EFFECT OF ROOTSTOCKS ON THE LEAF MINERAL CONTENT OF CITRUS

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ABSTRACT

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Leaves from 'Valencia', 'Hamlin' and 'Washington Navel' oranges grown on 'Rangpur' lime, 'Cleopatra' mandarin, 'Sour Orange', 'Troyer' citrange and 'Rough Lemon' rootstocks were analzed for N, P, K, Ca, Na, Cl, Fe, Mn, Cu and Zn. Significant differences among rootstocks were obtained for K, Ca, Ca/K, Na and Cl, but not for N, P, Fe, Mn, Zn and Cu. Scion leaves on 'Cleopatra' mandarin tended to be low in K and high in Ca/K and those on 'Rangpur' lime were high in K and low in Ca and Ca/K. 'Troyer' citrange induced higher uptake of Na and Cl than all other rootstocks. 'Washington Navel' leaves contained more Fe, Zn, Cu and Mn, and less Na, than 'Hamlin' or 'Valencia' leaves. 'Valencia' leaves contained more Ca and less K than the other two cultivars. The nutritional status of the trees was slightly low in N, K and Mn, optimum in Fe, Zn and Cu, normal-to-high in P, and contained non-toxic levels of Na and Cl. The statistical interaction of root stock and scion was found non-significant.

Keywords: citrus; minerals; rootstocks.

INTRODUCTION

The nutritional status is known to be one of the most important factors in citriculture. Different citrus rootstocks have been found to exert an important influence on the mineral composition of the scion leaves with respect to macro- and micro-nutrients (Sharpless and Hilgeman, 1972; Procoplou and Wallace, 1974; Wallace et al., 1979). Leaves of different citrus cultivars were also reported to vary in mineral composition (Embleton et al., 1973; El-Gazzar et al., 1974). The physiological interaction of scion and rootstock and its effect on the uptake of nutrients has not been extensively studied. Smith (1975) reported that citrus scion cultivars had affected Na, Al, Cu and Mg, and had the least effect on P. Rootstocks influenced citrus content of B,

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K, Cu, P and Na, but had the least effect on N. In another study on grapefruit (Wutscher and Shull, 1975), rootstocks were found to influence most fruit quality parameters, and also the leaf content of N, K, Mg, Na, Mn, Cu and B. In apples, Nagai and Ishii (1980) reported a significant stock—scion interaction in regard to N, P, K, Ca and Mg. Unlike citrus, apple scions had a more pronounced effect on the leaf mineral composition than rootstocks.

The present work was undertaken as a part of a long-term research program, started in February 1972, to study the performance of 'Rough Lemon', 'Troyer' citrange, 'Cleopatra' mandarin and 'Rangpur' lime rootstocks, under Libyan conditions, in order to find a possible replacement for the *tristeza*-susceptible 'Sour Orange' rootstock. The 'Sour Orange' rootstock is now the one most commonly used by citrus growers in Libya. Some orange trees grown on it were suspected of being infected with *tristeza* virus (Nour-Eldin and Fudl-Allah, 1976).

The objective of this work was to study the interaction between these rootstocks and three orange cultivars, namely 'Hamlin', 'Washington Navel' and 'Valencia', and their effect on the nutritional status of the trees.

MATERIALS AND METHODS

Three sweet orange cultivars (*Citrus sinensis* L. Osbeck) ('Washington Navel'; 'Valencia'; 'Hamlin') budded on 5 different rootstocks ('Sour Orange', *C. aurantium* L.; 'Rough Lemon', *C. jambhiri* Lush; 'Cleopatra' mandarin, *C. reshni*; 'Troyer' citrange, (*Poncirus trifoliata* L. Raf. × *C. sinensis* L.) Osbeck; 'Rangpur' lime, *C. limonia* Osbeck) were used in this study. The trees were planted in 1972 at the University Research Farm in Tripoli. The soil of the farm is a deep sandy loam, high in calcium carbonate and of pH 7.9, or slightly higher (Hassaballa and Fahmy, 1976). Irrigation of trees by sprinklers was carried out according to field requirement, using a medium saline water with salt concentration about 800 p.p.m., most of which was sodium chloride. No macro- or micro-nutrient foliage sprays had been applied during the growing season.

A randomized block design with 3 replications was adopted. Each of the main blocks was divided into 3 sub-blocks. Each sub-block represented an orange cultivar on the 5 rootstocks. Every scion/rootstock combination was planted in a single 4-tree row. About 50, spring-cycle, leaves per tree were taken in October 1980 from non-fruiting shoots. They were washed in 0.1% detergent solution, followed by 3 rinses in deionized water. After draining off the water, leaves (in perforated paper bags) were dried in a draft oven at 65°C to a constant weight. Leaves were then ground and placed in small glass jars to be used for analysis. Two grams of the powder were dry ashed at 550°C for 2 h (Chapman and Pratt, 1961). Analysis for K, Ca and Na was done by flame photometer; Zn and Cu by atomic absorption; P, Mn and Fe by spectrophotometer; N by micro-Kjeldahl; and Cl by titration with silver nitrate. Differences among scions and rootstocks, and interactions

between scion and rootstock were subjected to statistical analysis using analysis of variance.

RESULTS AND DISCUSSION

Macronutrients

Nitrogen. — There were no significant differences in leaf N among trees on the 5 rootstocks when the averages of all scions were compared (Table I). This was in agreement with Sharpless and Hilgeman (1972) and Wutscher and Olson (1970). Leaves of 'Washington Navel' were significantly higher in N than those of 'Halmin', whereas 'Valencia' leaf N was intermediate. The high level of N in 'Navel' leaves was also reported by Embleton et al. (1973) and Sharpless and Hilgeman (1972).

TABLE I

Effect of rootstock on macro-nutrient composition of scion leaves

Element (%)	Scion	Rootstock					Scion mean
		'Rangpur' lime	'Cleopatra' mandarin	'Sour Orange'	'Troyer' citrange	'Rough Lemon'	
N	'Valencia'	2.28 ab	2.05 b	2.69 a	2.40 ab	2.35 ab	2.35 ab
	'Hamlin'	2.37 ab	2.30 ab	2.26 ab	2.10 b	2.13 b	2.23 b
	'Navel'	2.48 ab	2.41 ab	2.43 ab	2.55 ab	2.63 a	2.30 a
Rootstock mean		2.37 a	2.25 a	2.46 a	2.35 a	2.37 a	
P	'Valencia'	0.197 abc	0.209 abc	0.177 bc	0.172 bc	0.235 a	0.199 a
	'Hamlin'	0.195 abc	0.137 bc	0.135 abc	0.171 bc	0.165 c	0.178 b
	'Navel'	0.188 abc	0.238 a	0.206 abc	0.201 abc	0.227 ab	0.212 a
Rootstock mean		0.193 a	0.207 a	0.190 a	0.181 a	0.210 a	
K	'Valencia'	0.918 def	0.698 g	0.835 fg	0.818 fg	0.852 fg	0.828 b
	'Hamlin'	1.108 ab	0.873 efg	0.958 cdef	1.025 bcd	1.018 bcd	0.997 a
	'Navel'	1.230 a	0.842 fg	1.043 bcd	0.995 bcde	1.085 abcd	1.039 a
Rootstock mean		1.086 a	0.804 c	0.946 b	0.946 b	0.985 b	
Ca	'Valencia'	2.73 bcd	3.19 ab	3.14 abc	2.86 bcd	3.53 a	3.09 a
	'Hamlin'	2.40 d	2.87 bcd	2.53 cd	2.65 bcd	2.76 bcd	2.60 b
	'Navel'	2.46 d	2.84 bcd	2.71 bcd	2.43 d	2.82 bcd	2.65 b
Rootstock mean		2.53 c	2.97 ab	2.79 abc	2.65 b	3.04 a	
Ca/K	'Valencia'	3.00 de	4.61 a	3.80 bc	3.55 bc	4.19 ab	3.83 a
	'Hamlin'	2.20 gh	3.44 cd	2.64 efg	2.62 efg	2.79 ef	2.73 b
	'Navel'	2.00 h	3.07 de	2.64 efg	2.47 fg	2.60 efg	2.56 b
Rootstock mean		2.40 d	3.70 a	3.03 bc	2.88 c	3.20 b	
Na	'Valencia'	0.131 b	0.125 b	0.111 b	0.124 b	0.126 b	0.124 a
	'Hamlin'	0.122 b	0.123 b	0.102 b	0.191 a	0.114 b	0.130 a
	'Navel'	0.126 b	0.097 b	0.096 b	0.122 b	0.103 b	0.109 b
Rootstock mean		0.126 ab	0.115 bc	0.103 c	0.145 a	0.114 bc	
Cl	'Valencia'	0.133 b	0.210 ab	0.180 ab	0.157 ab	0.130 b	0.162 a
	'Hamlin'	0.166 ab	0.179 ab	0.124 b	0.169 ab	0.133 b	0.154 a
	'Navel'	0.156 b	0.148 b	0.128 b	0.242 a	0.115 b	0.154 a
Rootstock mean		0.152 ab	0.179 a	0.144 ab	0.189 a	0.126 b	

Values followed by same letter, are not significantly different at $P = 0.05$.
Rootstock means should be compared horizontally, those for scion vertically, and rootstock × scion horizontally or vertically.

Phosphorus. — The P levels, as an average of all scions, were not significantly influenced by rootstocks (Table I). Similar results were reported on the same rootstocks (Minessy and Bahri, 1967; Procoplou and Wallace, 1974). However, Hassaballa and Fahmy (1976), working on the same trees, found that 'Cleopatra' mandarin and 'Troyer' citrange supplied their scion leaves with more P than the other rootstocks.

'Washington Navel' and 'Valencia' leaves were able to accumulate more P than those of 'Hamlin'. This was in line with a previous report by Hassaballa and Fahmy (1976).

Calcium, potassium and Ca/K. — Scion orange trees grown on 'Rangpur' lime tended to be low in Ca and high in K. This inverse relationship was less evident in the other rootstocks (Table I). Similar results were reported by Procoplou and Wallace (1974). A marked reduction in K content was noted in scion leaves budded on 'Cleopatra' mandarin. Similar effects on K uptake for 'Cleopatra' mandarin have previously been reported (Minessy and Bahri, 1967; Embleton et al., 1973). Therefore the highest Ca/K was found in scion leaves grown on 'Cleopatra' mandarin and the lowest in scion leaves grown on 'Rangpur' lime. 'Valencia' leaves contained significantly more Ca, less K and showed higher Ca/K than leaves of 'Washington Navel' and 'Hamlin'. Similar results were obtained by Sharpless and Hilgeman (1972) on 'Valencia' and 'Navel' leaves. Smith (1966) attributed the Ca—K inverse relationship to the strong antagonism between these elements.

Sodium and chloride. — Levels of sodium and Cl in scion leaves varied with rootstocks. 'Troyer' citrange induced higher uptake of Na and Cl than the other rootstocks, and 'Sour Orange' induced less Na uptake (Table I). Wutscher and Olson (1970) reported that the Cl level in leaves of grapefruit on 'Troyer' citrange was approximately twice as high as in leaves of grapefruit on 15 other rootstocks. Reports on the influence of rootstocks on the uptake of Na are not consistent. Sharpless and Hilgeman (1972) reported that 'Rough Lemon' induced a larger Na uptake than 'Sour Orange', while other reports showed that Na level in scion leaves was not affected by rootstocks (Minessy and Bahri, 1967; Wutscher and Olson, 1970; Wallace et al., 1979).

'Washington Navel' leaves tended to accumulate less Na than 'Hamlin' or 'Valencia', whereas Cl levels were not influenced by cultivars.

Micronutrients. — Iron, Zn, Mn and Cu were not influenced by rootstocks but were significantly different in scions. 'Washington Navel' leaves accumulated more Fe, Zn, Mn and Cu than 'Hamlin' or 'Valencia' leaves (Table II).

Wallace et al. (1979) found that 'Cleopatra' mandarin rootstock had not influenced the levels of Fe and Mn, but had enhanced the uptake of Zn in citrus leaves. Sharpless and Hilgeman (1972) reported than Zn, Cu and Mn values were not influenced by scion, whereas Fe was significantly higher in

TABLE II

Effect of rootstock on micro-nutrient composition of scion leaves

Element (p.p.m.)	Scion	Rootstock					Scion mean
		'Rangpur' lime	'Cleopatra' mandarin	'Sour Orange'	'Troyer' citrange	'Rough Lemon'	
Fe	'Valencia'	74.6 be	79.8 abc	82.1 abc	73.8 cb	85.4 abc	79.1 b
	'Hamlin'	73.8 bc	80.2 abc	68.2 c	84.0 abc	84.4 abc	78.1 b
	'Navel'	93.3 abc	97.7 ab	93.7 abc	90.6 abc	102.3 a	96.3 a
Rootstock mean		81.9 a	85.9 a	81.3 a	82.8 a	90.7 a	
Mn	'Valencia'	22.3 b	33.3 ab	22.8 b	26.7 ab	24.8 ab	26.6 ab
	'Hamlin'	20.8 b	25.8 ab	21.3 b	23.3 b	27.4 ab	23.7 b
	'Navel'	24.5 ab	33.2 ab	37.2 ab	29.5 ab	43.5 a	33.6 a
Rootstock mean		23.6 a	30.8 a	27.1 a	26.5 a	31.9 a	
Cu	'Valencia'	10.4 bcde	8.4 cde	7.4 c	8.9 dce	8.2 de	8.8 b
	'Hamlin'	8.9 dce	8.9 cde	9.6 bcde	9.6 bcde	10.4 bcde	9.5 b
	'Navel'	14.8 ab	13.3 abcd	14.8 ab	16.3 a	14.0 abc	14.7 a
Rootstock mean		11.4 a	10.4 a	10.6 a	11.6 a	10.9 a	
Zn	'Valencia'	32.1 b	27.9 b	29.3 b	29.3 b	36.3 b	31.0 a
	'Hamlin'	32.1 b	27.9 b	27.9 b	22.3 b	27.9 b	27.6 a
	'Navel'	58.3 a	80.66 a	65.6 a	64.5 a	74.6 a	70.3 b
Rootstock mean		38.7 a	45.5 a	40.9 a	40.9 a	40.9 a	

Values followed by same letter, are not significantly different at $P = 0.05$.
Rootstock means should be compared horizontally, those for scion vertically, and rootstock × scion horizontally or vertically.

'Navel' leaves than in 'Valencia'. He also found that 'Rough Lemon' and 'Sour Orange' did not affect the Zn, Cu and Fe uptake, but 'Rough Lemon' increased Mn uptake.

Nutrient status

According to Smith (1966) and Embleton et al. (1973), who gave the leaf analysis guides for diagnosing nutrients status of mature orange trees, the levels reported in the present work were as follows: N, K, and Mn, low to normal; Fe, Zn and Cu, within the normal range; P, normal to high; and Cl and Na at non-toxic levels.

Interaction. — The statistical interaction of rootstock and scion was found to be non-significant for all determined elements. Thus, the conclusion could be drawn that the rootstocks and scions were independent in their effect on the leaf mineral composition.

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