Citrus is one of the most important crops in Cyprus. In 1990 it occupied 7300 ha or 20% of the total irrigated land. Citrus production in 1990 reached 170,000 t of which 30% was oranges, 40% grapefruit, 22% lemons, and 5% mandarins. Ortanique is a new crop for Cyprus but has expanded rapidly during the last few years as a result of the high demand in the export market.

The origin of this attractive and promising variety is unknown, but Ortanique is reported (Jamaica Citrus Growers Assn., 1963) to be an old chance seedling that came to the attention of C.P. Jackson of Chellaston, Mandeville, Jamaica, in 1920. Because of the presence of wild orange and so-called tangerine trees in the vicinity of the original tree, and the distinctive features of the fruit, it was considered to be a natural tangor and was given the name Ortanique by H.H. Cousins. The name was a synthesis coined from orange, tangarine, and unique. The present clone probably represents a nucellar seedling of the parent tree (Hodgson, 1967).

In Cyprus, all citrus varieties are mainly budded on sour orange, which generally is the most commonly used rootstock, particularly in the Mediterranean region. Although sour orange was considered a satisfactory rootstock in several citrus-producing areas such as South Africa, South America (Brazil, Argentina), Florida, Texas, and part of California, it had to be replaced in some of these areas as a result of its susceptibility to citrus tristeza virus (Wallace, 1956a, 1956b; Salibe, 1973).

The occurrence of tristeza in the Mediterranean area (Bitters, 1973; Mendel, 1956) and its detection in Cyprus (Kyriakou and Polkarpou, 1989; Papasolomontos and Economides, 1968) have stimulated a search for alternative rootstocks. The currently limited presence of tristeza in Cyprus does not preclude the possibility that the disease will not become a problem in the future.

As an assurance for future plantings, a research program was initiated in Cyprus to find a suitable rootstock to replace sour orange if tristeza becomes epidemic. We here present data on the performance of eleven rootstocks, as measured by growth, yield, and fruit quality.

**Materials and Methods**

The rootstocks used were: sour orange, ‘Palestine’ sweet lime, rough lemon, ‘Red’ rough lemon, ‘Estes’ rough lemon, Rangpur, Trolley and Carrizo citranges, ‘Swingle’ citrumelo, Volkameriana and Ambly-carpia.

Seeds were obtained from Willits and Newcomb, Arvin, Calif., except for sour orange and ‘Palestine’ sweet lime seeds, which were obtained locally from selected healthy trees planted in Mar. 1976. The seedlings were planted in the nursery at the Paphos Experimental Station in Mar. 1977, and were budded in Oct. 1978, with buds from a single tree of Ortanique. The trees were grown in the nursery using standard practices and were planted in Mar. 1980 in a randomized block design with two-tree plots of each rootstock replicated six times. Tree spacing was 6.6 m between rows and 4.2 m within rows. The budding material had been imported from California in 1972 and was free of diseases known at the time. At some later stage, however, it must have become infected with the citrus exocortis viroid. Samples taken from the experimental block and indexed on several plant indicators were negative for tristeza, psorosis, vein reaction virus, and citrus cachexia viroid, but were positive for exocortis viroid, since they produced severe symptoms on citron (Citrus medica L.) and Gymnura aurantica D.C. (A. Kyriakou, unpublished data).

The soil was clayey (60% clay, 25% silt, 15% sand), contained 20% CaCO$_3$, had a pH value of 8.0 (1 soil : 2.5 water), and an EC value of 1.5 dS·m$^{-1}$ throughout the profile.

The area has an average annual rainfall of 460 mm, occurring mainly from October to April, and mean maxima air ranging from 17$^\circ$C in January to 31$^\circ$C in July, and mean minima from 9 to 22$^\circ$C. Relative humidity ranges from 60% to 75%.

A total of 25 irrigations were applied per year at weekly intervals during each irrigation season with microjets delivering 700 liters of water per tree at each application in the last year of the experiment. The water had a pH of 7.6 and an electrical conductivity of 0.7 dS·m$^{-1}$. It contained (in ppm): Cl-53; Na-57; Ca-58; Mg-20; SO$_4$-134; and HCO$_3$-128.

One month before flowering, ammonium sulphate, triple super-
phosphate, and potassium sulphate were applied in amounts increasing progressively each year to a maximum of 3.0, 0.5, and 1.0 kg per tree, respectively. The grove was cultivated, pruned, and sprayed with insecticides and fungicides, according to local practices.

Trunk cross-sectional area (TCSA) was recorded 15 cm above the bud union in Oct. 1991. Fruit were harvested in the middle of February, and yields were expressed on a tree basis. Samples (10 fruit from each tree) were taken from 1987 to 1991. Each fruit was weighed and cut in half. Rind thickness was measured with a digital caliper, and the juice was extracted with an electric juicer. Total SSC was measured with a temperature-compensated refractometer, and total acids were determined (as citric acid equivalent) by titrating with NaOH.

Results and Discussion

TCSA measurements indicated that trees on Amblycarpa were the largest, while those on sour orange, rough lemon, ‘Estes’ rough lemon, Rangpur, and Volkameriana were smaller and did not differ significantly from each other (Table 1). The smallest trees were those on Troyer and Carrizo citranges, but they did not differ significantly from trees on ‘Swingle’ citrumelo, ‘Palestine’ sweet lime, and red rough lemon.

The trees on Rangpur, ‘Swingle’ citrumelo, Troyer, and Carrizo citranges developed a severe overgrowth of the rootstock as compared to the scion, whereas ‘Palestine’ sweet lime and Amblycarpa rootstocks were only slightly larger than the scion. Trees on other rootstocks had normal bud unions. Trees on ‘Palestine’ sweet lime, Rangpur, ‘Swingle’ citrumelo, Carrizo, and Troyer citrange exhibited mild to moderate bark cracking below the bud union as a result of the presence of exocortis.

Trees on all rootstocks showed a general yield increase until 1987 (Table 1). In 1988, however, yield was generally lower, whereas in 1989, yield increased again. Trees on sour orange, rough lemon, Rangpur, Troyer and Carrizo citranges, ‘Swingle’

Table 1. Effect of rootstock on trunk cross-sectional area (TCSA) and yield of Ortanique tangor trees.

| Rootstock (1991) | Yield per tree (kg) | Cumulative yield (1984–91 per TCSA) |
|------------------|---------------------|-------------------------------------|
| TCSA (cm²)       | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | (1984–91) |
| Sour orange      | 185.0 | 8 c  | 32 cde | 48 cde | 88 abc | 45 bcd | 145 cde | 204 abc | 144 cd | 715 b | 3.8 cde |
| Palestine sweet  | 125.4 | 5 c  | 61 ab  | 60 bcd | 111 ab | 59 abc | 160 bcd | 151 bcd | 190 bc | 797 b | 6.3 a   |
| lime             | 158.1 | 22 ab | 64 ab  | 96 a  | 125 a | 85 a  | 189 ab | 236 ab | 213 ab | 1030 a | 6.5 a   |
| Rough lemon      | 146.0 | 2 c  | 6 fg   | 44 de | 81 bcd | 40 cde | 179 abc | 154 bcd | 205 ab | 711 b | 4.8 b   |
| Red rough lemon  | 157.7 | 17 b | 47 bc  | 85 ab  | 99 abc | 75 ab  | 211 a  | 200 abcd | 253 a | 970 a | 6.1 a   |
| Estes rough lemon| 157.0 | 8 c  | 44 bcd | 75 abc | 96 bcd | 43 bcd | 142 cde | 148 cde | 170 bc | 727 b | 4.6 bc  |
| Rangpur          | 118.1 | 0 c  | 0.5 g  | 15 f  | 33 e  | 9 e   | 88 f   | 134 e  | 88 e  | 368 d | 3.1 e   |
| Troyer citrange  | 120.0 | 3 c  | 11 efg | 30 ef  | 62 cde | 28 cde | 106 ef  | 157 bcd | 116 de | 513 c | 4.2 bcd |
| Carrizo          | 131.9 | 0 c  | 0.3 g  | 19 ef  | 45 de  | 22 de  | 124 def | 144 de  | 100 de | 457 cd | 3.4 de  |
| Swingle          | 161.3 | 29 a | 74 a   | 104 a  | 115 ab | 61 abc | 215 a  | 207 abc | 248 a  | 1054 a | 6.5 a   |
| citrumelo        | 217.0 | 6 c  | 24 def | 44 de  | 77 bcd | 47 bcd | 157 bcd | 208 ab  | 175 bc | 738 b | 3.4 de  |
| Volkameriana     | 17.0  | 80.6 | 52.6  | 40.2  | 38.4  | 52.9  | 19.9   | 25.2   | 25.3   | 15.5   |

3Mean separation within columns at P = 0.05 by Duncan’s multiple range test.
their smaller size, trees on ‘Palestine’ sweet lime may be planted more closely and yield equally well as largertrees on Volkameriana, rough lemon, and ‘Estes’ rough lemon.

The largest and heaviest fruit were produced by trees on red rough lemon, Rangpur, ‘Palestine’ sweet lime, and Volkameriana, whereas trees on Troyer and Carrizo citranges, ‘Swingle’ citrumello, and sour orange produced fruit that had a significantly smaller diameter and weighed less, although there was some overlap with intermediately productive rootstocks (Table 2). Trees on Rangpur, rough lemon, red rough lemon, ‘Estes’ rough lemon, and ‘Palestine’ sweet lime produced fruit with a significantly thicker rind than trees on Troyer citrange and Volkameriana. Rind thickness of fruit from trees on the other rootstocks was intermediate.

Trees on Carrizo and Troyer citranges and Amblycarpa produced fruit with the highest juice content, whereas trees on red rough lemon, Rangpur, and rough lemon produced the lowest (Table 3). Trees on sour orange produced the highest SSC, and trees on sour orange induced a higher total acid content than trees on any other rootstock. The sugar : acid ratio was lowest for sour orange, but it did not differ from that for ‘Estes’ rough lemon or Troyer citrange. The other rootstocks had similar ratios.

Although it is well known that fruit quality is at times markedly influenced by rootstocks, our observations did not reveal differences that could affect the market value of the fruit when harvested at dates used in this study. But it is quite possible that the magnitude of differences observed was sufficient to affect dates of earliest picking and the storage of fruit on the trees.

Tristeza is present in Cyprus, but apparently not in an epidemic form (Kyriakou and Polykarpou, 1989; Papasolomontos and Economides, 1968). This fact, however, does not mean that the disease may not become a serious problem in the future. Since sour orange, the standard rootstock commercially used in Cyprus, is highly susceptible to tristeza, consideration must be given to tristeza-tolerant rootstocks with good yielding potential of quality fruit to replace sour orange in future plantings. On the basis of our work, Volkameriana, rough lemon, and ‘Estes’ rough lemon deserve more attention in the future because a substantial increase in Ortanique production is possible with these rootstocks. However, final conclusions concerning the adoption of any new rootstocks will emerge only after extended trials under a range of commercial growing conditions.

### Literature Cited

Bitters, W.P., J.A. Brusca, and N.W. Dukershire, 1954. Exocortis transmission tests. California Agr. 8(4):4-5.

Bitters, W.P. 1973. World citrus rootstock situation. Proc. Ist Intl. Citrus Short Course, Univ. of Florida, p. 1-14.

Hodgson R.W. 1967. Horticultural varieties of citrus, p. 431-586. In: W. Reuter, H.J. Webber, and L.D. Batchelor (eds.). The Citrus Ind. vol. I, Univ. of California Press, Berkeley.

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**Literature Cited**

Bitters, W.P., J.A. Brusca, and N.W. Dukershire, 1954. Exocortis transmission tests. California Agr. 8(4):4-5.

Bitters, W.P. 1973. World citrus rootstock situation. Proc. Ist Intl. Citrus Short Course, Univ. of Florida, p. 1-14.

Hodgson R.W. 1967. Horticultural varieties of citrus, p. 431-586. In: W. Reuter, H.J. Webber, and L.D. Batchelor (eds.). The Citrus Ind. vol. I, Univ. of California Press, Berkeley.

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Jamaica Citrus Growers Assn., 1963. Ortaniques 3 pp. (Mimeo).

Kyriakou, A. and D. Polykarpou. 1989. Detection of citrus tristeza in Cyprus. Mediterranean Crop Improvement Council, News 12,3-4.

Mendel, K. 1956. The threat of tristeza in the Mediterranean basin. Food Agr. Organization Plant Protection Bul. vol. 4 (7):106-108.

Papasolomontos A. and C.V. Economides, 1968. The presence of tristeza virus in certain species of citrus in Cyprus. Food Agr. Organization Plant Protection Bul. vol. 16:8-9.

Salibe, A.A. 1973. The tristeza disease. Proc. 1st Intl. Citrus Short Course, Univ. of Florida, p. 68-76.

Wallace, J.M. 1956a. Tristeza disease of citrus with special reference to its situation in the United States. Food Agr. Organization Plant Prot. Bul. vol. 10(8):77-78.

Wallace, J.M. 1956b. Tristeza and stem-pitting disease of citrus in South Africa. Food Agr. Organization Plant Protection Bul. vol. 10(8):88-94.

Weir, C.C. 1976. Effect of various rootstocks on the growth and yield of Valencia orange, Marsh Seedless grapefruit, and Ortanique trees in Jamaica. Journal Agr. Univ. Puerto Rico 1976 60(4):485-490.