fe, Zn and Mn either alone or in different mixtures did not affect orange and lime yields. Likewise, Bacha (1975) found that Zn foliar sprays did not affect the yield of Succary and Balady orange cultivars.

(II) : Fruit Quality

(a) : Physical Properties of the Fruits: The data presented in Table (4) show that Balady orange trees sprayed with Fe, Zn and Mn, in both seasons, had no effect on fruit volume and length as compared with the control. During the second year, three applications caused a significant increased in fruit weight, diameter and peel thickness as compared with the control. Spraying trees two or three times during the second season gave a significant increase in the juice volume per fruit as compared with the control and those sprayed one time.

TABLE 4. Effect of foliar application of chelated-iron, zinc and manganese on the physical properties of Balady and Valencia orange fruits in 1992 and 1993 seasons.

Numbers of foliar applications of chelated- Fe, Zn, and Mn	Balady orange						Valencia orange					
	Fruit weight (g)	Fruit volume (ml)	Juice volume / fruit (ml)	Fruit length (cm)	Fruit diameter (cm)	Peel thickness (cm)	Fruit weight (g)	Fruit volume (ml)	Juice volume / fruit (ml)	Fruit length (cm)	Fruit diameter (cm)	Peel thickness (cm)
1992												
0 (Control)	125.4 a	152.1 a	64.8 a	6.29 a	6.61 a	0.50 a	156.9 a	168.5 a	76.0 a	6.50 a	6.65 a	0.45 a
1	127.2 a	163.3 a	66.9 a	6.50 a	6.64 a	0.51 a	168.3 a	174.5 a	77.0 a	6.83 ab	7.08 a	0.48 a
2	130.7 a	159.0 a	67.3 a	6.39 a	6.66 a	0.47 a	158.3 a	170.0 a	88.0 a	6.78 ab	6.83 a	0.50 a
3	130.5 a	153.9 a	63.0 a	6.23 a	6.60 a	0.54 a	173.7 a	180.8 a	90.5 a	7.13 a	7.20 a	0.56 a
1993												
0 (Control)	119.0 b	126.5 a	44.0 b	6.17 a	6.29 b	0.54 b	140 b	163.5 b	71.0 a	6.60 a	6.58 b	0.56 ab
1	117.0 b	123.0 a	42.8 b	6.18 a	6.16 b	0.58 ab	155 ab	171.3 b	68.3 a	6.90 ab	6.80 ab	0.52 b
2	132.0 ab	134.0 a	51.5 a	6.28 a	6.44 ab	0.58 ab	154 ab	169.5 b	76.6 a	6.70 bc	6.58 b	0.51 b
3	140.0 a	141.8 a	53.1 a	6.52 a	6.70 a	0.60 a	175 a	206.0 a	79.8 a	7.20 a	7.18 a	0.61 a

Means not sharing the same letter within columns are significantly different ($P < 0.05$), Duncan's multiple range test.

Regarding Valencia orange cultivar, data listed in Table (4) show that the influence of foliar spray treatments on the physical properties of the fruits was more noticeable in the second season. The highest values of fruit weight, volume, length, diameter and peel thickness were induced by spraying trees with the Fe, Zn and Mn three times per year. However, juice volume was not affected by the different treatments. Dube and Saxena (1971), Talakvadze (1975), Khadr *et al.* (1978) and Mdinaradze (1981) reported that the foliar applications of Fe, Zn and/or Mn on citrus trees had beneficial effects on the physical characteristics of the fruits.

(b) : Chemical Properties of the Fruits: Foliar application of chelated-Fe, Zn and Mn had no effect on the percentages of total soluble solids, acidity and vitamin-C contents in Balady orange fruits (Table 5). However, spraying Valencia orange cultivar two or three times per year, in the first season, caused a significant increase in the percentage of total soluble solids as compared with the control. No other significant differences were found among treatments.

TABLE 5. The chemical properties of Balady and Valencia orange fruits as affected by foliar application of chelated-iron, zinc and manganese applied to the trees in 1992 and 1993 seasons.

Numbers of foliar applications of chelated- Fe, Zn and Mn	Balady orange			Valencia orange		
	Total soluble solids (%)	Acidity (%)	Vitamin - C (mg/100 ml juice)	Total soluble solids (%)	Acidity (%)	Vitamin - C (mg/100 ml juice)
1992						
0 (Control)	13.1 a	1.4 a	45.1 a	12.9 a	1.6 a	38.6 a
1	13.0 a	1.4 a	46.1 a	14.1 a	1.5 a	40.7 a
2	13.6 a	1.4 a	46.0 a	14.8 a	1.6 a	41.6 a
3	14.5 a	1.4 a	47.1 a	14.8 a	1.6 a	41.8 a
1993						
0 (Control)	12.3 a	1.5 a	44.3 a	11.5 a	1.6 a	43.0 a
1	12.8 a	1.5 a	45.7 a	11.2 a	1.5 a	40.6 a
2	12.9 a	1.5 a	48.4 a	11.0 a	1.6 a	39.6 a
3	12.6 a	1.5 a	43.3 a	11.6 a	1.7 a	42.3 a

Means not sharing the same letter within columns are significantly different ($P < 0.05$), Duncan's multiple range test.

Manchanda *et al.* (1972), Nijjar and Brar (1977), Saad Alla *et al.* (1981), El-Kassas (1984), Kovanci *et al.* (1985) and Alla *et al.* (1985) working on citrus trees, found that the foliar application of Fe, Zn and Mn either alone or in different mixtures had no appreciable effect on the chemical properties of the fruits. Labanauskas *et al.* (1963), Bacha (1975), El-Gazzar *et al.* (1979) and Khera *et al.* (1985) working on different orange cultivars, found that the foliar application of Fe, Zn and Mn either alone or in different combinations improved fruit quality.

(III) : Leaf Mineral Composition

(a) : Macronutrients: Data presented in Table (6) show that spraying Balady orange trees with chelated- Fe, Zn and Mn three times per year, in the second season only, significantly increased the leaf nitrogen content as compared with the control and those sprayed one time. While, spraying the trees one time, only in the second season, significantly increased the leaf phosporus content as compared with the control. Spraying the trees one time, in the first season, and three times per year, in the second season, gave a significant decrease in leaf calcium content when compared with the control. Also, spraying trees one time, only in the first season, significantly reduced leaf magnesium content as compared with the control and those sprayed three times per year. Potassium was not affected by the different treatments.

Regarding Valencia orange cultivar, data listed in Table (7) show that spraying trees one time, in the first season, significantly increased leaf nitrogen content as compared with those sprayed two or three times per year. While, in the second season spraying trees one, two or three times per year significantly increased leaf nitrogen content as compared with the control. Spraying trees with Fe, Zn and Mn two times, only in the second season, significantly reduced leaf potassium content as compared with the con-

trol. Meanwhile, spraying trees two times, in the first season, significantly increased leaf calcium content as compared with those sprayed one or three times per year. But spraying trees one, two or three times per year in the second season significantly increased leaf calcium content as compared with the control. Spraying trees one time gave a significant increase in leaf magnesium content as compared with those sprayed three times per year, in the first season, and all of other treatments including the control, in the second season. Leaf phosphorus content was not affected by the different treatments in both seasons.

TABLE 6. Effect of foliar application of chelated-iron, zinc and manganese on the leaf mineral composition of Balady orange trees in 1992 and 1993 seasons.

Numbers of foliar applications of chelated-Fe, Zn and MN	% on dry weight basis					ppm on dry weight basis		
	N	P	K	Ca	Mg	Fe	Zn	Mn
1992								
0 (Control)	2.52 a	0.20 a	1.07 a	6.88 a	0.43 a	72.00 a	34.25 b	25.25 b
1	2.54 a	0.18 a	1.12 a	6.05 b	0.39 b	73.00 a	36.00 b	26.00 b
2	2.42 a	0.18 a	1.11 a	6.88 a	0.42 ab	92.00 a	43.25 ab	30.25 a
3	2.38 a	0.18 a	1.07 a	6.33 ab	0.43 a	63.25 a	55.00 a	27.50 ab
1993								
0 (Control)	2.15 c	0.19 b	0.94 a	6.25 a	0.41 a	56.75 a	28.00 c	32.75 c
1	2.41 bc	0.23 a	0.96 a	6.58 a	0.45 a	24.00 a	31.25 bc	42.00 b
2	2.59 ab	0.21 ab	0.91 a	6.25 a	0.45 a	57.50 a	33.50 b	51.00 a
3	2.82 a	0.20 ab	0.88 a	4.88 b	0.42 a	29.00 a	39.00 a	49.75 a

Means not sharing the same letter within columns are significantly diferent ($P < 0.05$), Duncan's multiple range test.

TABLE 7. Effect of foliar application of chelated-iron, zinc and manganese on the leaf mineral composition of Valencia orange trees in 1992 and 1993 seasons.

Numbers of foliar applications of chelated-Fe, Zn and MN	% on dry weight basis					ppm on dry weight basis		
	N	P	K	Ca	Mg	Fe	Zn	Mn
1992								
0 (Control)	2.24 bc	0.20 a	1.24 a	7.171ab	0.40 ab	86.25 a	30.00 b	25.50 b
1	2.39 a	0.20 a	1.27 a	6.75 b	0.42 a	83.25 b	26.00 c	22.00 b
2	2.27 ba	0.19 a	1.19 a	7.70 a	0.38 ab	121.50 a	30.50 b	31.00 a
3	2.14 c	0.19 a	1.23 a	6.71 b	0.35 b	126.50 a	35.50 a	33.25 a
1993								
0 (Control)	2.77 b	0.20 a	1.02 a	5.36 b	0.46 b	182.25 b	33.25 b	36.75 b
1	3.10 a	0.20 a	1.01 ab	8.00 a	0.62 a	195.75 b	33.25 b	49.00 a
2	3.08 a	0.17 a	0.93 b	8.18 a	0.33 b	305.50 a	85.00 a	51.75 a
3	3.26 a	0.19 a	0.97 ab	7.74 a	0.37 b	233.75 b	87.25 a	47.00 b

Means not sharing the same letter within columns are significantly diferent ($P < 0.05$), Duncan's multiple range test.

In general, spraying Balady and Valencia orange trees with chelated- Fe, Zn and Mn caused changes in the leaf macronutrient concentrations, but there were no obvious trend among treatments. Inconsistent results were reported by other authors. Dube and Saxena (1971) on orange, found that Zn-EDTA foliar sprays was more effective in respect of leaf N content. Manchanda (1974) on orange, found that foliar N was unaffected, but foliar P was increased by Mn and Zn + Cu + Fe sprays and decreased by Zn + Cu + Mn. Also, Rawash *et al.* (1983) on lime, found that foliar application of chelated- Zn and Mn increased leaf N, but failed to decreased leaf Ca content. On the other hand, Bacha (1975) on Succary and Balady oranges, found that Zn, Cu and Zn + Cu foliar sprays did not affect the concentrations of N, P, Ca and Mg. Similarly, Nijjar and Brar (1977) on mandarins, found that leaf N, P and K contents were little affected by Zn sprays. Also, Mann *et al.* (1985) on orange, found that the foliar application of micronutrients did not affect the levels of N, P and K in the leaves.

(b) : Micronutrients: The data in Table (6) show that spraying Balady orange trees with Fe, Zn and Mn, in both seasons, did not affect leaf iron content as compared with the control. Whereas, spraying trees three times per year, in both seasons, significantly increased the leaf zinc content as compared to the control. While, spraying trees two times, in the first season, and one, two or three times per year, in the second season, significantly increased leaf manganese content when compared with the control.

Concerning Valencia orange trees, data of both seasons presented in Table (7) show that increasing the number of spraying the trees with chelated- Fe, Zn and Mn, gradually, increased the leaf iron, zinc and manganese composition as compared with the control.

These findings were, generally, in agreement with those obtained by Manchanda (1974) on orange, who found that the foliar application of Zn, Cu, Mn and Fe alone and their combinations, increased the leaf concentrations of the elements being applied without having antagonistic effects on the other micronutrients levels. Similarly, Bacha (1975) on oranges and Nijjar and Brar (1977) on mandarins, found that Zn foliar sprays increased leaf Zn content, but leaf Fe and Mn contents, however, were little affected. Meanwhile, Rawash *et al.* (1983) on lime, found that the foliar spraying of chelated-Zn and Mn increased leaf Zn and Mn contents, but decreased leaf Fe content. Mann *et al.* (1985) on orange, found that the foliar application of Zn, Cu, Mn and Fe increased the concentrations of the respective nutrients in the leaves.

Generally, data of the soil analysis presented in Table (1) indicated that the soil of the experimental orchard contained high percentages of $CaCO_3$ and low organic matter. Also, the soil contained low extractable- Fe and Mn, according to the values obtained by Lindsay and Norvell (1978). In addition, analysis of leaves of both orange cultivars for the two growing seasons of the present study listed in Tables (6 and 7) revealed that the iron, zinc and manganese concentrations of the control trees in Balady orange ranged from 56.8 to 72, 28 and 34 and 25 to 33 ppm, respectively. Whereas, the concentration of these elements in Valencia orange trees ranged from 86 to 182, 30 to 33 and 23 to 37 ppm, respectively. It seems from the values of these elements reported by Chapman (1968) and Benett (1993) working on orange trees, that the leaf iron, zinc and

manganese were at the satisfactory levels. Hence, the discussion of the results of this investigation will be mainly concerned with studying the effect of these elements as nutritional sprays on yield, fruit quality and nutrient concentrations in the leaves of both Balady and Valencia orange trees.

Conclusion

Foliar applications of iron, zinc and manganese are being used as nutritional sprays to correct visual symptoms of micronutrient deficiencies that frequently appear on leaves of Valencia and Balady orange trees grown on the calcareous soil at Dirab Experimental and Research Station, College of Agriculture, King Saud University. Spraying Balady and Valencia orange trees with chelated- Fe, Zn and Mn caused slight increase in the yield and improved the fruit quality as compared with the control. Although, analysis of leaves in the present investigation did not indicate the existence of iron, zinc or manganese deficiency, spraying Balady orange trees with Fe, Zn and Mn had little effect on the leaf iron content, but significantly increased the leaf zinc and manganese contents. In addition, increasing the number of spraying Valencia orange trees with Fe, Zn and Mn, gradually increased the concentrations of these elements in the leaves.

References

Alla, M.A.S., El-Shourbagy, M.A., El-Nokrashy, M.A., Seleman, A.F. and **El-Wazzan, R.A.** (1985) Effect of foliar applications on different micronutrient on yield and fruit quality of Valencia orange trees. *Agric. Res. Rev.*, **59**(3): 83-92.

Al-Mustafa, W.A. (1992) Availability of manganese in calcareous soil in Saudi Arabia. *J. King Saud Univ., Agric. Sci.*, **4**(1): 127-138.

Association of Official Analytical Chemists (1980) *Official Methods of Analysis.* The A.O.A.C. 13*th* ed., Washington D.C., USA.

Bacha, M.A. (1975) Responses of "Succary" and "Balady" orange trees to foliar sprays of zinc and copper. *Indian J. Agric. Sci.*, **45**(5): 189-193.

Bennett, W.F. (1993) *Nutrient Deficiencies & Toxicities In Crop Plants.* Citrus: Chap. 17: 165-170. The American Phytopathological Soc., St. Paul, Minnesota, USA.

Chapman, H.D. (1968) The mineral nutrition of citrus. *Citrus Ind.* Vol. **II,** Chap. 3, pp. 127-289. Univ. Calif., USA.

—— and **Pratt, P.** (1961) *Methods of Analysis for Soil, Plant and Waters.* Univ. Calif. Div. of Agric. Sci., pp. 175-179.

Dube, S.D. and **Saxena, H.K.** (1971) Effectiveness of zinc chelate (Zn-EDTA) vs. zinc sulfate ($ZnSO_4$) in orange (*Citrus sinensis*, Osbeck). *Punjab Hort. J.*, **11**(3/4): 246-250 (*Hort. Abst.* **43:** 3121).

El-Gazzar, A.M., El-Azab, S.M. and **El-Safty, M.** (1979) Response of Washington navel orange to foliar applications of chelated iron, zinc and manganese. *Alex. J. Agric. Res.*, **27**(10): 19-26.

El-Kassas, S.E. (1984) Effect of iron nutrition on the growth, yield, fruit quality and leaf composition of seeded Balady lime trees grown on sandy calcareous soils. *J. Plant Nutrition*, **7**(1-5): 301-311.

Embleton, T.W., Walliha, E.W. and **Govdail, C.E.** (1965) Coastal lemons, zinc and manganese fertilization. *Calif. Citrograph*, **51:** 131, 140, 142-143, bibl. 2.

Evanhuis, B. (1976) *Simplified methods for foliar analysis.* Parts I-VII. Internal report, Royal Tropical Institute, Amsterdam.

Evanhuis, B. and **DeWaard, P.W.F.** (1980) *Principles and Practices in Plant Analysis.* Royal Tropical Institute, Amsterdam, Paper, 15: 152-163.

Khadr, A.A.; Mougheith, M.G. and **El-Ashram, M.** (1978) Influence of foliar application of some nutrient elements on growth, yield, fruit quality and leaf mineral composition of Washington navel orange trees. *Annals Agric. Sci. Moshtohor*, **9:** 138-156.

Khera, A.P., Singh, H.K. and **Daulta, B.S.** (1985) Correcting micronutrients deficiency in citrus cv. Blood Red. *Haryana J. Hort. Sci.*, **14**(1/2): 27-29. (*Hort. Abst.* **57:** 2972).

Koo, R.C.J. (1988) Citrus Micronutrients in Perspective. *Soil and Crop Sci. Soc. Florida Proc.*, **47:** 9-12.

Kovanci, I., Hakerlerler, H., Oktay, M., Ozercan, A. and **Karacali, I.** (1985) The effect of Nervanaid- Zn 14 on Zn deficiency in Satsumas of the Izmir region. *Doga Bilim Dergisi*, D2, **9**(3): 304-311. (Hort. Abst. 56: 2858).

Labanauskas, C.K., Jones, W.W. and **Embleton, T.W.** (1963) Effects of foliar application of manganese, zinc and urea on yield and fruit quality of Valencia oranges and nutrient concentrations in the leaves, peel and juice. *Proc. Amer. Soc. Hort. Sci.*, **82:** 142-153.

Lindsay, W.L. and **Norvell, W.A.** (1978) Development of DTPA Soil Test for Zinc, Iron, Manganese and Copper. *Soil Sci. Soc. Amer. J.*, **42:** 421-428.

Manchanda, H.R. (1974) Chemical composition of sweet orange leaves [*Citrus sinensis* (L.) Osbeck] as affected by foliar applications of Zn, Cu, Mn and Fe alone and their combinations- var. Pineapple. *Indian J. Hort.*, **31**(1): 34-37.

———, **Shukla, U.C.** and **Randhawa, N.S.** (1972) Effect of soil and foliar applications of Zn and foliar applications of Cu, Mn, Fe alone and in combination with Zn on the incidence of chlorosis, fruit fall, granulation and fruit quality in sweet orange [*Citrus sinensis* (L.) Osbeck] var. Blood Red. *Indian J. Hort.*, **29**(1): 19-29.

Mann, M.S., Josan, J.S., Chohan, G.S. and **Vij, V.K.** (1985) Effect of foliar application of micronutrients on leaf composition, fruit yield and quality of sweet orange (*Citrus sinensis*, Osbeck) cv. Blood Red. *Indian J. Hort.*, **42**(1/2): 45-49.

Mdinaradze, T.D. (1981) Effects of different rates of zinc fertilizers on some qualitative indices of mandarin fruit. *Subtropicheskie Kul'tury*, No. **5:** 49-51. (*Hort. Abst.* **52:** 3308).

Modaihsh, A.S. (1992) Urea and urea-based fertilizers influence on Oat forage yield, nitrogen uptake and nitrogen leaching losses. *J. King Saud Univ., Agric. Sci.*, **4**(1): 139-150.

Murphy, J. and **Riley, J.P.** (1962) A modified single solution for the determination of phosphate in natural water. *Anal. Chem. Acta.*, **27:** 31-36.

Nijjar, G.S. and **Brar, S.A.** (1977) Comparison of soil and foliar applied zinc in Kinnow mandarins. *Indian J. Hort.*, **34**(2): 130-136.

Rawash, M.A., Bondk, A. and **El-Shazly, S.** (1983) Leaf mineral content of lime trees as affected by foliar application of chelated zinc and manganese. *Annals of Agric. Sci., Ain Shams Univ.*, **28**(2): 1021-1031.

Razeto, M.B., Longueira, M.J., Rojas, Z.S. and **Reginato, M.G.** (1988) Correction of manganese and zinc deficiencies in orange. *Agricultura Tecnica*, **48**(4): 347-352 (*Hort. Abst.* **59** 7874).

Saad Alla, M.A., El-Shourbagy, M.A., El-Nokrashi, M.A., Seleman, A.F. and **El-Wazzan, R.A.** (1981) Effect of foliar applications of different micronutrients on yield and fruit quality of Valencia orange trees. *Agric. Res. Rev.*, No. **3:** 83-92.

SAS (1986) *SAS User's Guide. Statistical Analysis System.* Statistics N.C., SAS Institute Inc.

Steel, R.G. and **Torrie, J.H.** (1980) *Principles and Procedures of Statistics.* 2*nd* ed., McGraw-Hill Book Comp., New York.

Taha, M.W., El-Gazzar, A.M. and **Nawar, A.** (1979) Timing of foliar application of iron, zinc and manganese on responses and mandarin trees. *Alex. J. Agric. Res.*, **27**(1): 11-18.

Talakvadze, K.B. (1975) Foliar and soil nutrition of citrus trees with urea and minor elements. *Subtropicheskie Kul'tury*, No. **5:** 56-60 (*Hort. Abst.* 47: 3012).

استجابة أشجار البرتقال البلدي و الفالنشيا النامية في أرض جيرية للرش بالحديد والزنك والمنجنيز

صبّاح محمود صبّاح و محمد علي باشه
قسم الإنتاج النباتي - كلية الزراعة - جامعة الملك سعود - الرياض
المملكة العربية السعودية

المستخلص . أجرى هذا البحث خلال عامي ١٩٩٢ و ١٩٩٣م بغرض دراسة تأثير الرش بعناصر الحديد والزنك والمنجنيز المخلوبة قبل الإزهار ، بعد الإزهار ، و/ أو أثناء نمو الثمار على المحصول وجودة الثمار و المحتوى المعدني للأوراق في أشجار البرتقال البلدي والفالنشيا نامية في أرض جيرية بمحطة الأبحاث والتجارب الزراعية بمزرعة كلية الزراعة ، جامعة الملك سعود بديراب .

أظهرت النتائج أن رش أشجار البرتقال البلدي بالحديد والزنك والمنجنيز المخلوب ثلاث مرات ، في الموسم الأول ، أدى إلى زيادة عدد الثمار والمحصول لكل شجرة بالمقارنة بتلك التي تم رشها مرة واحدة . بينما أدى رش أشجار البرتقال الفالنشيا مرتين خلال موسمي التجربة ، إلى زيادة عدد الثمار والمحصول لكل شجرة بالمقارنة بالكنترول . كما أظهرت النتائج أيضًا أن رش أشجار البرتقال البلدي بالحديد والزنك والمنجنيز قد أدى إلى زيادة في وزن الثمار وعرضها وسمك القشرة بالمقارنة بالكنترول ، بينما كان له تأثير طفيف على حجم الثمار وطولها ووزن القشرة والنسبة المئوية للمواد الصلبة الذاتية والحموضة وكذلك فيتامين (ج) . وكان تأثير معاملات الرش في البرتقال الفالنشيا على الصفات الطبيعية واضحًا في الموسم الثاني . كما لوحظ أيضًا أن رش أشجار البرتقال الفالنشيا لم يكن له تأثير على الحموضة وفيتامين (ج) ولكنه أدى إلى زيادة مؤكدة في المواد الصلبة الذائبة في ثمار الأشجار التي تم رشها ثلاث مرات خلال العام بالمقارنة بالكنترول .

وقد أظهرت النتائج أيضًا أن رش أشجار البرتقال البلدي والفالنشيا بالحديد والزنك والمنجنيز المخلوب يؤدي إلى حدوث تغيرات واضحة في تركيز معظم العناصر الكبرى في الأوراق . وبالإضافة إلى ذلك وجد أن رش أشجار البرتقال البلدي بالحديد والزنك والمنجنيز لم يكن له تأثير على محتوى الأوراق من الحديد ، بينما زاد محتواها من عنصري الزنك والمنجنيز بالمقارنة بالكنترول . وقد أدت زيادة عدد مرات الرش في البرتقال الفالنشيا إلى حدوث زيادة مقابلة في تركيز الحديد والزنك والمنجنيز ، وذلك بالمقارنة بالكنترول خلال موسمي التجربة .