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*Tristeza Tolerant Rootstocks—Their Behavior
after Twelve Years in Orchard*

AMONG 400 varieties tested in a nursery as rootstocks, cooperatively by the Instituto Agronômico and the United States Department of Agriculture, only 77 were considered to be tolerant to tristeza virus (1). Three trees from each apparently tolerant stock-scion combination were transplanted to a plot at the Limeira Experiment Station in 1950-51.

Several reports covering the tristeza aspects of these investigations were made (1, 2, 3) but none referred to the productivity of the trees. In this paper, data are presented on the fruitfulness of the trees from 1955 to 1962 when scions of nucellar Barão sweet orange [*Citrus sinensis* (L.) Osbeck], Valencia orange, Dancy tangerine (*C. tangerina* Hort. ex Tanaka), and Eureka lemon [*C. limon* (L.) Burm. f.] were used as tops. Observations on the reaction to drought of the orange and tangerine scions on the 77 rootstocks are also mentioned.

Materials and Methods

The materials and detailed methods of this tristeza-tolerant rootstock experiment have been previously reported (1, 2). Five seedlings of each variety used as a stock were budded with each variety used as a scion. All plants were infected with tristeza virus in the nursery by aphid inoculation. Three trees of each scion-rootstock combination that survived the tristeza infection were transplanted to the field in 1950-51. No irrigation was given to the trees.

Results

FRUIT PRODUCTION.—The yields of the trees are summarized in Table 1. The data refer to total production (number of fruit) per tree from

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TABLE 1. DROUGHT RESISTANCE AND YIELDS OF NUCELLAR BARÃO AND VALENCIA LATE ORANGE, DANCY TANGERINE, AND EUREKA LEMON BUDDED ON 77 TRISTEZA-TOLERANT ROOTSTOCKS. TOTAL NUMBER OF FRUIT PER TREE (1955-62)

	Drought resistance	Barão orange	Valencia orange	Dancy tangerine	Eureka lemon
Rangpur lime (limão cravo) (<i>Citrus limonia</i> Osbeck)	good	5,931	3,662	—	—
Sunki mandarin (<i>C. sunki</i> Hort. ex Tanaka)	good	4,645	2,723	—	—
Kinnow mandarin (<i>C. reticulata</i> Blanco)	low	4,069	1,783	—	—
Morton citrange [<i>C. sinensis</i> x <i>Poncirus trifoliata</i> (L.) Raf.]	good	3,497	2,745	7,606	879
Hamlin orange	low	3,415	2,751	—	—
Florida sweet seedling	low	3,284	3,383	—	—
Citrumelo 4477	good	3,270	—	—	—
Parson Brown orange	low	3,127	2,272	—	—
Cleopatra tangerine [<i>C. reshni</i> (Engl.) Hort. ex Tanaka]	low	3,118	1,906	6,290	2,163
Seminole tangelo (<i>C. paradisi</i> Macf. x <i>C. reticulata</i>)	low	3,037	2,274	—	—
Swatow tangerine 10031 (<i>C. tangerina</i> Hort. ex Tanaka)	good	3,005	—	—	—
Mandarin 117477	good	2,977	1,936	3,223	1,489
Kara mandarin	low	2,910	2,814	—	—
Clementine tangerine	low	2,896	2,534	3,079	2,071
Ling Ming mandarin	good	2,880	1,703	5,256	1,130
Oneco tangerine	low	2,834	3,301	—	—
Rusk citrange	fair	2,748	1,811	5,033	2,106
Minneola tangelo	low	2,661	2,018	—	—
Citrumelo 4475	good	2,615	3,475	—	—
Orlando tangelo	low	2,599	2,456	4,990	—
Dancy tangerine	fair	2,562	2,732	—	—

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TABLE 1 (Continued)

	Drought resistance	Barão orange	Valencia orange	Dancy tangerine	Eureka lemon
Troyer citrange	fair	2,550	2,668	—	—
Pineapple orange	low	2,532	3,165	—	—
Valencia late orange	low	2,470	—	—	—
Nobilis 10642	low	2,466	2,232	—	2,823
King of Siam (<i>C. nobilis</i> Loureiro)	low	2,445	1,311	2,479	1,617
Swatow tangerine 14054	low	2,396	3,030	—	—
Satsumelo 10-V-3	fair	2,305	2,408	—	—
Swatow tangerine 10032	low	2,305	—	—	—
Sampson tangelo	fair	2,217	2,017	—	—
Murcott Honey tangor	low	2,169	1,104	2,514	1,137
Tavares limequat [<i>C. aurantifolia</i> (Christm.) Swing. x <i>Fortunella</i> <i>japonica</i> (Thumb.) Swing.]	low	2,164	—	—	—
Chao Chou Tien Chieh mandarin	good	2,154	—	4,943	1,082
Citrumelo 4482	good	2,112	—	—	—
Sweet lemon 1158 (<i>C. limetta</i> Risso)	fair	2,084	2,516	—	—
Cowgill Narcot	low	2,062	—	—	—
Ponkan tangerine 18027		2,059	2,505	—	—
Sunshine tangelo	low	1,939	2,318	—	—
Mandarin 10630	low	1,864	—	3,666	1,925
Tresca hybrid	low	1,788	1,167	4,199	2,361
Sum Chu Shu Kat mandarin	fair	1,784	2,366	3,739	2,346
Mandarin 114412	low	1,740	1,955	4,212	2,918
Pook Ling Ming mandarin	fair	1,732	2,255	3,035	1,140

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TABLE 1 (Continued)

	Drought resistance	Barão orange	Valencia orange	Dancy tangerine	Eureka lemon
Caipira sweet orange	low	1,671	411	2,367	—
Navel orange	low	1,659	1,873	3,760	1,939
Temple tangor	fair	1,587	2,449	—	—
Williams tangelo	low	1,573	1,804	—	—
Suwanee tangelo	low	1,543	1,652	—	—
Suen Kat mandarin	fair	1,507	2,110	—	—
San Jacinto tangelo	low	1,476	581	1,133	999
<i>P. trifoliata</i> l/f.	low	1,468	2,400	—	—
Webber tangelo	low	1,442	1,570	—	—
Savage citrange	fair	1,413	207	704	713
Florida Rough lemon (<i>C. jambhiri</i> Lushington)	fair	1,379	—	—	—
Calashu	low	1,319	1,706	2,520	1,961
Umatilla tangor	low	1,299	1,778	—	—
Mediterranean sweet orange	low	1,195	392	2,152	1,254
Ruby Blood orange	low	1,182	1,863	2,522	1,921
Lima da Persia (sweet lime) (<i>C. limettioides</i> Tanaka)	fair	1,136	1,308	2,558	1,476
Yalaha tangelo	low	1,129	880	—	—
Uvalde citrange	fair	1,123	—	3,163	1,999
Satsuma tangerine	fair	1,074	—	—	—
Homosassa orange	low	1,066	—	3,675	2,830
Pera sweet orange	low	1,035	493	3,222	1,816
Kumembo mandarin	fair	1,035	—	—	—
Cunningham citrange	low	1,009	1,005	1,950	186
Kalpi lime	good	926	1,555	—	—

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TABLE 1 (Continued)

	Drought resistance	Barão orange	Valencia orange	Dancy tangerine	Eureka lemon
<i>Citrus taiwanica</i> Tanaka et Shimada	low	923	1,463	3,747	1,950
Lue Gim Gong orange	low	817	1,829	3,761	1,486
Jaffa orange	low	731	—	—	—
Limeira rough lemon	fair	713	—	—	2,455
Cravo tangerine	low	624	—	2,295	2,540
Weshart tangerine	low	613	1,154	2,981	914
Shamouti orange	low	578	1,271	2,225	1,004
Tangelo 18-H-6	low	566	—	3,434	1,658
Tangor 653	low	40	541	1,902	1,167
Lamb's Summer orange	low	0	1,020	5,286	1,350

1955 to 1962. All trees with Duncan and Foster grapefruit (*C. paradisi* Macf.) and West Indian lime [*C. aurantifolia* (Christm.) Swing.] scions made poor growth and showed severe stem pitting, independently of the rootstock used. Production of these trees was small and a great majority of the fruit was unmarketable.

Some rootstock varieties such as Columbia sweet lime (*C. limettioides* Tanaka), Sweet lime (USDA—PI 1158), Lima da Persia (*C. limettioides*), Sweet lemon (*C. limetta* Risso), Kalpi lime, Tavares limequat (*C. aurantifolia* x *Fortunella japonica* Swing.), and *Micromelum tephrocarpa* had a low tolerance to tristeza virus with all scion varieties. The trees on these rootstocks produced relatively large crops the first few years, but remained stunted or died subsequently.

Certain rootstocks, such as Mediterranean, Pera, and Lamb's Summer orange, Yalaha and Webber tangelo (*C. reticulata* x *C. paradisi*), Morton and Rusk citrange [*C. sinensis* x *Poncirus trifoliata* (L.) Raf.], and *Citrus taiwanica* Tanaka et Shimada showed wood pitting in different degrees; but the trees made normal growth. They may, however, decline in the future.

Almost all trees of Eureka lemon developed shell bark, and this may have interfered with their productivity.

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Cropping began in 1955 and the number of fruit produced per tree has been recorded since then. The Valencia trees did not start to produce until 1956. A great variation in cropping capacity was noticed among the various scion-rootstock combinations. The biggest crops were produced by the Dancy tangerine trees, followed by those of Barão and Valencia orange trees. The Eureka lemon trees produced the smallest crops in the experiment.

Rangpur lime, Sunki mandarin, and Hamlin and Florida sweet orange rootstocks had the largest crops when the tops were Barão and Valencia orange. The tangelo, tangerine, and mandarin stocks were the best with tops of Dancy tangerine and Eureka lemon. Unfortunately, these two top varieties were not budded on Rangpur lime. The Ling Ming mandarin, a citrus variety very similar to Rangpur lime, was one of the best with Dancy tangerine top. The Cleopatra mandarin remained among the ten best rootstocks when budded with Barão orange, Dancy tangerine, and Eureka lemon but dropped to 30th place with Valencia orange scions.

DROUGHT RESISTANCE.—In 1961 and 1963, the “paulista” plateau suffered two very dry winters. In 1961, the dry season, which generally ends in September, extended two months longer and hence there was a severe fruit drop after the September spring bloom. In December, another general bloom set a very late crop. In March, 1962, the trees with sweet orange tops showed three different kinds of behavior according to the rootstock they were on: (a) some held only fruit from the first bloom, (b) others held only fruit from the second bloom, (c) some held equally fruit from both blooms. The trees budded on Rangpur lime, Ling Ming mandarin, and Citrumelo were in the first group; those budded on sweet orange, trifoliolate orange, and rough lemon were in the second group; and the trees on rootstocks of tangerine, mandarin, and citrange were in the third group. The various varieties of tangelo dropped into the second and third groups.

In 1963, the dry season started unusually early and the citrus trees all over the plateau suffered much more than in 1961. The 1963 winter was the driest since 1890. All the trees in the rootstock planting suffered from the drought and their leaves wilted. The various rootstocks were grouped according to the relative degree of wilting of the trees as inducing good, fair, or low drought resistance (Table 1).

The Rangpur lime, Ling Ming mandarin, and Citrumelo once more induced good resistance to the sweet orange scions. The two rough lemon

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varieties, Florida and Limeira, did not follow the same pattern of 1962; they induced fairly good drought resistance to the tops.

Discussion and Conclusions

The results here reported justify the preference expressed by Brazilian citrus growers for Rangpur lime as their main rootstock, following the tristeza outbreak. Rangpur lime induced the largest crops and good drought resistance. Choice of a rootstock, however, depends upon the variety used as a top. Rangpur lime and Sunki and Kinnow mandarin rootstocks induced the best crops for the Barão orange trees. This variety is a midseason orange. The Rangpur lime, Citrumelo 4475, and Florida sweet orange induced the highest yields to the Valencia late orange top. The Dancy tangerine trees gave the largest crops when budded on Morton citrange, Cleopatra tangerine, and Ling Ming mandarin. The best bearer trees of Eureka lemon were those budded on Mandarin 114412, Homosassa orange, and on *Citrus nobilis* Loureiro 10642. The trees giving the greatest production were as a rule the most vigorous, as shown by Grant *et al.* (3).

The choice of a rootstock would seem to depend also upon the season, for trees on the various rootstocks showed different degrees of drought resistance. The rootstocks inducing the best drought resistance were Rangpur lime, Morton citrange, varieties of Citrumelo, and certain varieties of mandarin, whereas trifoliolate orange, sweet orange, and tangelo induced least resistance. The other varieties induced a somewhat intermediate resistance. Horanic and Gardner (4) reported observations on the drought resistance of different rootstocks that agree with those here reported.

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