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Authors

Mendt, M.
Plaza, G.
Boscan, R.
et al.

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Spread of Citrus Tristeza Virus and Evaluation of Tolerant Rootstocks in Venezuela

R. Mendt, G. Plaza, R. Boscán, J. Martínez, and R. Lastra

ABSTRACT. Citrus Tristeza Virus (CTV) was detected by ELISA (enzyme-linked immunosorbent assay) in 55% of the citrus trees tested in Aragua, Carabobo, Yaracuy and Zulia States in Venezuela. High infestation with the aphid *Toxoptera citricida* Kirk was found in all surveyed areas. Several CTV tolerant rootstocks budded with Valencia and Washington navel oranges were compared in two different ecological areas. The following parameters were taken into consideration: foliage, volume, fruit yields, efficiency, % of juice, °Brix and % of acidity. From the preliminary results the most promising rootstocks seems to be Cleopatra mandarin, Volkamer lemon, Swingle citrumelo and Troyer and Carrizo citranges. The selection of a single rootstock would not be feasible due to the different climatic and soil conditions.

In Venezuela citrus is an important crop with approximately 40,000 ha grown commercially in the northern states of Aragua, Carabobo, Yaracuy and Zulia. Citrus tristeza virus (CTV) is the most important viral disease affecting citrus in this country, because most varieties are budded on sour orange, which is very susceptible to the disease. The first report of CTV in Venezuela was in 1960 (4), however, for several years it was restricted to a small area, probably because an efficient vector was absent. The aphid *Toxoptera citricida* Kirk, appeared in Venezuela in 1975 (2, 3), from neighboring countries, and today is present in all the growing areas. The first important outbreak of the disease occurred in 1980 and since then the number of affected plants has increased every year. This paper reports on the spread of the disease and on trials with tolerant rootstocks.

MATERIALS AND METHODS

Samples were collected from commercial citrus orchards in the Aragua, Carabobo, Yaracuy and Zulia states, from plants showing tristeza-like symptoms and from surrounding trees. Young shoots were collected and kept in plastic bags at 4°C until analyzed.

Citrus tristeza virus was diagnosed by ELISA. Young bark tissue was homogenized at a 1/20 (w/v) dilution in PBS-Tween pH 7.4, containing 2% polyvinyl pyrrolidone (PVP-40). ELISA tests were performed following the procedure by Bar-Joseph et al. (1) with two replications per sample. Healthy and CTV-infected Mexican lime tissue from greenhouse plants was used as controls.

Rootstocks trials for Valencia oranges were carried out in Guigue, Carabobo state (10°13' N. lat. 68°00' W. long.) located at 468 m elevation with an average rainfall and daily temperature of 1.028 mm and 25 C respectively. Soil type was a light clay with a pH of 7 and organic matter content of 6.22%. The rootstocks assayed were: Carrizo citrange, Troyer citrange, Swingle citrumelo, Volkamer lemon, *C. amblycarpa*, *C. taiwanica*, Cleopatra mandarin and rough lemon. Planting density was 204 trees/ha and at the time of evaluation plants were 4 years old.

Rootstocks assays for Washington Navel oranges were carried out in Aguirre, Carabobo state (10°13' N lat. & 68°20' W. long.) located at 690 m elevation with an average rainfall and temperature of 969 mm and 20 C respectively. Soil texture was clay with an or-

ganic matter content of 3.3% and a pH of 6.3. The rootstocks assayed were: Volkamer lemon, *C. taiwanica*, sour orange, Troyer citrange, and Swingle citrumelo. Planting density was 235 trees/ha, and at the time of evaluation the trees were 7 years old.

Fruit was evaluated for °Brix and acidity. The juice of ten fruits was pooled for analysis.

RESULTS

Citrus tristeza is widespread in the region surveyed, and incidence of the disease has increased during the last three years. Few were found infected in 1981 in 1,000 ha planted with citrus trees in the Aragua state. However, 20,000 trees (equivalent to 100 ha) died in 1982, presumably because of tristeza. We are expecting 500 ha to be affected by CTV in 1983. Table 1 shows the samples tested during the last 3 years, collected in 207 localities in the 4 mentioned states. Positive reactions were detected in 54.9% of the samples tested by ELISA.

The growth of Valencia trees on different rootstocks is summarized in Table 2. Foliage volume was largest for plants budded on Volkamer lemon and Carrizo citrange. These two combinations also showed the highest yield and the largest numbers of fruits per plant. Trees budded on Cleopatra mandarin and rough lemon had the poorest yields. The rest of the Valencia/rootstock combinations produced medium yields (table 2). However, the most efficient (kg fruits/m³ of foliage) combinations were Valencia with Swingle citrumelo and Troyer citrange rootstocks.

The best fruit quality was exhibited by Valencia oranges budded on Swingle citrumelo and Cleopatra mandarin. Trees grafted on rough lemon and Volkamer lemon had the lowest fruit quality.

Fruits that showed the highest sugar content/acidity relationship were those from Valencia trees budded on Cleopatra mandarin, Carrizo citrange and Troyer citrange (table 3).

The foliage volume of Washington Navel oranges was larger when budded on Volkamer lemon, *C. taiwanica*, and sour orange than when budded onto Swingle citrumelo and Troyer citrange. However, the highest yields and the largest number of fruits were produced when the scion was budded to Volkamer lemon and sour orange. The most efficient combination was that of Washington navel oranges budded on sour orange followed by Swingle citrumelo, Troyer citrange, Volkamer lemon and *C. taiwanica* (table 4).

The highest °Brix were obtained from Washington Navel oranges budded on Troyer citrange. All other combinations were similar in juice quality. The relationship between sugar content and acidity was highest when *C. taiwanica* and Volkamer lemon were used as rootstocks followed by Troyer citrange, Swingle citrumelo, and sour orange (table 5).

DISCUSSION

Citrus tristeza virus is now found frequently in Venezuela. Since the first main outbreak of the disease in 1980, it has been increasing in all cultivated areas and large numbers of trees are killed each year.

The tendency in the Venezuela citriculture is to replace susceptible rootstocks, mainly sour orange, with tolerant varieties. However, since there was no experience with these new rootstocks, a first priority was to evaluate their performance in our citrus areas. From our preliminary trials it seems that the more promising rootstocks could be: Cleopatra mandarin, Volkamer lemon, Swingle citrumelo,

TABLE 1
SPECIES AND NUMBER OF CITRUS TREES SAMPLED BY REGIONS AND
INFECTED WITH CTV

Species or hybrid rootstocks	No. of trees/ (positive/no. sampled)				Total
	Carabobo*	Aragua*	Yaracuy*	Zulia*	
Valencia/sour orange	313/590	123/241	190/297		626/1128
Washington navel/sour orange	34/105	13/39	8/15	1/1	56/160
Pineapple/sour orange	157/251	48/75	6/6		211/332
Valencia/Cleopatra mandarin	12/24	—†	—	—	12/24
Tangor/sour orange	3/8	—	—	—	3/8
Grapefruit/sour orange	—	—	—	-/3	-/3
Lime/sour orange	—	—	—	3/4	3/4
Total	519/978	184/355	204/318	4/8	911/1659

*Localities sampled, Carabobo 87, Aragua 62, Yaracuy 57, Zulia 1.

†Not tested.

TABLE 2
EVALUATION OF VALENCIA ORANGES BUDDED TO TRISTEZA TOLERANT
ROOTSTOCKS*

Rootstocks	Foliage† volume (m ³)	Fruit yields (kg/plant)	Efficiency (kg/m ³)	Number of fruits/plant
Swingle citrumelo	22.5	66.1	2.93	226
Troyer citrange	31.6	76.5	2.42	248
Carrizo citrange	40.5	93.3	2.30	296
Volkamer lemon	48.6	89.1	1.83	304
<i>Citrus taiwanica</i>	30.0	50.8	1.69	177
<i>Citrus amblycarpa</i>	35.7	48.0	1.34	147
Cleopatra mandarin	29.7	27.1	0.91	105
Rough lemon	29.5	26.1	0.88	76

*Four-year-old trees, located in Guigue, Carabobo state, 1982-1983 crop.

†Calculated following Turrel's formula (6).

TABLE 3
FRUIT QUALITY EVALUATION OF VALENCIA ORANGES GRAFTED TO
TRISTEZA TOLERANT ROOTSTOCKS

Rootstocks	Juice (%)	(TSS*/°Brix)	Acidity (%)	TSS*/acidity ratio
Swingle Citrumelo	55.95	8.18	0.96	8.58
Troyer Citrange	51.71	7.17	0.80	9.05
Carrizo Citrange	54.27	7.56	0.85	9.05
Volkamer lemon	49.19	6.83	0.83	8.36
<i>Citrus taiwanica</i> Tan.	55.22	6.88	0.84	8.39
<i>Citrus amblycarpa</i> Ochse.	52.61	7.27	0.92	7.90
Cleopatra mandarin	54.89	7.63	0.82	9.39
Rough lemon	50.57	6.89	0.82	8.54

*Total soluble solids.

TABLE 4
EVALUATION OF WASHINGTON NAVEL ORANGES BUDDED TO TRISTEZA
TOLERANT ROOTSTOCKS*

Rootstocks	Foliage volume (m ³)	Fruit yield (kg/plants)	Efficiency (kg/m ³)	Number of fruits/plant
Volkamer lemon	26.91	70.7	2.62	252
Troyer citrange	17.73	50.5	2.84	199
Swingle citrumelo	18.34	53.6	2.92	208
<i>Citrus taiwanica</i>	25.47	62.8	2.46	222
Sour orange	21.23	67.2	3.16	254

*Seven-year-old trees, located in Aguirre, Carabobo state, 1982-1983 crop.

Troyer citrange, and Carrizo citrange. Furthermore, it seems that the selection of only one rootstock will not be feasible due to the different climatic conditions and types of

soils in the various citrus growing areas. Some of our observations are in accordance with previous results (5).

TABLE 5
FRUIT QUALITY EVALUATION OF WASHINGTON NAVEL ORANGES
GRAFTED TO TRISTEZA TOLERANT ROOTSTOCKS

Rootstocks	Juice (%)	(TSS*/°Brix)	Acidity (%)	TSS*/acidity ratio
Volkamer lemon	47.7	10.83	0.63	17.54
Troyer citrange	48.2	12.33	0.73	16.93
Swingle citrumelo	50.3	11.16	0.68	16.63
<i>Citrus taiwanica</i> Tan.	49.5	11.16	0.60	18.63
Sour orange	48.8	11.50	0.77	14.93

*Total soluble solids.

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