Mineral Nutritional Problems Of Trifoliate Orange Rootstock

A. H. KHADR · A. WALLACE · E. M. ROMNEY

Although the citrus rootstock, trifoliate orange, is disease and cold resistant and offers good fruit quality, it is affected more by zinc and iron deficiencies than some other rootstocks, according to this report from U.C., Los Angeles. Other nutrient disorders seem to result from high potassium and phosphorus conditions, low magnesium supplies and certain nitrogen levels.

THE USE OF TRIFOLIATE ORANGE rootstock in citrus offers some advantages including cold resistance, disease resistance, and improved fruit quality. However, it is more susceptible to zinc and iron deficiencies than are other rootstocks used for citrus, as well as nutritional complications under conditions of high phosphorus and high potassium. It seems to be less tolerant of a low magnesium supply than many other plant species; it is subject to a peculiar type of chlorosis which has never been identified, and nitrogen levels seem to influence its development of dormancy. As a rootstock, this species tends to dwarf at moderate and low temperatures but not at high temperatures, but whether or not this is related to mineral nutrition is not known.

The purpose of this investigation was to determine some causes of these mineral nutrient peculiarities. It was not the purpose of this study to determine which citrus rootstock is best for a given set of conditions, but rather to find why different rootstocks and other plant species behave as they do.

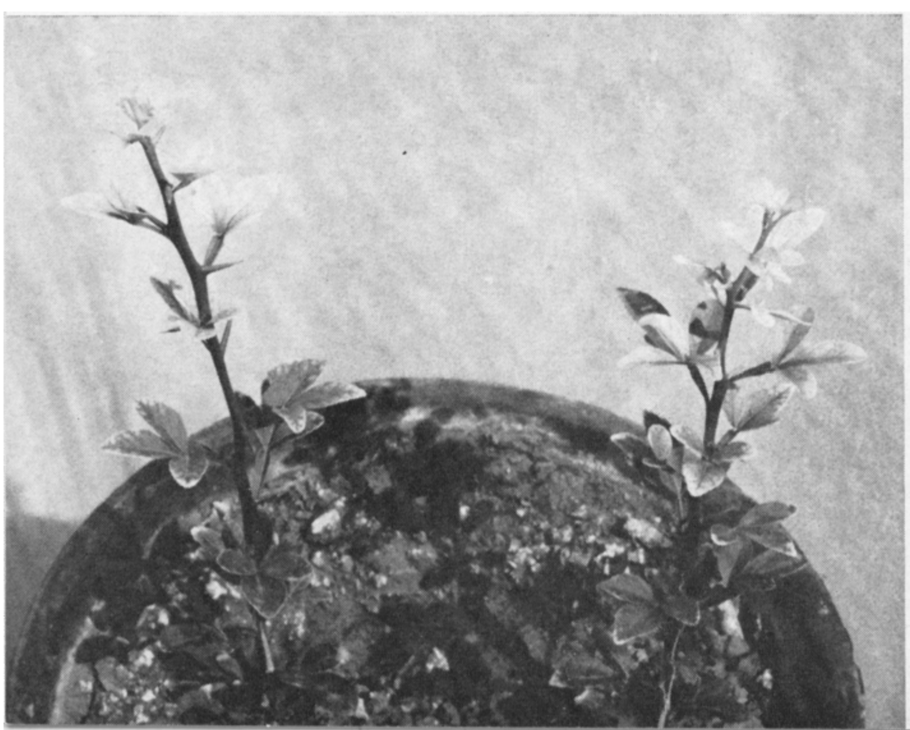
Seedlings of the Rubidoux clone of trifoliate orange (*Poncirus trifoliata*) were grown in a calcareous soil (Hacienda loam) and in a noncalcareous soil (Yolo loam) with various amendments. Relative growth and mineral contents of these plants were compared with rough lemon seedlings. Seedlings and plants grafted to Valencia orange were also grown in solution culture, and absorption and translocation of radioactive iron and radioactive zinc were compared for the two species.

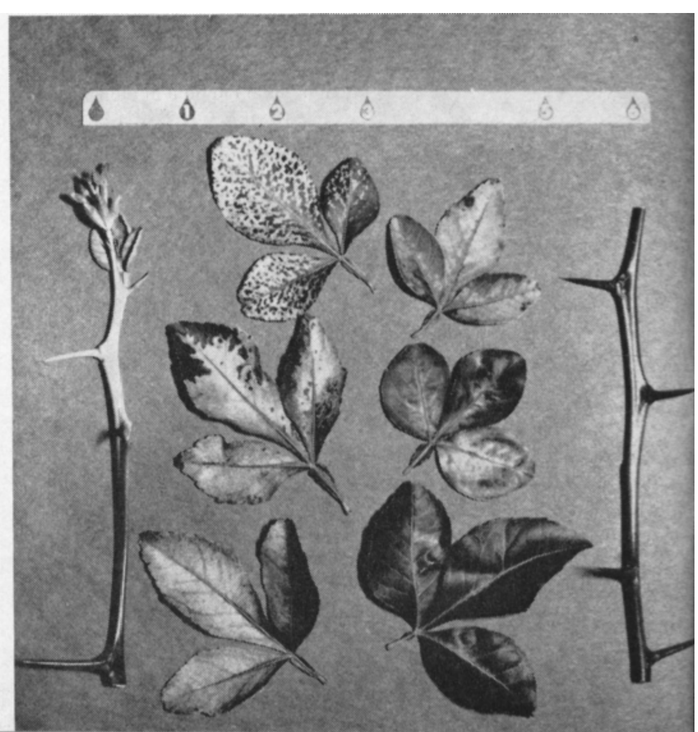
Iron chlorosis

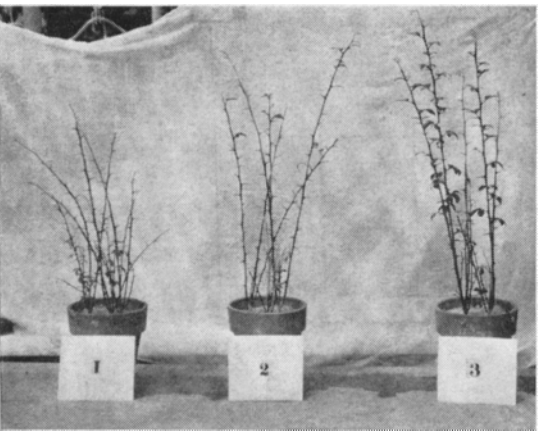
Trifoliate orange seedlings were iron chlorotic when grown on the calcareous Hacienda loam soil. A relatively high level (40 lbs of iron per acre) of iron chelate (EDDHA) applied over a period of four months corrected the iron chlorosis and increased the iron content of leaves from 41 to 117 ppm on the dry weight basis. This level of iron chelate is too high for economical use, but in subsequent studies much lower levels were effective. A level of zinc chelate (EDTA) equal to that of iron (40 lbs zinc per acre) increased both iron and zinc contents and improved growth. Rough lemon seedlings grown under the same conditions were free of iron and zinc deficiencies. When the seedlings were grown in the noncalcareous Yolo clay loam, the trifoliate orange responded to the zinc chelate; the rough lemon did not.

Tests with radioactive iron indicated that susceptibility to iron chlorosis in trifoliate orange is related to its poor ability to absorb iron at low iron concen-

Iron chlorosis of trifoliate orange seedlings, left photo, when grown in calcareous soil. The cause of chlorosis of trifoliate orange seedlings, shown in detail on leaves in right photo, has never been identified.







Trifoliate orange seedlings grown in sand culture with a high level of potassium (50 milliequivalents per liter) with three levels of magnesium (1, 2, and 3 respectively are 0.1, 1.0, and 10 milliequivalents per liter of magnesium).

trations and also to its ability to translocate iron from roots to shoots. At high external concentrations of iron the susceptible trifoliate orange and the resistant rough lemon absorbed and translocated equal quantities of the radioactive iron.

Use of radioactive zinc indicated that trifoliate orange is susceptible to zinc deficiency because of a translocation failure from roots to leaves. Total uptake for the two species was about equal, but rough lemon translocated up to about 20 times as much zinc as did trifoliate orange. Results for both iron and zinc were essentially the same, whether with seedlings or with seedlings that had been whip grafted to Valencia orange scions.

Additional studies with radioactive isotopes indicated that high calcium levels greatly depressed the absorption of zinc by both species and that a high level of bicarbonate and also of phosphate greatly depressed translocation of iron with trifoliate orange, but much less so with rough lemon. High bicarbonate had no effect on zinc translocation, but high phosphate did. High phosphate, however, depressed zinc translocation with rough lemon more than with trifoliate orange. Several metabolic inhibitors were used with the radioactive isotopes, but no great differences were found between the two plant species.

When trifoliate orange seedlings were grown in the glasshouse with high levels of potassium they were severely injured. Seedlings of other citrus rootstocks were not damaged with similar treatments. Studies were made with seedlings in sand culture and in solution culture to better characterize the different relationships involved.

GRAMS DRY WEIGHT PER PLANT AND MINERAL CONTENT OF TRIFOLIATE ORANGE LEAVES WHEN GROWN IN SAND CULTURE AT DIFFERENT POTASSIUM LEVELS

Potassium levels	Dry weight	Fe	K	Mg	Ca
me/liter	g/plant	Dry weight ppm	Per cent of dry weight		
0.1	15.4	108	1.2	.34	2.03
1.0	20.3	100	1.8	.20	1.30
10	19.8	96	2.8	.10	0.70
50	3.5	77	5.7	.06	0.25

At least part of the effect of high potassium appeared to be a greatly decreased content of magnesium. The plants with the high potassium levels all had severe tip dieback and considerable shoot-branching from the base to give a bushy appearance. This occurred for all magnesium levels when potassium was high.

High magnesium had a slight tendency to overcome the effect of high potassium. Moderately good growth and extremely poor growth were both obtained with leaf magnesium levels of around 0.04%. The major difference was that the high potassium level resulted in a toxicity beyond inducing magnesium deficiency. A high level of potassium also severely decreased the calcium contents of leaves.

The present study, still in its introductory stages, is based on the premise that knowledge of such physiological behavior will lead to the best use and control of citrus rootstocks and other plant species. For example, it may develop that desirable and undesirable characteristics are inseparably linked together.

A. H. Kahdr is Research Assistant; A. Wallace is Professor of Plant Nutrition, Department of Agricultural Sciences, and E. M. Romney is Associate Research Soil Scientist, Department of Nuclear Medicine and Radiation Biology, University of California, Los Angeles. Photographs were taken by C. P. North.

FRESH WEIGHTS OF TRIFOLIATE ORANGE (T.O.) AND ROUGH LEMON (R.L.) SEEDLINGS GROWN 14 MONTHS IN A CALCAREOUS SOIL (HACIENDA LOAM) AND IN A NONCALCAREOUS SOIL (YOLO CLAY LOAM) IN POTS IN A GLASSHOUSE

Treatments	Calcareous soil		Noncalcareous soil	
	T.O.	R.L.	T.O.	R.L.
	Grams fresh weight			
Control	8	321	97	340
Iron EDDHA	54	353	126	456
Zinc EDTA	67	290	160	438
	Zinc content of leaves, ppm of dry weight			
Control	18	38	28	45
Iron EDDHA	23	40	29	41
Zinc EDTA	42	49	49	80
	Iron content of leaves, ppm of dry weight			
Control	41	76	97	99
Iron EDDHA	117	106	132	126
Zinc EDTA	56	77	111	95

ZINC ABSORBED AND TRANSLOCATED BY SEEDLINGS DURING A 48-HOUR TEST AS DETERMINED WITH RADIOACTIVE ZINC

Concentration of $ZnSO_4$	T.O.	R.L.	T.O.	R.L.
	leaves		whole plant	
molar	micromoles zinc/gram dry weight			
10^{-6}	.001	.019	0.35	0.76
10^{-5}	.024	.061	2.0	2.5
10^{-4}	.029	.210	13.4	13.5

IRON ABSORBED AND TRANSLOCATED BY SEEDLINGS DURING A 48-HOUR TEST AS DETERMINED WITH RADIOACTIVE IRON

Concentration of iron EDDHA	T.O.	R.L.	T.O.	R.L.
	leaves		whole plant	
molar	micromoles iron/gram dry weight			
10^{-5}	0.002	0.006	.066	.39
10^{-4}	0.08	0.27	.51	.91
10^{-3}	0.52	1.23	10.6	15.0
5×10^{-3}	8.1	8.9	34.2	34.1

Iron chlorosis of trifoliate orange seedlings grown in calcareous soil was corrected by chelates (nos. 4 and 5).