MINERAL COMPOSITION IN THE ECOSYSTEMS OF FRUIT TREES IN EGYPT
Citrus reticulata, Blanco. and *Citrus aurantium*, L.

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SUMMARY : The study aims at estimating the mineral nutrient composition of Citrus reticulata, Blanco. (Balady mandarin) and Citrus aurantium, L. (Sour orange) and its relation to soil factors in five different ecosystems in Egypt. The results indicated that Na, Mg and Fe were optimum or excessive in all locations, while K was the only element which exhibited a low or deficient range. The high percentage of $CaCO_3$ (about 25%) may cause antagonism with K uptake, so foliar application of K-fertilizers is more appropriate to correct K deficiency in Citrus locations. The leaf enrichment factor (LEF= element concentration in leaves/element concentration in soil) ratio was relatively higher for N, P, K, Ca and Fe in sandy soil, for Mg in sandy and sandy loam, for Na in sandy and clayey and for Cu and Mn in sandy loam soil. Step-wise multiple regression model reveals that pH and $CaCO_3$ concentration of soil were the most affecting factors on the concentration levels of more than 50% of the total elements in the two species.

Key Words: Citrus reticulata, citrus aurantium, ecosystems.

INTRODUCTION

Making comparisons on the basis of chemical composition between plants from different habitats, may provide some indication of how the nutrient availability in these habitats affects the concentration and rate of translocation of different nutrient elements in these plants.

Citrus is the most important fruit in Egypt as far as its acreage, production and exportation potentials are concerned (6). The total cultivated area is about 210 thousand feddan, produces about 1.300.000 tones, according to 1982 statistics (9). In terms of tonnage, citrus (32% of the whole world fruit trade) is second in volume only to banana (33%); in terms of value, it is the most important fruit crop. The total world production exceeds 22 million tones, grown on 1.4 million hectare (10).

This paper is the first in a series aiming at evaluating the mineral composition of some fruit trees in Egypt. It gives an account on the mineral nutrient composition of two evergreen fruit trees: *Citrus reticulata*, Blanco. (Balady mandarin) and *Citrus aurantium*, L. (Sour orange) grown in different locations in Egypt. The information obtained may provide an idea about the nutritional status of these fruit trees and its relation to the edaphic factors of their habitats.

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MATERIALS AND METHODS

The selected sites

The orchards selected for the present study represented a wide range of environmental conditions (Table 1). Two were located in El-Behira governorate (1. El-Tarh orchard, about 15 km east of Alexandria, and 2. El-Bousseli orchard, about 75 km east of Alexandria), two in the New Valley (3. El-Dakhla Oasis orchard, about 150 km west of El-Kharga oasis and 450 km west of the Nile Valley, and 4. El-Farafra oasis orchard, located at about 350 km west of Assuit city and about 120 km north west of El-Dakhla oasis) and one in Kafr El-Sheikh governorate (5. Desouk orchard, about 85 km south east of Alexandria). The trees in El-Tarh and El-Bousseli orchards were fertilized with organic manure at a rate of about 20-40 kg/tree. Urea was added two times a year at a rate of about 600 gm/tree, once at the beginning of the growing season in March, and another time at the maximum vegetative activity in June. The two orchards were irrigated with Nile water 6-8 times during the growing

Table 1 : Climatic characteristics of the different locations in the present study (2).

Locations	Mean minimum temperature	Mean maximum temperature	Mean minimum R. humidity	Mean maximum R. humidity	Evapotraspiration (mm/day)
I and II	8.2	35.7	60	72	4.63
III	4.4	38.6	25	48	6.52
IV	3.9	37.6	27	53	6.30
V	12.6	33.6	54	72	4.31

season. The trees in El-Dakhla and El-Farafra oasis orchards were grown without any fertilization and received irrigation water by a number of small canals from wells 5-6 times during the growing season. Desouk orchard trees were fertilized only with organic manure at a rate of about 30-50 kg/tree, and were irrigated with Nile water 5-7 times during the growing season.

Sampling and analysis technique

Five representative trees of each orchard were selected for sampling of plant material and the soil underneath. The trees were of about the same size and age (15 years).

Five samples of each organ (leaves, branches and roots) were taken from each orchard. The organs were then washed with tap water, and rinsed 4 times with distilled water. After oven-drying to a constant weight at 65°C, the samples were ground using a Weily mill and digested with triple acid reagents (HNO_3: H_2SO_4: $HClO_4$ 10: 1:1). Plant digests were analyzed using an atomic absorption spectrophotometer for K, Na, Ca, Mg, Cu, Fe and Mn. N and P were determined, by micro-Kjeldahl and Stannous chloride methods, respectively. The total ash content was determined by ashing the samples for three hours at 500°C. At each orchard, four soil samples were taken from beneath each of the relevant species at the zone of active roots (30-60 cm). The samples were analyzed for physical and chemical properties.

The samples of plant material and soil were collected during the period of maximum vegetative growth (August-September). The leaves and branches were sampled from the fruitless spring shoots. The procedures of analysis were outlined by Allen *et al.* (1).

RESULTS

Soil properties

The data concerning physical and chemical properties of the soil are presented in Table 2. Generally, the soils in location I and II were closely similar in most of their properties. The main difference between location III and IV lies mainly in their texture (sandy loam and sandy soil, respectively) and consequently in their capacity to retain water. Location V exhibited distinct properties, where the soil is loamy and attained the highest total organic matter content and water holding capacity if compared to all other locations. With respect to the concentrations of different minerals, the soil in location V attained the maximum concentrations of N, P, K, Mg and Cu, while those of Ca and Fe were attained in location III. Na and Mn respectively attained their maximum concentrations in locations II and IV.

Table 2 : Physical and chemical properties of soil collected beneath trees of *Citrus reticulata* and *Citrus aurantium* grown in different locations in Egypt.

Location	Species	H.M. %	W.H.C. %	Porosity %	Bulk density g/cm^3	Loss in ignition % dry wt	E.C. mmohs/cm	pH	$CaCO_3$ %	HCO_3 m.e./L	% Soil texture: Send	Silt	Clay	Nutrient concentration (mg/gm): N	P	K	Na	Ca	Mg	Cu	Fe	Mn
El-Tarh I	C. reticulata	0.0668	24.20	13.14	1.57	0.997	0.18	8.45	24	1.0	96.35	2.50	1.15	0.96	0.049	0.04	0.025	0.8	0.12	1.1	3	1.4
	C. aurantium	-	25.15	11.11	1.59	1.154	0.29	7.97	26	1.5	97.15	1.70	1.15	0.67	0.037	0.08	0.040	0.8	0.18	1.1	5	1.8
El-Bouss II	C. reticulata	0.0628	26.83	11.11	1.59	0.549	0.15	8.12	25	1.0	97.65	0.40	1.95	0.63	0.042	0.03	0.01	0.4	0.06	1.2	2.0	1.25
	C. aurantium	0.0583	27.24	12.03	1.50	0.608	0.22	8.12	28	1.0	93.65	5.15	1.20	0.96	0.040	0.02	0.05	0.8	0.18	1.1	1.5	1.60
El-Dakhla III	C. reticulata	1.368	44.62	11.90	1.34	4.120	0.19	7.63	19	1.5	51.95	33.2	14.85	2.86	0.158	0.10	0.02	0.8	0.42	1.2	65	1.4
	C. aurantium	1.525	47.02	12.80	1.26	5.133	0.25	8.15	12	1.5	43.2	41.7	15.10	2.35	0.138	0.23	0.035	2.7	0.48	1.2	53.6	1.4
El-Farafra IV	C. reticulata	1.029	36.90	13.74	1.40	3.49	0.25	8.04	20	1.5	69.55	15.3	15.15	1.94	0.081	0.11	0.020	1.7	0.24	0.5	3.5	2.5
	C. aurantium	1.069	36.87	14.39	1.40	3.74	0.25	8.03	19.4	1.5	80.60	7.3	12.10	1.78	0.093	0.10	0.025	2.0	0.3	0.4	3.5	2.0
Desouk V	C. reticulata	6.095	52.62	14.72	1.30	10.72	0.43	7.97	18	2.0	40.0	28.25	32.75	3.42	0.142	0.32	0.021	2.6	0.66	1.1	2.5	2
	C. aurantium	5.74	49.73	12.70	1.29	10.48	0.43	8.13	16	2.5	39.4	31.6	29.80	3.81	0.173	0.44	0.025	1.7	1.21	1.1	2.5	1.75

H.M. : Hygroscdpic moisture, W.H.C. : water holding capacity, E.C. : Electric conductivity

Table 3 : Elemental concentrations (mg/gm dry weight) in leaves, branches and roots of *Citrus reticulata* grown in different locations in Egypt.

Elements	Location organs	El-Tarh I	El-Bousseli II	El-Dakhla III	El-Farafra IV	Desouk V	L.S.D.	
							0.05	0.01
N	Leaves	22.40	18.200	29.960	21.000	26.300	2.490	3.900
	Branches	12.50	8.960	18.200	7.300	3.640	1.100	1.730
	Roots	8.40	13.160	7.300	11.200	7.000	1.080	1.700
P	Leaves	0.650	1.100	3.250	2.370	1.750	0.397	0.622
	Branches	0.850	0.650	1.120	1.120	0.870	0.270	0.423
	Roots	0.150	0.850	1.370	0.750	0.500	0.230	0.361
K	Leaves	7.400	3.800	4.000	8.300	6.600	1.970	0.622
	Branches	3.200	3.100	5.800	3.500	5.400	0.270	0.423
	Roots	2.300	3.100	2.800	2.700	1.300	0.230	0.361
Na	Leaves	2.300	2.500	1.000	1.500	8.300	1.520	2.380
	Branches	2.900	1.600	1.000	1.100	2.800	1.370	2.140
	Roots	2.500	1.600	0.900	0.900	4.400	1.360	2.140
Ca	Leaves	35.000	21.000	18.000	32.000	20.000	4.380	6.868
	Branches	10.000	22.000	22.000	32.000	10.000	6.080	9.540
	Roots	9.000	14.000	50.000	80.000	6.000	6.030	9.450
Mg	Leaves	9.000	16.200	8.400	22.800	6.000	2.300	3.600
	Branches	7.200	3.000	1.800	4.800	1.800	2.080	3.270
	Roots	1.800	12.600	9.000	2.400	2.400	1.850	2.900
Cu	Leaves	0.011	0.020	0.018	0.020	0.021	0.004	0.006
	Branches	0.099	0.024	0.011	0.110	0.014	0.017	0.026
	Roots	0.011	0.068	0.011	0.005	0.015	0.003	0.005
Fe	Leaves	0.135	0.150	0.080	0.215	0.340	0.020	0.031
	Branches	0.090	0.105	0.065	0.110	0.130	0.012	0.018
	Roots	0.300	0.670	0.050	0.045	0.140	0.165	0.259
Mn	Leaves	0.020	0.017	0.006	0.031	0.020	0.013	0.021
	Branches	0.006	0.006	0.004	0.009	0.009	0.004	0.006
	Roots	0.016	0.100	0.014	0.011	0.021	0.009	0.014
Ash	Leaves	155.900	120.200	104.400	180.200	135.400	0.569	0.893
	Branches	69.900	72.100	82.200	90.200	82.100	0.219	0.343
	Roots	51.200	184.900	68.700	39.400	57.600	0.146	0.229

Table 4 : Elemental concentrations (mg/gm dry weight) in leaves, branches and roots of *Citrus aurantium* grown in different locations in Egypt.

Elements	Location organs	El-Tarh I	El-Bousseli II	El-Dakhla III	El-Farafra IV	Desouk V	L.S.D.	
							0.05	0.01
N	Leaves	21.600	12.320	23.800	16.800	25.200	1.674	2.625
	Branches	9.300	7.840	12.600	8.960	5.900	1.845	2.894
	Roots	8.100	10.080	9.800	5.300	10.900	2.065	3.234
P	Leaves	0.600	0.600	0.870	0.500	0.870	0.334	0.523
	Branches	0.650	1.000	1.120	0.750	1.750	0.354	0.556
	Roots	0.200	3.000	1.120	1.120	0.810	1.658	2.601
K	Leaves	6.700	2.600	3.600	5.700	8.000	1.235	2.012
	Branches	7.700	4.900	3.000	3.300	4.900	1.618	2.537
	Roots	2.700	4.500	2.800	8.900	1.850	2.008	3.149
Na	Leaves	1.700	3.000	1.900	1.050	1.500	0.927	1.454
	Branches	1.350	1.800	1.050	0.850	2.000	0.501	0.786
	Roots	2.300	2.800	1.000	1.100	3.200	1.336	2.095
Ca	Leaves	9.000	40.000	30.000	24.000	13.000	6.704	10.514
	Branches	30.000	14.000	17.000	28.000	3.750	6.802	10.668
	Roots	11.000	16.000	20.000	18.000	8.000	5.206	8.164
Mg	Leaves	9.600	6.000	12.000	6.600	7.200	3.352	5.257
	Branches	7.800	3.000	16.200	1.800	3.000	2.930	4.590
	Roots	1.200	3.000	7.800	7.200	1.800	2.462	3.861
Cu	Leaves	0.010	0.001	0.017	0.0097	0.015	0.003	0.004
	Branches	0.010	0.010	0.014	0.0097	0.011	0.002	0.003
	Roots	0.010	0.034	0.011	0.0120	0.029	0.008	0.012
Fe	Leaves	0.160	0.280	0.120	0.135	0.180	0.084	0.131
	Branches	0.125	0.100	0.085	0.065	0.120	0.045	0.071
	Roots	0.305	0.120	0.055	0.060	0.140	0.327	0.513
Mn	Leaves	0.020	0.007	0.022	0.025	0.014	0.016	0.026
	Branches	0.007	0.003	0.011	0.005	0.010	0.002	0.004
	Roots	0.011	0.078	0.046	0.014	0.015	0.004	0.006
Ash	Leaves	132.000	175.900	187.700	183.800	100.000	2.972	4.660
	Branches	74.400	7.030	127.700	121.700	67.300	2.300	3.606
	Roots	42.500	15.410	68.800	55.900	51.200	1.955	3.065

Mineral element concentration

The mineral element concentrations (mg/gm dry weight) in leaves, branches and roots of *Citrus reticulata*, Blanco. and *Citrus aurantium*, L. grown in different locations are given in Tables 3 and 4.

The N concentration varied between 3.64 to 29.96, and from 5.9 to 23.8 mg/gm in *C. reticulata* and *C. aurantium* respectively. Higher levels occurred in leaves than in branches or roots. Location III and V attained the maximum concentrations, respectively, for the two species, while the minimum was attained in location II.

In *C. aurantium* P was one of the elements for which the concentration in branches and roots reached or exceeds that in leaves. In location I and V, P attained the highest values in branches while in locations II, III and V the highest values were attained in roots. In contrast, the leaves in *C. reticulata* attained the highest concentration in all locations except location I where the concentration in branches slightly exceeded that in leaves.

K was one of the least variable nutrient element. Its concentration ranged from about 1.3 to 8.3 and from 1.85 to 8.9 mg/gm in *C. reticulata* and *C. aurantium* respectively. The highest concentrations were attained in leaves of *C. reticulata* in all locations except location III where the concentration in branches was the highest. In *C. aurantium* the highest concentrations were attained in roots in location IV, by leaves in locations III and V, and by branches in locations I and II.

Na concentration in *C. reticulata* did not differ much between organs in the locations I, II, III and IV, while in location V the values in branches and roots were at least one-half that in leaves. In *C. aurantium*, the roots achieved their highest concentrations in locations I, IV and V. In the last location, the concentration in roots were more than two times that in leaves.

Ca concentration varied considerably, in a range of about 6.0 to 80 and of 3.75 to 40 mg/gm in *C. reticulata* and *C. aurantium* respectively. In the former Species, roots accumulated much more Ca than leaves and branches in locations III and IV, while in the latter species the leaves accumulated more Ca than branches and roots in locations II, III and V.

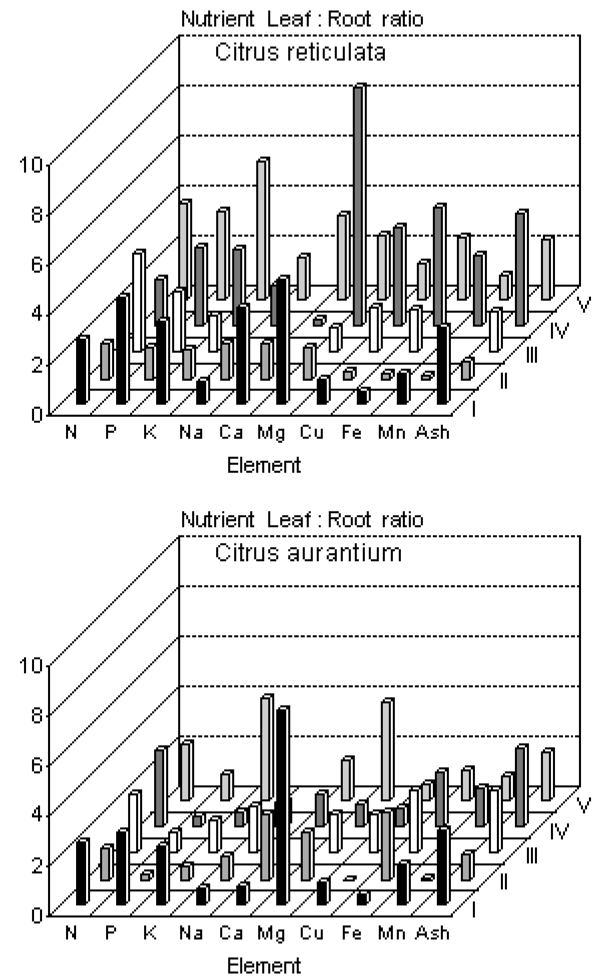
In *C. reticulata*, Mg attained its highest concentrations in leaves in locations I, II, IV and V, while in *C. aurantium* the highest concentrations were in locations I, II and V. In the two species, the concentration ranged, from 1.8 to 22.8 and from 1.2 to 16.2 mg/gm respectively.

The concentration of micronutrient elements varied considerably. The highest concentrations of Fe and Mn in *C. reticulata* were attained by roots in locations I and II, and however leaves nearly exceeds in the other locations. Branches achieved the highest concentrations of Cu in locations I and IV. In *C. aurantium* the roots attained the highest concentrations of Cu in locations II, IV and V, of Fe in location I and of Mn in locations II and III.

The ash content was generally higher in leaves of both citrus species as compared with that in branches and roots in all locations, except in location II where roots attained higher ash content more than leaves.

The analysis of variance was applied to assess the significance of variations in nutrient concentrations with organ and location. In most cases, the variations in concentrations of most elements were highly significant ($P<0.01$) except for Mn in branches of *C. reticulata* and for Fe, Mn and P in branches and roots, in leaves and roots, and in leaves, respectively, of *C. aurantium*. Differences in concentrations between each location and all the other locations as evaluated by the LSD-test were in most cases significant.

Figure 1: Nutrient leaf: root ratio in *Citrus reticulata* and *Citrus aurantium* grown in different locations of Egypt.



I: El-Tarh, II: El-Boussile, III: El-Dakhla, IV: El-Farafra, V: Desouk

Nutrient leaf/root ratio

The magnitude of translocation of elements from roots to leaves, judged by nutrient leaf: root ratio is presented in Figure 1. In *C. reticulata*, N attained its highest ratio in location III, Na in location V, Ca in location I and Mg, Cu and Fe in location IV. In *C. aurantium*, the highest ratio for N was in location IV for Na and Cu in location III, for Ca and Fe in location II and for Mg in location I. Moreover, the two species coincided for the same element in the same location. For example; the highest ratio for P was attained in location I, for K in location V and for Mn and ash in location IV.

Leaf enrichment factor (LEF)

Figure 2 illustrates the relationship between the leaf enrichment factor (LEF=element concentrations in leaves/element concentrations in soil) and the concentration of each element in the soil under the two citrus species.

It may be noted that the elements N, P and Cu were concentrated more in leaves of *C. reticulata* than in *C. aurantium* in all locations except the location I. On the other hand *C. aurantium* achieved high LEF values for Na, Ca and Fe in locations I, II and III while the values were high for *C. reticulata* in location IV and V.

For K, Mg and Mn, high values were attained by *C. aurantium* in locations I and III, locations I, III, V and in locations I, III and IV respectively. Nevertheless, *C. reticulata* achieved high values in locations II, IV and V, in locations II and IV and in locations II and V, respectively, for the three elements.

With respect to the magnitude of the LEF, the values tended to be in the following descending order: (K, Na and Fe) > (Ca and Mg) > (N, P, Mn and Cu). The first group was consistently more concentrated in all locations except in location III and V for each of K and Na and in location I and III for Fe. In the second group, Ca LEF value was very low in all locations except location II while the reverse somewhat was true for Mg, where all locations exhibited high values. For the third group, all locations were characterized by having high values for N, P, Mn and Cu.

The relationship between average LEF for the two citrus species and the concentrations of elements in soil is presented in Figure 3. With the exception of Mn, significant negative correlations were found between LEF values for each element and soil concentrations of the same element.

Figure 2: Leaf enrichment factor (LEF) for *Citrus reticulata* (□) and *Citrus aurantium* (■) grown in different locations in Egypt (I: El-Tarh, II: El-Boussile, III: El-Dakhla, IV: El-Farafra and V: Desouk).

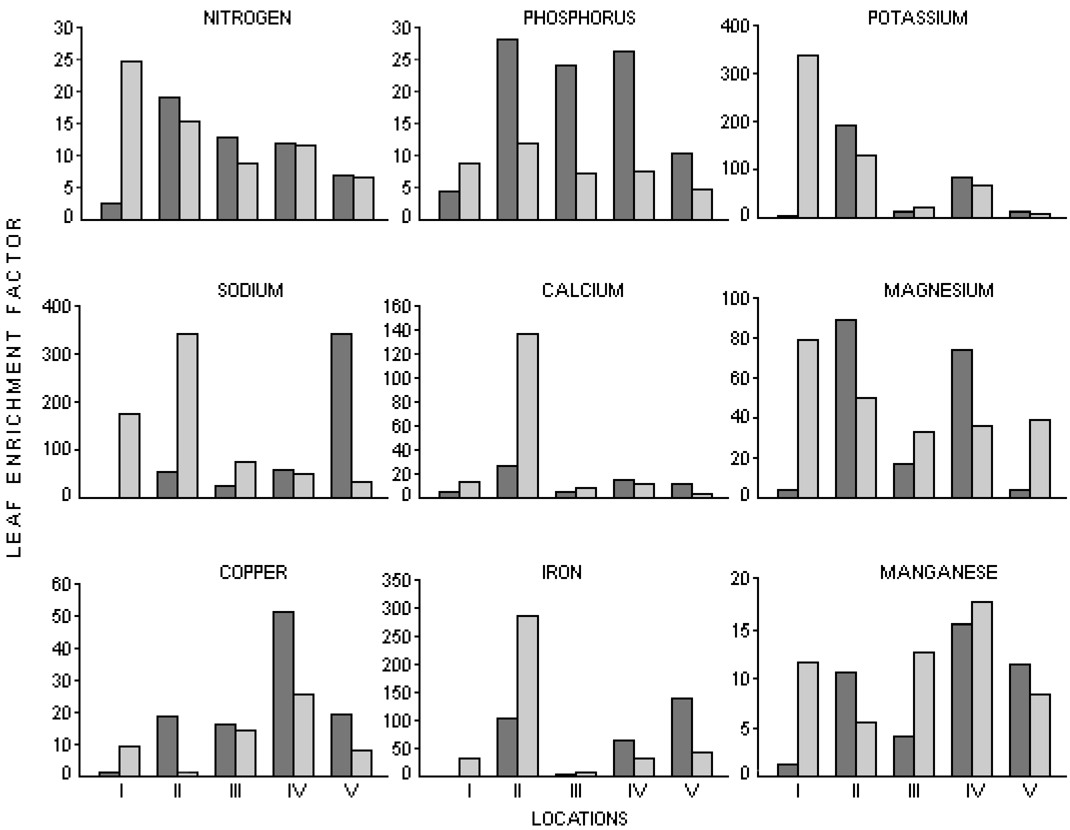
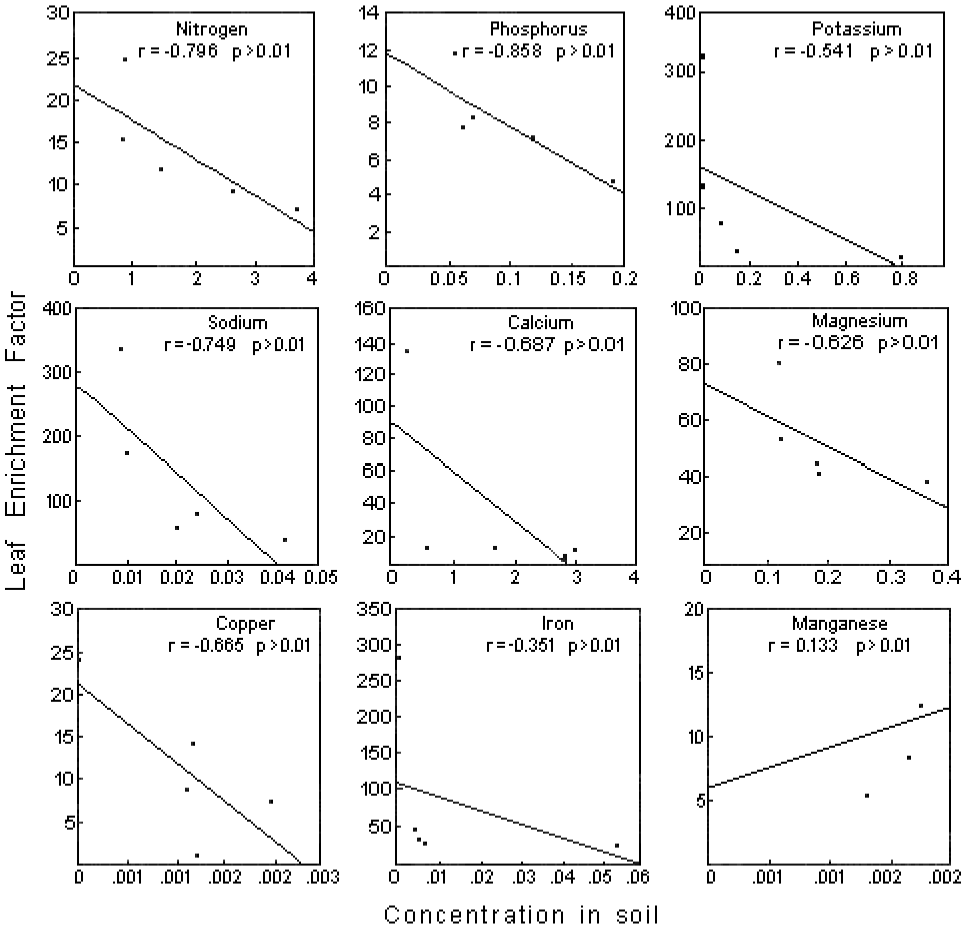


Figure 3: The leaf enrichment factor for nine mineral elements in relation to the concentration (mg/gm) of these elements in the soil (the average of the two citrus species).



DISCUSSION

In making comparisons between plants from different habitats with specific soil and environment, two approaches are possible. The first is to compare the chemical composition of unrelated plant species from different habitats which differ markedly in their nutrient status. The second approach (the method adopted here) is to investigate the same plant species or a number of closely related species a long number of different habitats with a different nutrient gradient (11).

The plant offers a more promising means of diagnosing nutrient status and fertilizer requirements than the soil. At the same time it is recognized that the overall evaluation of plant condition, fertilizer requirements, and recommended soil management practices will require considerable soil and management information in addition to what is furnished by the analysis of the plant. In the present study, the concentrations of different elements in leaves of *Citrus reticulata*, Blanco and *Citrus aurantium* L. were compared with the ranges suggested by many workers as Reuther and Smith (16), Chapman (3) and Embleton *et al.* (7). The results indicate that for the two species N was optimum in location I, III, and V while Na, Mg and Fe were optimum or excessive in all locations. On the other hand, K was the only element which exhibited a low or deficient range in all locations. Mn seems to be low or deficient in all locations for *C. aurantium* and in locations I, II and III, for *C. reticulata*. The deficiency has also been confirmed in the orchards and sprays with 0.45% $MnSO_4$ (28% Mn) with 0.36 $ZnSO_4$ (36% Zn) was recommended by Ministry of Agriculture (meeting with 19 orchard's owners). There was no indication of low values for Cu or Fe. The correction of trace deficiencies may improve the citrus orchard. For example, it improves acidity, soluble solids, sugar and vitamin C contents (10).

In the present study one may suggest a mean for correcting the K problem in the five locations by soil application of either K_2SO_4 or KNO_3 or sprays of both. The selection of the appropriate method depends in large

Element Variable	Species	N	P	K	Na	Ca	Mg	Cu	Fe	Mn
Texture	C.ret. C.aur.	**a 145.84 *a 7.58	- - - -	- - - -	**a 89.93 **a 69.59 **d	- - - -	- - - -	- - - -	**a 35.66 **a 87.84	- - **a 12.87
O.M	C.ret. C.aur.	- - - - **b	- - - -	- - - -	16.34 - -	- - - -	- - - -	- - - -	- - - -	- - - -
W.H.C.	C.ret. C.aur.	131.80 *b 4.66	- - - -	- - - -	- - - - *b	- - - -	- - - -	- - - -	- - **b 231.35	- - **b 117.28 **a
H.M	C.ret. C.aur.	- - -.-	- - - - **	- - - -	7.30 - -	- - - - *	- - - -	- - - - **b	- - - - **b	18.10 - - **b
pH	C.ret. C.aur.	- - c 2.87	45.19 * 6.03	- - **a 13.15	- - **b 37.46 **c	8.86 - -	- - - -	91.67 - - **c	14.65 - - **c	12.36 - -
E.C	C.ret. C.aur.	- - - - **c	- - - -	- - - - *b	34.72 - -	- - - -	- - - -	78.67 - -	158.57 - -	- - - -
$CaCO_3$ (%)	C.ret. C.aur.	69.81 - -	- - - -	9.66 **b 10.54 **a	- - **c 148.46	- - - -	- - - -	- - ** 18.22	- - **c 21.00	- - **c 104.83 **c
Air Temp.	C.ret. C.aur.	- - - -	- - - -	32.40 **c 19.56	- - - -	- - * 7.94	- - - -	- - - -	- - - -	35.47 - -

C.ret: Citrus reticulata. C.aur: Citrus aurantium. *: Significant at 0.05. **: Significant at 0.01
Letters a,b and c indicate the arrangement of importace of the variables.

extent on the $CaCO_3$ content of the soil. Crop plants especially apple, citrus, grapevine, peanut, soybean, sorghum, and dry-land rice (12, 13) mentioned that the high $CaCO_3$ content of most Citrus soils may depress K uptake. Antagonism of ions in plant uptake has been discussed by Epstein (8) and by Mengel and Kirkby (14). An experiment in the Morphou area in Cyprus compared soil and spray application of K in its effects on leaf K content and yield. The results of this experiment indicate that soil application of K failed to raise leaf K content but sprays increased it ($CaCO_3$ % was about 25). In our results the $CaCO_3$ ranges between 16-28%; a value may cause antagonism with K uptake, so foliar application of K fertilizer may consider the more suitable application to correct the K deficiency in Citrus locations. Phosphorus deficiency occurred in some locations in the present study may correct by foliar application of polyphosphate. Hernando (10) stated that foliar application of P as polyphosphate offers great possibilities, being very efficient and economical as so much up to 4/5 applied to the soil is not available in the first year to the plant. Finally it must be taken into account in making fertilizer recommendations, the level of one nutrient in the fertilizer used can considerably affect other nutrients in the leaf. Sometimes a nutrient deficiency can be more easily corrected by reducing the rate of another than by applying more of the first.

Hernando, (10) reviewed that, soil and climate are both important, but citrus is particularly demanding of climate. He added that the trees will tolerate a considerable variety of soils, from sandy to clay loam, though the sandy loams are the best. Good structure and permeability are more important than the texture, and the depth of soil should be 1.5 meter or more. Shalhevet *et al.* (17) stated that the physical and chemical properties of a soil are of prime importance in citrus culture than climate.

In the present study the edaphic factors were only available rather than climatic factors. Step-Wise regression model was used to select the most important factors that may affect the concentration levels of most nutrients in leaves of *Citrus reticulata* and *Citrus aurantium*. The independent variables introduced to the model were mainly edaphic factors as, electric conductivity (EC), organic matter (OM), texture, pH, $CaCO_3$ concentration, water holding capacity (WHC), and hygroscopic moisture (HM), in addition to air temperature. The following table summarize the variables selected by the model that may have a great influence upon each element.

One Way ANOVA was used to asses the significance of variation between the different variables introduced to the model. It is remarkable that the F-values for most variables and elements were highly significant. It is obvious that the F-values was significant in all cases except for N in *Citrus aurantium* for the pH variable. It may be noted that Mg was the only element that did not affected by any one of the variables introduced in the model. It is worth to mention that the two variables; pH and $CaCO_3$ concentration of the soil were the most affecting factors on the concentration levels of more than 50% of the total elements in *C. reticulata* and *C. aurantium* respectively.

The use of species within one genus for comparative studies clearly reduces much variation due to the morphological and physiological differences that are seen in species from different families (11). However, the two species used in the present study come from a range of habitats which differed particularly in soil fertility and also in altitude and topography. The percentages of available nutrients rather than their absolute amounts must be considered in correlating the chemical composition of the vegetation with the underlying soil properties. Page and Martin (15) mentioned that although NH-acetate extractable K was essentially the same in San Joaquin sandy soils and Sierra soils (20 ppm) of California, the citrus plants grown in the first soil uptaked approximately twice as much as K as those in Sierra soil. This was attributed to the fact that extractable K was 0.3% for Sierra soil in comparison to 0.8% for San Joaquin soil. Unfortunately, the amount of elements uptaked not estimated in the present study, but a ratio of element concentration in leaves to that in soil (leaf enrichment factor=LEF) was calculated. Such ratio is more dependent on absolute values of concentration rather than the percentages of their relative amounts. Shehata (18) calculated the LEF for some nutrient elements as affected by soil types in grapes, oranges, olives and guavas. He found that the gravely soil for N and P, sandy soils for K, Ca, Mg and Na, sandy loam for Cu, Fe and Mn and clayey soils for Zn were characterized by having high LEF in the four fruit species. In the present study higher ratios were attained in sandy soils for N, P, K, Ca and Fe, in sandy and sandy loam for Mg, in sandy and clayey for Na and in sandy loam for Cu and Mn. This may indicate that the LEF of most elements tended to increase as the surface area of soil particles decreased i.e. decreasing clay content of the soil decreased cation adsorption capacity and this increasing the uptake of certain ions by plant roots. Significant negative correlations were found between LEF for each element and soil concentrations of the same element. This may indicate that the citrus species exhibits a feature of accumulating most nutrient elements in its vegetative parts against their concentrations in soils. Such conservative feature in citrus cultivations makes it possible to survive to some extent the limited nutrient resources in different locations. This behavior is also demonstrated by El-Darier (4, 5) for olive and fig cultivations in the western desert of Egypt. The previous conclusion may support the idea that citrus trees behave in response the prevailing conditions in a similar way as that of most desert trees.

CONCLUSIONS

We arrived at the following conclusions:

1. K was the only element that have a low or deficient range in all location. High $CaCO_3$ content may cause antagonism with K uptake.

2. Mn was deficient in all locations for *C. aurantium* and in location I, II and III for *C. reticulata*.

3. The LEF attained higher values for most elements in sandy soils and tended to increase as the surface area of soil particles decreased.

4. Citrus trees have the ability to accumulate nutrients in higher concentrations in their vegetative parts relative to their soils. This may indicate an adaptational strategy to meager concentrations of nutrients in the different locations.

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