The Libyan Journal of Agriculture: volume 6, part 1, 1977

The Effect of Different Rootstocks and Potassium Sulfate Fertilizer on Leaf Potassium, Calcium and Sodium in Young 'Clementine' Mandarin Trees.

IBRAHIM FAHMY AND ISSAM A. HASSABALLA[1]

ABSTRACT

This work was undertaken to study the influence of five different citrus rootstocks and the level of potash applications on absorption and accumulation of potassium, calcium and sodium in the leaves of young Clementine mandarin trees. It was also intended to determine whether or not the supply of these three elements was inadequate, satisfactory or unnecessarily high.

Among the rootstocks tested, the Cleopatra mandarin supplied the least but adequate amounts of potassium to the Clementine mandarin leaves. By the end of the fifth growing season in the field, the Troyer citrange rootstock induced the highest postassium and the lowest calcium levels in the scion leaves. Addition of potash in amounts equivalent to half the annual application rate of nitrogen increased significantly the potassium and depressed the calcium contents in the scion leaves, regardless of the rootstock. However, under no potassium fertilization program, potassium as well as calcium concentrations in the Clementine mandarin leaves were always within the optimum nutritional standards if not higher in case of potassium only, depending upon the rootstock used. No effect could be detected between rootstocks or amounts of potassium sulfate fertilizer on the sodium content which was present in amounts less than 0.16%.

INTRODUCTION

The indiscriminate use of fertilizers is a common practice in the Libyan citriculture. No attention is given to the proper balance between the various nutrients applied to the soil for their most efficient use, if not for other reasons. Meanwhile, published reports are lacking, with regard to citrus in Libya, to show the actual needs of citrus trees for the various nutritional elements.

As with other elements, potassium deficiency can result, among other conditions, from failure of the plant roots to secure enough potassium from the soil. Fudge in 1964 (4) reported that increased calcium and magnesium in the soil would decrease potassium uptake by citrus trees to some extent. Willson and Arey (8) stated that in mature, pro-

[1] Horticultural Section, Department of Plant Production, Faculty of Agriculture, University of Alfateh, Tripoli, Libya.

ductive Pineapple and Valencia orange groves in Florida leaf potassium was found to vary in an unpredictable manner from one year to the next and from one grove to another. In the extreme case where potash was left out of the program for three years there were plots showing the same level of leaf potassium as those in other areas where potash was used regularly. Bahrt and Roy (1) found that several years were required to materially lower the K content of the leaves by omission of K from fertilizers. Wallace *et al.* (7) reported that both the rootstock and the scion variety affect the nutritional status of the tree to some extent.

The main objective of this report was to study the influence of various citrus rootstocks and the level of potash applications on absorption and accumulation of potassium, calcium and sodium in the leaves of young 'Clementine' mandarin trees. It was also intended to determine whether or not their supply was inadequate, satisfactory or unnecessarily high.

MATERIALS AND METHODS

This experiment was initiated on the experimental farm of Alfateh University in Tripoli, Libya.

An orchard of 1.25 hectares of 'Clementine' mandarin *Citrus reticulata* Blanco budded on five different citrus rootstock varieties was set in the field in late February, 1972. Any replanting was carried out in early fall of the same year. The seedling rootstock varieties used were sour oranges *C. aurantium* L., rough lemon *C. jambhiri* Lush., 'Rangpur' lime *C. limonia* Osbeck, 'Cleopatra' mandarin *C. reshni* Hort. ex. Tan. and 'Troyer' citrage [*Poncirus trifoliate* (L.) Ref. × *C. sinensis* (L.) Osbeck]. The orchard soil is deep sandy loam, low in inherent fertility, calcareous in nature, and with a pH value of about 7.9. The orchard was kept under clean cultivation in summer by disking and planting purple vetch as a winter covercrop. A low-head sprinkler irrigation system was used throughout this experiment.

In the field layout, the plots of each of the five scion/rootstock combinations consisted of 18 trees; lines in 6 raws spaced 6 meters apart from north to south. The sub-plot was represented by 3 trees of each combination spaced 7 meters apart from east to west. This gives a total of 90 trees for each of the two replications included in this study. One raw of the seedling rootstock varieties separated the two replications. Each rootstock variety was represented by three or four trees. This was done to test and compare the general performance of the seedling rootstock varieties under local conditions. The orchard was surrounded by one guard raw of budded trees. For protection against adverse weather conditions, a windbreak of *Casuarina species* was established at least 8 meters away from the guard trees. Since the establishment of the orchard all trees received uniform applications of ammonium sulfate and superphosphate fertilizers but variable amounts of potassium sulfate. The total amounts of nitrogen (N) applied annually during the first five years were 150, 210, 400, 420 and 500 grams per tree respectively. Half of these amounts of phosphorus pentoxide (P_2O_5) were also added annually. The three different potash (K_2O) levels used in combination with a fixed annual ratio of N: P_2O_5 were $1:\frac{1}{2}:0$, $1:\frac{1}{2}:\frac{1}{2}$ and $1:\frac{1}{2}:1$. The superphosphate and potassium sulfate fertilizers were applied all at one time early in the fall. However, nitrogen was split into two or three applications during the growing season. Even though the trees were young, precautions were taken to keep guard raws between the three levels of potassium treated trees.

A composite leaf sample was taken from each of the three-tree-sub-plots which

constituted the treatment, early in October of 1975 and 1976. Preparation and determination of potassium, calcium and sodium in leaf material were carried out as described by Chapmann and Pratt (2). A Carl Zeiss PF5 flame photometer was used for all determinations.

RESULTS AND DISCUSSION

The leaf analysis guide for diagnosing the nutrient status of mature trees given by Embleton *et al.* (3) was used as the reference in this report. The optimum ranges given are 0.70 to 1.09% for potassium, 3.0 to 5.5% for calcium and less than 0.16% for sodium.

Potassium

Apparently, the orchard soil of this experiment was supplying enough potassium to the 5 year-old Clementine mandarin trees growing under no potassium fertilization program since planting in the field. Under this treatment, the average potassium values of 1.00% in 1975, and 1.22% in 1976 were considered within the high optimum nutritional range or higher. Ground application of potassium sulfate to the trees did undoubtedly increase the level of potassium in the scion leaves, Table 1. However, no significant difference could be detected between the two different potash ratios used: $1N:\frac{1}{2}P_2O_5:\frac{1}{2}K_2O$ and $1N:\frac{1}{2}P_2O_5:1K_2O$. The maximum differences in leaf potassium between the

Table 1 The effect of different rootstocks and amounts of potassium sulfate fertilizer on levels of potassium and calcium in the leaves of young 'Clementine' mandarin trees.

	Ratio of $N:P_2O_5:K_2O$ in fertilizer							
	$1:\frac{1}{2}:0$	$1:\frac{1}{2}:\frac{1}{2}$	$1:\frac{1}{2}:1$		$1:\frac{1}{2}:0$	$1:\frac{1}{2}:\frac{1}{2}$	$1:\frac{1}{2}:1$	
Rootstock	1975 season		Mean 1975		1976 season			Mean 1976
	Per cent potassium in dry leaves[a]							
Sour orange	1.05	1.29	1.48	1.27b	1.28	1.19	1.29	1.25b
Rough lemon	1.17	1.32	1.34	1.27b	1.25	1.59	1.43	1.42c
Rangpur lime	1.13	1.36	1.33	1.27b	1.17	1.43	1.32	1.30b
Cleopatra mandarin	0.89	1.03	1.25	1.05a	1.05	1.11	1.16	1.10a
Troyer citrange	0.79	1.46	1.57	1.27b	1.34	1.69	1.52	1.51c
Mean	1.00a	1.29b	1.39b		1.22a	1.40b	1.34b	
Max. diff.%	48	42	26		28	52	31	
	Per cent calcium in dry leaves[a]							
Sour orange	5.20	3.90	4.38	4.49a	4.75	4.40	4.28	4.48c
Rough lemon	5.00	4.40	4.70	4.71a	4.73	4.40	4.28	4.47bc
Rangpur lime	4.60	3.70	4.20	4.18a	4.25	3.73	4.10	4.03ab
Cleopatra mandarin	5.05	4.93	4.75	4.91a	4.60	4.25	4.20	4.35bc
Troyer citrage	4.70	3.78	4.55	4.34a	4.03	3.55	4.05	3.88a
Mean	4.91b	4.16a	4.52ab		4.47b	4.07a	4.18ab	
Max. diff.%	13	33	13		18	24	6	

[a] Mean values for each element within each season, either between rootstocks or between ratios of potash in fertilizer when followed by the same letter indicate no significant differences from each other at the 0.05 level, according to Duncan's multiple range test.

non-fertilized and fertilized potassium treatments were 39% in 1975 and 15% in 1976. These differences were shown to be significant at the 0.01 level. Willson and Arey (8) has shown that leaf potassium varied considerably from year to year with little or no relationship to the potash fertilizer program.

A marked reduction in potassium content was noted in the leaves of Clementine mandarin on Cleopatra mandarin rootstock compared to the other four rootstocks under study, Table 1. This was evident in both years. The same antagonistic effect of Cleopatra mandarin rootstock to potassium uptake and accumulation in the leaves of Clementine mandarin was reported by Marchal *et al.* in 1974 (6). Gorton *et al.* (5) also found less potassium and more calcium in the leaves of Webb Red Blush grapefruit when grown on Cleopatra mandarin rootstock than when grown on sour orange. By comparing the average results of the other four rootstocks at the end of the fifth growing season in the field, it was evident that Troyer citrange followed by rough lemon induced higher potassium levels in the leaves of Clementine mandarin top than Rangpur lime and sour orange rootstocks.

Table 2 Leaf potassium content of 'Clementine' mandarin scion compared with that of seedling rootstock trees.

	Tree top			
	1975		1976	
Rootstock	Seedling	Scion	Seedling	Scion
	Mean per cent potassium in dry leaves[a]			
Sour orange	0.84b	1.29a	0.69a	1.19a
Rough lemon	0.80b	1.32a	0.79ab	1.59c
Rangpur lime	1.05c	1.36a	0.89b	1.43b
Cleopatra mandarin	0.66a	1.03a	0.66a	1.11a
Troyer citrange	0.73ab	1.46a	0.76ab	1.69c
Max. diff.%	59	42	35	52

[a] Values within each column followed by the same letter indicate no significant differences from each other at the 0.05 level, according to Duncan's multiple range test.

Table 2 shows the potassium content in the leaves of the five different citrus seedling rootstocks compared to the leaf potassium in Clementine mandarin budded on the same rootstock varieties. All trees were set in the field at the same time and received the same cultural and fertilization treatments. The fertilizer ratio was maintained at 1N:$\frac{1}{2}$ P_2O_5:$\frac{1}{2}$ K_2O. Examination of the data indicates that the leaf potassium in the seedling rootstock varieties was consistently less than in the corresponding Clementine mandarin scion. In other words, higher concentration of potassium in the scion leaves was evident compared to the seedling rootstock varieties. Mention should be made that, in the field, the seedling rootstock varieties had noticeably greater spread and extended growth than the budded plants.

In the Troyer citrange seedlings, the percentage of leaf potassium, in both seasons, was half that present in the Clementine mandarin budded on Troyer citrange rootstock. This was also noted in the rough lemon rootstock in 1976. The Cleopatra mandarin seedling rootstock and its combination with the Clementine mandarin scion contained the least amounts of leaf potassium in 1975 and 1976.

Calcium

In 1975, at the end of the fourth growing season in the field, no marked variations were observed in the leaf calcium of Clementine mandarin on the five different rootstocks. However, a year later, in 1976, the Troyer citrange reduced significantly the calcium concentration in the scion leaves compared to the other four rootstocks. This agrees with a report by Marchal *et al.* (6).

Under no potassium fertilization, the calcium content in the leaves averaged 4.91 and 4.47% in 1975 and 1976 respectively. These concentrations are considered within the optimum range for calcium. Addition of potash in amounts equivalent to half the annual application rate of nitrogen depressed significantly the calcium uptake, regardless of the rootstock. However, doubling the amount of potash in the fertilizer did not result in any further reduction in calcium uptake; in fact, gave intermediate calcium concentrations in the leaves, Table 1.

Sodium

The analytical results revealed that the sodium in the leaves ranged between 0.10 to 0.12% which is considered below the normal level of this element in the leaves and would constitute no problem or hazard as far as growth, and production of the trees is concerned.

Under the prevailing conditions of this experiment, neither the rootstock nor the amount of potassium sulfate applied showed any effect on the sodium content of the Clementine mandarin leaves.

LITERATURE CITED

1. Bahrt, G. M., and W. R. Roy. 1940. Progress report of the effects of no potassium and various sources and amounts of potassium on citrus. Proc. Fla. State Hort. Soc. 53:26–34.
2. Chapman, H. D., and P. F. Pratt. 1961. Methods of Analysis of Soils, Plants and Waters. Univ. Calif. Div. Agric. Sci. Berkeley, Calif.
3. Embleton, T. W., W. W. Jones, C. K. Labanauskas, and W. Reuther. 1973. Leaf analysis as a diagnostic tool and guide to fertilization, pp. 183–210. *In* W. Reuther (ed.). The Citrus Industry. Vol. III. Univ. Calif. Div. Agric. Sci., Berkeley, Calif.
4. Fudge, B. R. 1964. The effect of applications of calcium and magnesium upon absorption of potassium by citrus. Proc. Fla. State Hort. Soc. 59:46–51.
5. Gorton, B. S., W. C. Cooper, and A. Peynado. 1954. Relation of calcium and potassium accumulation in citrus as influenced by rootstock and salinity of irrigation water. Proc. Amer. Soc. Hort. Sci. 63:49–52.
6. Marchal, J., P. Martin-Prével, L. Blondel, J. Cassin, and P. Lossois. 1974. Influence des porte-greffe sur la composition foliaire du clémentinier et d'autres espèces d'agrumes sous différents climats. [The influence of rootstocks on the foliar composition of the clementine and other citrus species in different climates.] Fruits 29 (2):131–148. Hort. Abs. 1975. 45 (2):1252.
7. Wallace, A., C. J. Naude, R. T. Mueller, and Z. I. Zidan. 1952. The rootstock-scion influence on the inorganic composition of citrus. Proc. Amer. Soc. Hort. Sci. 59:133–142.
8. Willson, A. E., and W. J. Arey. 1958. Potash relationships in commercial groves. Proc. Fla. State Hort. Soc. 71:181–186.