The Performance of Exotic Citrus Tristeza Virus Isolates as Preimmunizing Agents for Sweet Orange on Sour Orange Rootstock Under Natural Disease Pressure in South Africa

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ABSTRACT. Eleven mild citrus tristeza virus (CTV) isolates from Florida (USA), Israel and South Africa were inoculated to Valencia sweet orange on sour orange rootstock. The trees were planted in an orchard where they were exposed to a natural challenge of field CTV isolates by the vector, the black citrus aphid, *Toxoptera citricidus*. Quick decline symptoms appeared 4 yr after planting in the presence of some mild isolates. Only one isolate, Micveh T from Israel, appeared to have potential commercial value under these climatic conditions.
Index words. cross protection, quick decline, citrus tristeza virus, sour orange rootstock.

Citrus tristeza virus (CTV) is almost ubiquitous in areas infected with blight (4, 7), and as a result the use of sour orange as a rootstock for sweet orange is precluded in these areas. Apart from resistance to *Phytophthora* root and collar rot (6), sour orange is also tolerant to blight (11). To control blight in areas where CTV is endemic, it would be advantageous to find a selection of sour orange tolerant to quick decline CTV (9), or to find a mild CTV isolate to protect sweet orange on sour orange rootstock.

Since the interaction of mild CTV isolates with various commercial citrus types with regard to cross protection is specific with regard to biological activity (5), CTV isolates for protection of sweet orange on sour orange will not be available in countries where CTV causing quick decline is endemic. In such countries CTV isolates derived from citrus cultivars other than sweet orange on sour orange must be evaluated, generally with little chance of commercial success (5), or the desired CTV isolates can be obtained from other countries where quick decline is not epidemic (3). These imported isolates should be evaluated against the local disease pressure. A preliminary evaluation can be done in the glasshouse (10, 12) and finally in the field where they will be subjected to natural challenge of indigenous CTV strains by aphid vectors (8).

This paper reports on the performance of exotic and local CTV isolates in sweet orange on sour orange rootstock under conditions where the tristeza quick decline is endemic.

MATERIALS AND METHODS

A Florida selection of sour orange was grown under insect-free conditions in a glasshouse and budded with virus-free Delta Valencia sweet orange. When the scions had grown out approximately 200 mm, the trees were bud-inoculated with CTV isolates derived from different sources (table 1). Each treatment had five replicates; control plants were left virus-free. Three months were allowed for the CTV isolates to become established in the plants which were then planted in an orchard in a randomized block design. No treatments were applied specifically to control the insect vector, *Toxoptera citricidus* Kirk., but treatments applied to control *Trioza erytreae* (Del Guercio) to restrict greening disease introduction were also effective against the aphids.

Trunk circumference and tree volume were recorded (1). The condition of the trees 4.5 yr after planting were rated as follows: 0 = healthy, 1 = healthy but sparse foliage, 2 = declin-

TABLE 1
SOURCES OF CITRUS TRISTEZA VIRUS ISOLATES INOCULATED IN SWEET ORANGE ON SOUR ORANGE ROOTSTOCK

Isolate	Country of origin	Host source	Reaction rating
SOSS 1[z]	South Africa	Sweet orange	Severe
GFSS 1[z]	South Africa	Grapefruit	Severe
GFMS 12[z]	South Africa	Grapefruit	Mild
GFMS 35[z]	South Africa	Grapefruit	Mild
LMS 6[z]	South Africa	Lime	Mild
T 26[y]	Florida, USA	Sweet orange	Mild
T 30[y]	Florida, USA	Lime	Mild
T 32[y]	Florida, USA	Sweet/sour	Mild
T 33[y]	Florida, USA	Sweet/sour	Mild
T 54[y]	Florida, USA	Sweet/sour	Mild
T 55[y]	Florida, USA	Sweet/sour	Mild
Micveh T[x]	Israel	Sweet/sour	Mild
Micveh T 127000[x]	Israel	Sweet/sour	Mild

[z]see reference 10; Van Vuuren (unpublished data).
[y]see reference 4
[x]M. Bar-Joseph, The S. Tolkowsky Laboratory, The Volcani Centre, Bet-Dagan, Israel (personal communication).

ing symptoms and 3 = dead. A Friedman rank analysis was applied to the data.

Yield was recorded and the fruit size analysed in a commercial packhouse according to export size categories. Yield efficiency according to tree canopy volume was calculated.

RESULTS

Growth and general tree condition in the different treatments are given in table 2. All the trees inoculated with the severe isolate SOSS 1 were dead 3 yr after planting. This isolate was more severe than isolate GFSS 1 where only three out of five inoculated plants died over the same period. With the mild isolates, the first deaths occurred 4 yr after planting. Trees that died from infection with the two severe isolates and LMS 6, as well as the one control plant, exhibited declining symptoms for more than a year before death, whereas those inoculated with isolates T30, T33, T54, T55 and Micveh T 127000 displayed typical quick decline symptoms. No trees died where isolates Micveh T (Israel), T 26 and T 32 (Florida), and GFMS 12 and GFMS 35 (South Africa) were inoculated, but some trees inoculated with T 32, GFMS 12 and GFMS 35 displayed decline symptoms.

TABLE 2
THE INFLUENCE OF CTV ISOLATES ON THE GROWTH OF VALENCIA SWEET ORANGE TREES ON SOUR ORANGE ROOTSTOCK[z]

CTV isolate	Trunk circumference (mm)[y]	Tree condition (rank)[x]
Micveh T	162.2 a	20.5 a
T 32	151.4 ab	37.0 ab
T 26	147.6 ab	24.5 a
T 55	123.4 abc	37.5 abc
T 54	107.4 abc	41.5 bcd
Micveh T 127000	104.6 abc	36.0 abc
GFMS 35	102.8 abc	23.5 a
T 33	94.8 abc	41.5 bcd
T 30	92.0 abc	38.5 bc
GFMS 12	85.8 bc	24.0 a
LMS 6	65.2 c	27.0 ab
Control	98.2 abc	51.0 cde
GFSS 1	—	58.0 de
SOSS 1	—	64.5 e
LSD P = 0.05	73.2	17.2

[z]Trees 4.5 yr old
[y]LSD test. Numbers followed by the same letter do not differ significantly at the 5% level.
[x]Rated on a scale of 0 = healthy, 1 = sparse foliage, 2 = decline symptoms, and 3 = dead. Numbers are cumulative totals. Numbers followed by the same letter do not differ significantly at the 5% level using Friedman rank analysis.

TABLE 3
CANOPY VOLUME AND TREE EFICIENCY OF SWEET ORAGE ON SOUR ORANGE ROOTSTOCK INOCULATED WITH DIFFERENT CTV ISOLATES

CTV isolate	Tree volume[z] (m^3)	Yield (kg/tree)[y]	Yield Efficiency[y] (kg/m^3)	Fruit > 67 mm diam (%)
Micveh T	2.7 a	28.4	10.5	29.9
T 26	1.9 ab	13.7	7.2	37.2
T 55	1.6 bc	10.9	6.8	31.2
T 32	1.5 bc	12.9	8.6	36.4
T 33	1.5 bc	15.4	10.3	64.9
T 54	1.2 bcd	7.5	6.3	34.7
Micveh T 127000	1.0 bcd	7.2	7.2	47.2
T 30	0.7 cd	5.4	7.7	50.0
GFMS 35	0.6 cd	6.5	10.8	70.2
GFMS 12	0.3 d	2.8	9.3	42.9
LMS 6	0.3 d	1.8	6.0	66.7
Control	0.7 cd	2.5	3.6	36.0
LSD P = 0.05	1.1			

[z]Numbers followed by the same letter do not differ significantly at the 5% level.
[y]yield for last crop

Data representing tree ratings with the different treatments are presented in table 3.

DISCUSSION

The general poor condition (table 2), and poor performance (table 3) of the control trees, indicated that all the trees were naturally challenge inoculated by CTV isolates transmitted by the black citrus aphid, *Toxoptera citricidus* although treatments to prevent greening disease could possibly have retarded the challenge. Tree condition and performance of all the trees inoculated with the mild isolates were better than the control trees, indicating that all the mild isolates gave some protection.

Trees inoculatd with T 30 (Florida), and the three S.A. isolates (GFMS 12, GFMS 35 and LMS 6) were dwarfed and had significantly smaller canopies than trees inoculated with isolates T 26 (Florida) and Micveh T (Israel) (table 3). The isolates inducing dwarfing were derived from grapefruit or lime hosts, whereas all the other isolates were from sweet orange (table 1).

Yield efficiency of the control trees was poor, while those inoculated with the mild isolates varied between average (6-8 kg/m^3) to above average (greater than 8 kg/m^3, H. J. Breedt, personal communication). Trees with the Micveh T isolate were highly productive, but fruit size was small. The decrease in fruit size could be attributable to either CTV or physiological size reduction due to overbearing stress. Interestingly, trees inoculated with isolates T 33 and GFMS 35 exhibited high yield efficiency as well as large fruit sizes.

The growth and performance of trees inoculated with isolates Micveh T and T 26 were not significantly different, although trees with isolate T 26 were more sparsely foliated and showed general signs of stress. Thus, it appears from the present data that Micveh T is the only isolate which may have commercial value under the environmental conditions of this study. The same isolates are presently being evaluated in a hotter climate which may result in different symptom expression (2).

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